Rolling Stock Maintenance Manuals

TA PROJECT TO STRENGTHEN THE CAPACITY OF REGULATOR AND TO ESTABLISH OPERATION AND MAINTENANCE COMPANY OF METROPOLITAN RAILWAY LINES IN HANOI CITY

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Hanoi, November 2015
Rolling Stock Maintenance Manuals

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1) Legal Basis and Reference

1.1 Legal Basis
- Railway Law
- Circular No. 02/2009/TT-BGTVT, Circular No. 36/2011/TT-BGTVT by MOT and other related regulations: Regulations on inspection of quality, technical safety and environmental protection for railway vehicles
- Circular No.21/2015/TT-BGTVT on working hours and break time of employees who engage in specific operations in railway transportation.

1.2 Reference
- Decree No. 114/2004 and No. 46/2015/ND-CP dated on 2015/5/12 on quality control and maintenance of structural objects.
- Circular No. 20/2013/TT-BGTVT dated 2013/8/16 on management and maintenance of railway structure.
- Circular No. 15/2009/TT-BGTVT on response to railway accidents and incidents.
- General technical regulations concerning urban railway operation and maintenance (Draft)
- Basic design of urban railways 2, 2A and 3 lines
- Experience and knowledge regarding preparation of train allocation plan, maintenance personnel calculation, renew, purchase of new trains, budget preparation, training method, how to deal with accidents, etc. at Tokyo Metro.
- Regulation dated 2015/8 on railway operation.
- Line-2A (Cat Linh-Ha Dong) Training Plan Ver. 16.0.

2) Purpose and Definitions of Manual

2.1 Purpose
The purpose of this manual is to instruct personnel in practical rolling stock maintenance including how to create the train allocation plan, how to calculate the number of necessary maintenance personnel, how to implement renewing/restoring and new rolling stock procurement, budget preparation procedures, training methods, regulation revisions, how to operate and manage Maintenance Center, and how deal with accidents.

2.2 Definitions
a. Train allocation
   Train allocation denotes allocation of trains to be operated on a daily, monthly and annual basis to implement the periodic maintenance.

b. Maintenance budget
   A rolling stock maintenance budget is prepared for the rolling stock maintenance work in consideration of the workload, unit price and comparable standards in the implementation plan.
c. Maintenance personnel
   Maintenance personnel refers to the people who are directly engaged in the maintenance work in the specific place of maintenance.

d. Renewal
   Renewal is changing performance of rolling stock, or changing the structure or specifications of a main motor, bogie, brake system, coupler or car body from the initial design.

e. Railway traffic accident
   A railway traffic accident is a problem caused by railway transportation means that gives damages to human life or health, or property as a result of collision, derailment, over-turning or bursting into flames. A collision in this context includes that with people, other transportation means and obstacles.

f. Incidents in urban railway
   It is a problem that occurs in the transportation activities of the urban railway. It is not categorized as a railway accident though it affects the railway operation.

3) Train Allocation Plan Preparation Procedure
   This includes allocating trains for operation and inspection to be implemented on a daily, monthly, quarterly and annual term basis, and the operation plan and other maintenance plan.

3.1 Principle of Train Allocation for the Inspection that is Implemented on an Annual, Monthly and Daily basis
   - Ensuring the train operation plan.
   - Implementing the inspection within the specified periods and train operation kilometrage.
   - Equalizing the workload to minimize the number of personnel throughout the entire period.
   - Equalizing kilometrage of each train at the planning stage.
   - Ensuring sufficient time for cleaning, wheel grinding, training, and other tasks.
   - Ensuring safety during maintenance, and effect of cost and quality in the train allocation.

3.2 Preparation Procedure of Train Allocation in Inspection Periods that is in Accordance with Workload in Respective Maintenance
Figure 1 describes the workload in of the medium-scale repairs carried out by at Tokyo Metro. Although the total maintenance implementation period is 20 days, workloads vary depending on the day (same as above). An "Equalizing" approach is employed by Tokyo Metro in order to secure the required work progress, equalize the maintenance workload, and enable rolling stock maintenance personnel to fulfill their abilities as shown in the figure.

However, workload may not be so large when HMC starts the operation. Since maintenance personnel for medium- and large-scale repairs are not included in Line-2A training program at the start of the operation, it may not yet be necessary to introduce train allocation based on "equalizing" as shown in Figure 2. After multiple lines are opened in the future, workload will be increased along with an increase in train kilometrage and the number of trains targeted for periodic maintenance. At that point, HMC may study whether to allocate trains based on the above approach.

3.2.1 Train Allocation in Medium- and Large-Scale Repair
- The train allocation preparation method described in this manual is based on the hypothesis developed by Tokyo Metro.
- Medium- and large-scale train repairs are conducted in four-year and eight-year inspection.
- Two types of train allocation are employed for medium- and large-scale repairs. One is a centralized approach, and the other is a distributed approach (allocated evenly in the period) as shown in the figure below.
The approach you should choose depends on initial factors existing at the time the plan is created such as personnel, costs, training, and other work plans.

In the train allocation for medium- and large-scale repairs carried out by Tokyo Metro, where the lines and maintenance personnel are stabilized, the workload is evenly allocated to each period every year as shown in the above figure.

Allocating an even workload in the annual maintenance plan provides the following advantages.

<table>
<thead>
<tr>
<th>Number of personnel</th>
<th>- It allows averaging of the workload at each phase, so you can minimize the number of personnel required.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- It allows averaging of the maintenance budget at each phase.</td>
</tr>
<tr>
<td>Work quality</td>
<td>- It provides opportunities for personnel to gradually gain and enhance their knowledge and skills (in particular at a new company).</td>
</tr>
</tbody>
</table>

There are no personnel for medium- and large-scale repairs at HMC in the initial stage according to training program for opening. In the initial stage, train maintenance can be carried out in accordance with the manufacturer's regulations. Since there is no demand for medium- or large-scale repairs at the initial stage, a medium-scale repair should be carried out at least four to five years in the future. Therefore, it is not possible at this stage to develop a plan to allocate the same workload each year for medium- or large-scale repairs. Thus, the initial maintenance plans should be concentrated in the final phase of the periodic maintenance period as shown in the lower figure in Figure 2.
If inspection personnel can be hired stably for maintenance work once, the next step is to develop train allocation for the next and later medium-scale repairs in such a way that the same workload is allocated each year. See the upper figure in Figure 2.

In order to ensure an appropriate allocation, the requirements for creating the daily and monthly plans should be determined in consideration of the periods of large-scale repairs, medium-scale repairs, daily and monthly maintenance (see the example below for details).

a) Train Allocation Preparation Method

For example, when the period of medium-scale repairs is four years and that of large-scale repairs is eight years for 11 train sets:

The average number of train maintained (each maintenance) is as shown below.

- 8 years: 11 train sets/8 years = 1.4 ≈ 1 to 2 train sets/year
- 4 years: 11 train sets/4 years = 2.75 ≈ 2 to 3 train sets/year
- 3 months: 11 train sets/3 months = 3.66 ≈ 3 to 4 train sets/month
- 6 days: 11 train sets/5 days = 2.2 ≈ 2 to 3 train sets/day

The necessary time per train is set as follows to average the workload.

- 8-year inspection: 96 months / 11 train sets = 8.7 months/train set
- 4-year inspection: 48 months / 11 train sets = Approximately 4.4 months / train set -> Approximately 4.5 months / train set
- 3-month inspection: 90 days / 11 train sets = 64 business days / 11 train sets = 5.8 business days / train set -> 6 business days/train set
- 6-day inspection: 6 days / 11 train sets = 0.54 days/train set

Thus, the result of the study was as shown below.

- 8 years: 1 to 2 train sets / year
- 4 years: 2 to 3 train sets / year
- 3 months: 3 to 4 train sets / month (Inspection day 6 days/train set)
- 6 days: 2 to 3 train sets / day

However, the above average number of trains is for managing the workload of medium- and large-scale repairs. When creating a plan to evenly allocate the workload as shown above, some troubles may emerge. Because operation of 11 train sets is started at almost the same time, their planned maintenance period will be virtually identical. Thus, the implementation as shown in the above calculation will not be able to be used. At VNR, maintenance management is carried out based on the kilometrage. So, when calculating the number of the locomotives/trains to be maintained, they convert actual kilometrage or planned kilometrage (train operation diagram) of every train on every line calculated from the day, month and year to the corresponding maintenance period-based kilometrage to classify the locomotives/trains. In order to evenly allocate the workload, they allocate trains unevenly by adjusting the specific train operation program. In this way, they prevent occurrences of trains having the same maintenance and repair periods at a time.
The following shows the formula used to calculate the number of locomotives/trains on which large-scale repairs are conducted in a year.

\[ n_o = \frac{L_{5}}{L_{CKD}}, \text{ locomotive/trains (Lckd: Kilometrage of the large-scale repair period)} \]

The following shows the number of locomotives/trains on which medium-scale repairs are conducted in a year.

\[ n_T = \frac{L_{\Sigma}}{L_T} \left( 1 - \frac{L_T}{L_D} \right), \text{ locomotives/trains} \]

Where,

- \( L_{\Sigma} \): Total of kilometrage of every train on all lines in a year, km
- \( L_D, L_T, \ldots \): Kilometrage-based maintenance cycle of medium- and large-scale repairs

When a train's kilometrage is 150,000 km/year, for example, the number of trains targeted for medium-scale repairs conducted every four years calculated based on the above formula is as shown below.

\[ nD = \frac{150,000 \times 11}{1,200,000} = 1.37 \text{ (1 to 2 trains / year)} \]

1,200,000 indicate the inspection period 1,200,000 km for medium-scale repairs of Line-2A.

However, it is necessary to consider and manage the possible cases where occurrence of equipment failures installed in such trains will be earlier due to the increased travel distance, which may affect the operation plan compared with other trains. It is necessary to manage the devices and equipment which require inspection, maintenance and repairs based on the kilometrage (such as wheel grinding, brakes, etc.)

+ Train allocation for 4- and 8-year maintenance
+ Annual plan
- Work of periodic 4-year maintenance is included.

+ Monthly plan
- It includes the work within a month as well as cleaning and wheel grinding and trains targeted for periodic maintenance of 8 years, 4 years, 3 months and 10 days.
- For 10-day maintenance, prepare a plan with an approximately 7 to 10 day.
- The planned 10-day maintenance period, cleaning and wheel grinding are implemented after the train operation time.
- Regarding 3-month maintenance, check whether it is possible to carry this out on weekdays during daylight hours.
- Based on the annual medium- and large-scale repair plans, prepare the corresponding daily and monthly plans as described below.
Appendix8-6-6-1-B

Daily maintenance and train allocation plan

Describe the commercial trains to be operated, rolling stock maintenance and other work on a daily basis. The location where maintenance will be carried out and the departure and arrival locations are also included. This is reference material concerning the train allocation to be submitted to the Train Operation Department.

<table>
<thead>
<tr>
<th>日付 Date</th>
<th>02/May</th>
</tr>
</thead>
<tbody>
<tr>
<td>番号 Operation No.</td>
<td>編成番号 Train No.</td>
</tr>
<tr>
<td>A</td>
<td>03</td>
</tr>
<tr>
<td>B</td>
<td>04</td>
</tr>
<tr>
<td>C</td>
<td>05</td>
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<td>02</td>
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<td>H</td>
<td>10</td>
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<tr>
<td>I</td>
<td>08</td>
</tr>
<tr>
<td>予備 Spare</td>
<td>11</td>
</tr>
</tbody>
</table>

The Line-2A maintenance plan

Average number of trains maintained:
1-month: \( \frac{13 \text{ train sets}}{30 \text{ days}} = 0.43 \text{ train sets/day}, \text{ or } \frac{30 \text{ days}}{13 \text{ train sets}} = 2 \text{ days/train set} \)

1-day: \( 13 \text{ train sets/day} \)

5 days: \( \frac{13 \text{ train sets}}{5 \text{ years}} = 2.6 \text{ train sets/year} \)

10 days: \( \frac{13 \text{ train sets}}{10 \text{ years}} = 1.3 \text{ train sets/year} \)

The train allocation includes a plan for train cleaning, wheel grinding and other maintenance work.

(For the train allocation of Line-2A, see Attachment 1.)

### 3.3 Preparation and Approval of Train Allocation

3.3.1 The process in which the plan is created and rolling stock maintenance is implemented at the Workshop.

- Prepare the annual plan based on the long-term maintenance plan (4 to 8 years, and 10 years) of the company.

- Daily and monthly work plans at the Workshop for each line are carried out in accordance with the maintenance manual, which is prepared based on the specifications of each line. The Head of Workshop and management personnel are responsible for handling sudden events that can occur on a daily basis. Depending on circumstances, such events may be reported to the Head of the depot (see below) in order to receive their opinion. After approving the monthly plan, the Head of the Workshop reports on it to the Head of depot.
Detailed procedures are as described below.

- Step 3: After the annual plan has been approved, the Workshop Management personnel announces the plan to the personnel and concerned parties of the Workshop and Inspection Yard, and allocate the work among them.

- Step 9: After the maintenance work is completed at the Workshop, the Head of Workshop checks the result and current condition of the trains, and decides to put the trains into operation as planned.

- Step 10: After the maintenance is completed, the Head of Workshop reports on the results of implementation to the Head of the depot to receive their approval.

- Step 11: The Workshop Management personnel has responsibility to consider next train allocation based on the inspection period and current results.
3.3.2 Flow of preparing train allocation at Inspection Yard (Maintenance Center)

- Monthly train allocation: Based on the approved annual plan, the Inspection Yard prepares the detailed monthly train allocation. The Inspection Yard prepares the daily and monthly inspection plans along with other maintenance plans, and submits them to the management personnel in Maintenance Implement division in OU to receive their approval. The monthly inspection plan and the train allocation must be approved at least 10 days before the implementation date.
The following shows the flow of preparation, approval and implementation of the monthly inspection plan.

- The head of the Inspection Yard (Maintenance Center) checks appropriateness of putting the trains into operation as planned after the monthly inspection in consideration of the inspection result report. The Inspection Yard is responsible for reporting on the monthly inspection result and the weekly condition of trains to the Head of the depot.

- Daily plan: Based on the monthly plan, the Inspection Yard Management personnel has a responsibility of preparing the detailed daily plan. The approver is the Head of the Inspection Yard (Maintenance Center). The daily train allocation must clearly express the work to be implemented, location and trains.

- The daily train allocation must include the details, and must be approved at least one day before the implementation date.
Appendix 8-6-6-1-B

Preparation of daily maintenance plan

- Daily train allocation to be sent to the Operation Section and OCC: The daily train allocation (based on the monthly train allocation) prepared in accordance with the daily operation plan must be sent to the Operation Section and OCC at least one day before the implementation. If any changes or adjustments are made, they must also be reported promptly.

3.3.3 Plan Modification Process

If any incidents or accidents occur, an already prepared train allocation may be changed in accordance with the actual situation.

In consideration of such a case, the train allocation change process should be prepared in advance. Its procedure conforms to the above procedure.

a. Change in daily plan

The Head of Inspection Yard (Maintenance Center) or Head of Workshop may adjust the daily train allocation or work plan in their charge if such an adjustment will not affect the monthly plan or incur any cost.

b. Change in monthly plan

The Head of Inspection Yard (Maintenance Center) or Head of Workshop may review and adjust a monthly plan, and report on it to the Head of the depot if such adjustment does not affect the overall annual plan and does not exceed the approved budget target.

c. Change in annual plan

OU may review and approve the change and report on it to the Manager of the Rolling Stock Maintenance Management division in HQs if such change does not exceed the approved budget target. Even when the budget target is exceeded, OU must submit it to HQs for their review.

3.4 Rolling Stock Maintenance Management at HMC
In the early stage of the operation (2015 to 2020), HMC plans to carry out operation and maintenance management of three lines: Line-2A, Line-3 and Line-2. Each line is built thanks to ODA from different countries. As a result, the specifications of rolling stock and the operation and maintenance processes as well as the technology used for each line differ. HMC is a new company and does not have experience in operation and maintenance of urban railways. Therefore, they are going to meet the safety and technical requirements at the start of the operation based on the rules, procedures and manuals provided by the contractor. In order to ensure integrated management of maintenance, HMC will establish common maintenance rules including regulations on inspection periods and items. However, they will not describe details of the technical requirements.

However, some time after operations on each line have started, HMC must establish common management rules in order to ensure safe and effective maintenance while taking the following factors into consideration.

- Frequency, cause and prevention measures of failures and accidents.
- Contents and measures of inspection and repair.
- Compatibility of the maintenance process with the current state of Vietnam and of the company.

In the rules, periods, items and methods of inspection may be integrated - as shown below - for every line. Inspection periods: Appropriate inspection periods to ensure safe operation will be considered and determined. The appropriateness of the periods may be the shortest period among the all lines. However, if failures rarely occur on the line with the shortest period, an average period can be considered.

Inspection items: Inspection items should be integrated. Among the available lists of inspection items, the one with the most detailed contents may be selected.

Inspection method: Among the inspection methods used on each line, those that are most effective and advanced will be employed.

Note: Satisfying all of the above requirements will increase maintenance costs for personnel, equipment and technology etc.

4) Calculation of Number of Maintenance personnel

4.1 Method of Calculating Number of Maintenance Personnel

Several methods are available at present for calculating the number of personnel required.

- Method of calculating number of personnel
- Calculation method based on the workload and work standard
- Calculation method based on work efficiency
- The way of employing a similar method
- Comprehensive method

4.2 Calculation of Number of Necessary Maintenance Personnel Based on Experience at Tokyo Metro
This manual describes how to calculate the number of personnel who are directly engaged in the maintenance. The calculation method applied here is based on the workload and work standard. The following describes how to apply this calculation method to personnel including a personnel on duty and administrators.

The maintenance personnel must include personnel who engage in rolling stock maintenance and monthly maintenance at Inspection Yard, and personnel who carry out medium- and large-scale repairs at Workshop.

a) The number of personnel who directly carry out maintenance is calculated as shown below (medium-and large-scale repairs).

Divide the maintenance work into small groups, and set the time required for each task as $T_n$.

Total time for each task is $T_t = \sum T_n$ ($n = 1$ to $n$).

In order to determine $T_n$, each personnel must report the work to be carried out and the amount of time required to complete it.

Example: When three maintenance personnel are allocated for bogie (P1, P2 and P3)

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>day1</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>day2</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>day3</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>day4</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>day5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>day6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>15</td>
<td>35</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

According to the above formula,

$T_t = T_1 + T_2 + T_3 + T_4 = 105$

Total work time per year is: $T_y = T_t \times N_y + \alpha$

$N_y$: The number of trains maintained per year

$\alpha$: Backup time for the maintenance. At Tokyo Metro, Backup time = 40% to 50% of $T_y$ time is usually set (Training, cleaning of Workshop, meetings, research, etc.).

Here, the backup time per day is set to 1 to 2 hours/personnel based on the given conditions in Vietnam. In this case, backup time $\alpha$ is 12 to 25% of $T_y$.

Total working hours of personnel per year:

$P_t = 8 \times (365 - d_1 - d_2 - d_3 - d_4)$

$d_1$: Number of weekends in a year, $d_2$: Annual national holidays, $d_3$: Annual paid holidays, $d_4$: National holidays for various reasons. “8” represents the number of working hours in a day in Vietnam.

Thus, the required number of personnel is:

$P_n = \frac{T_y}{P_t}$

Upon the opening of Line-2A, $T_t$ cannot be determined based on actual work. Therefore, to calculate $T_t$ of Line-2A, and the number of personnel and time required for maintenance work are compared based on the assumption that the maintenance plan and working items are almost the same in China and Japan.
At Tokyo Metro, $T_t$ is as shown below (When inspecting a 10-car train)

b) Calculation of the number of personnel who are directly engaged in work (Monthly, daily)

In Tokyo Metro's Inspection Yard, the following personnel are allocated.

- Administrative personnel (personnel management, preparation of maintenance plan and dealing with failures)
- Monthly inspection personnel
- Rolling stock inspection personnel
- Repair personnel
- Operation line response personnel (restoration of troubles on operation lines)
- Other maintenance personnel
- Drivers at depots
- Signal control personnel at depot
- Rolling Stock cleaning personnel
- Wheel grinding personnel

The number of personnel who are directly engaged in the monthly inspection is calculated as shown below.

$$P_n = T_t \times N_m \times (1+\beta)/8$$

(Where, $N_m$: The number of trains to be inspected per day)

Total time required to complete inspection of 1 train set is $T_t = \Sigma T_n$ ($n = 1$ to $n$). “8” represents the number of working hours in a day in Vietnam.

- In order to determine $T_n$, each personnel must report the work to be carried out and the amount of time required to complete it.
- $N_m$: The number of train sets to be inspected per day.
- In Japan, $\beta < 1$ ($\beta$: Additional time includes the time for moving from a place to another, waiting time, break time, etc.) As the above $\alpha$, $\beta$ should be set appropriately (0.13 to 0.25).
Upon the opening of Line-2A operation, Tt cannot be determined based on actual work. Therefore, to calculate Tt of Line-2A, the number of personnel and time required to carry out maintenance work are compared based on the assumption that the maintenance plan and working items are almost the same in China and Japan.

- **Number of personnel for daily inspection**
  
The personnel for 10-day inspections are divided into several groups. Each group, consisting of two personnel, engages in rolling stock inspection. The time required for inspection of 1 train set is 1 to 2 hours.

- **See Attachment 2 for the estimated number of personnel required for Line-2A.**

- **Duty hours:**
  
  - The personnel responsible for technical inspections, medium- and large-scale repairs carry out their assignment during business hours.
  
  - Regarding daily inspection personnel, Shift work system are adopted in order to ensure allocation of daily inspection personnel to carry out inspections and operations at a depot in accordance with the daily train operation plan from 5:00 to 23:00.
  
  - Personnel who engage in daily inspections at the depot are classified into four groups (A, B, C and D). Their shift duty hours are as described below.
  
  - Shift1: 4:00 to 13:00
  
  - Shift2: 12:00 to 21:00
  
  - Shift3: 20:00 to 4:00 the next morning
  
  - Example: Three shifts for a week is prepared for daily inspection, dispatching and driving at the depot.

<table>
<thead>
<tr>
<th>Group</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Shift 1</td>
<td>Shift 2</td>
<td>Shift 3</td>
<td>Holiday</td>
<td>Shift 1</td>
<td>Shift 2</td>
<td>Shift 3</td>
</tr>
<tr>
<td>B</td>
<td>Shift 2</td>
<td>Shift 3</td>
<td>Holiday</td>
<td>Shift 1</td>
<td>Shift 2</td>
<td>Shift 3</td>
<td>Holiday</td>
</tr>
<tr>
<td>C</td>
<td>Shift 3</td>
<td>Holiday</td>
<td>Shift 1</td>
<td>Shift 2</td>
<td>Shift 3</td>
<td>Holiday</td>
<td>Shift 1</td>
</tr>
<tr>
<td>D</td>
<td>Holiday</td>
<td>Shift 1</td>
<td>Shift 2</td>
<td>Shift 3</td>
<td>Holiday</td>
<td>Shift 1</td>
<td>Shift 2</td>
</tr>
</tbody>
</table>

Daily inspection of Line-2A must be carried out after train operation hours or during a time when the train are not in operation during the day. Therefore, three shifts shall be considered based on the following.

**Principles of three shifts**

- To observe the labor regulations.
- To satisfy the workload and work requirements.
- To secure the minimum number of personnel necessary.
- To avoid taking over between shifts during busy hours.
- The break time for each shift is 1 hour.
5) Renovation of Rolling Stock and Procurement of New Rolling Stock

5.1 Outline of Service Life of Rolling Stock and Work on Rolling Stock During the Service Life

- Generally speaking, the service life of rolling stock in Japan is about 40 to 50 years. However, according to the specifications of urban lines in Hanoi such as Line-2A and Line-3, the service life of trains in this country is about 30 years.

- In order to meet the requirements for safety, operating capability, passengers' demands and advanced technology during the service life, a rolling stock is generally renovated halfway through its service life (about 20 to 25 years) after its initial use.

- The following shows examples of the work carried out on rolling stock in Japan during their service lives.

5.2 Procurement of New Rolling Stock

- Consideration on basic items related to procurement of new rolling stock

  - Consideration on procurement of new rolling stock
    - Replacement with a new rolling stock can save more maintenance cost than renovating it. However, purchasing new rolling stock will cost more than renovating initially. Therefore, it is necessary to consider total costs for life cycle of the rolling stock so as to be most effective to make decision alternatives of procurement of new rolling stock or renovation.
    - Decision on equipment for new rolling stock or renovation needs to take requirement of long-term use of the equipment into consideration; the equipment must ensure normal operation for durable years. Consideration and diagnostic of degradation level of the equipment in use can be performed by manufacturer before replacing them, if necessary.

  - Selection of equipment with modern, advanced standards and high reliable level
    - Basically, it is required to select modern, advanced equipment with high reliability as equipment shall be used in a long time, thus slow degradation and aging is required in the future. Moreover,
advanced equipment that met requirements can be provided by the contractor as spare equipment if necessary in a long term.

✓ Equipment must meet high reliability, efficiency, and durability and test requirements before selection.

- Consideration of technical optimization
  ✓ It is necessary to consider specifications based on operational requirements and cost of the equipment, ensuring compliance with plans and financial capacity of the company.
  ✓ Consideration, which is for equipment with advanced technical specifications on new rolling stock and renovation, should be carried out based on a basis of suitability with actual operation, maintenance and management capacity of the company as well as consideration of optimizing number of spare device saving cost.
  ✓ It is required to consider integrating specifications for new rolling stock and rolling stock renovation in the future.

  Therefore, optimal requirement is made based on the current state of financial capability, planning, operational capacity, maintenance and technical specifications of the equipment.

- Selection of equipment suitable with customer demand
  ✓ Selection of equipment satisfying customer demand.

❖ Plan of Procurement New Rolling Stock
- Plan of purchasing new rolling stocks is made annually, allocating amount and timing of procurement.
  Procurement plan must ensure the effectiveness of procurement and consider investment balance of procurement of new one of the years.
- After new rolling stock are introduced, trial run and training must be carried out.
- Purchasing new rolling stock is also considered in some emergency case such as accidents, change of operational plans etc.
- Replacement of signal equipment (new technology) on new rolling stock will be considered in accordance with signal device on track when change is requested.

- Bidding for procurement of new rolling stock
  ✓ Usually new rolling stock are purchased on the basis of technical specifications, the Company will require manufacturers to offer completely assembled product. However, as some companies that have experience and capabilities in Japan as Tokyo Metro, JR, the Company will place an order to the manufacturers specializing in producing such corresponding carbody, equipment control, brake, bogie. After that these equipment shall be sent to carbody manufacturer to assemble complete rolling stock.
  ✓ The advantages and disadvantages of placing an order with one contractors for assemble and completion and contractors specializing in producing one device and one company managing completion. It is as follows;

<table>
<thead>
<tr>
<th>One manufacturer</th>
<th>Several manufacturers producing different equipment</th>
</tr>
</thead>
</table>

Appendix8-6-6-1-B
### 5.3 Renovation and Remodel of Rolling Stock

- Renovation and/or remodel work of rolling stock is conducted halfway through their respective service lives (about 20 to 25 years after launch although this depends on the technical specifications of the rolling stock in question. In Hanoi City, this work is conducted about 15 years after launch according to the current specifications of urban railway lines in the city.) Large scale renovation in Japan generally requires three months. In such a case, a range of steps are taken to enable equipment to operate up to the limit of their service lives. Basically, when carrying out renovation of rolling stocks some equipment such as body, bogie frame can be retained when these parts are inspected to be requirement ensured.

- Carbody: Mostly replace display panel, internal control, electrical wiring, and electrical insulating materials, sound proof materials etc.

- Equipment: Basically to be considered to replace almost all. Some other equipment after inspection, maintenance and repair in the Workshop are found to ensure operations can be reused. Replacing main motors, control equipment, braking equipment, power supply equipment, ventilation etc.

- The costs of renovation in Japan are about 50% of that required to purchase a new rolling stock.

- Replacement of signalling equipment (new technology) will be considered suitable with signalling device on the track when change is requested.

- Replacement of electric devices should be considered approximately 10 years after launch.

The process of renovation and remodel of rolling stock is complied with Circular 02/2009/TT-TT BGTVT and No.05/VBHN-BGTVT dated 27 Jan 2014 regarding quality control, safety engineering technical and environmental protection.

- Design
- Design evaluation
- Check of manufacturing, installation and completion

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
</table>
| - Management of coordinated interface will be responsible by the main manufacturer.  
- Cost may be lower.  
- Suitable with company that does not have much experience as well as maintenance capacity. | - Management of detail and quality of equipment as required. Increase reliability, availability, and safety of the rolling stock.  
- Convenient in maintenance of each device afterward. |
| - Difficult to manage each detail of each equipment as required.  
- Maintenance process of each equipment afterward shall not have a close contact and assurance of each equipment with manufacturer of that equipment. | - Management of coordinated interface will be responsible by the company, leading to request of a large number of personnel – increase of costs.  
- High capacity personnel to manage and supervise each equipment. |
- Periodical inspection of vehicles

Concerning the above:

+ Three copies of the design documents prepared by a design company or production company that meet the design requirements in the regulation are submitted to the registration body for verification.

The following points are considered for the design documents.

a) Entire drawings before and after the renovation.

b) Technical documents which includes configuration of equipment and systems used for the renovation.

c) Descriptions and calculation sheets regarding details of the renovation.

+ Certification of design

a) Review of the design documents is conducted for the product before production, before first assembly or before the renovation.

b) Certification of design involves collating and checking the product's design documents against existing technical criteria and standards. Certification of design takes place within 15 days of receipt of legitimate design documents. When the certification body extends the certification period due to the necessity of receiving additional documents, the certification body must notify the design company or production company of this fact in writing.

+ Inspection of renovated vehicles by Registration Authority

Technical documents used in the inspection process include the following.

a) Design documents of renovated means that are verified by the registration body.

b) Quality certificate (when quality certificate is necessary for a product) of the system and equipment configuration used for renovation of the vehicles, or technical documents.

c) Production company's documents on the inspection and inspection for acceptance.

Contents of the inspection include inspection of the quality of the renovating vehicles in the context of the existing technical criteria and standard, and review and evaluation of the design documents for renovation that have been verified by the registration body.

Inspection method: Inspection on a vehicle basis

6) Maintenance Budget Calculation Method

- Budget calculation method (11/2012/TT-BXD)

Workload- and unit price-based method: It is based on the unit price of each relevant to the budget prepared for the workload, inspection, maintenance, periodic and additional repair that are implemented according to the maintenance plan.

Ratio-based method: This method applies to calculation of the costs for preparation of the maintenance plan as well as preparation and management of the maintenance documents.

- Basically, the costs involved in maintenance include the following items.

  a. Personnel
This cost is not referred to in the maintenance budget calculation since it is calculated as part of the overall costs of the company.

b. Materials and equipment
They refer to every necessary device and supplies. They include the following:
- Devices and equipment for replacement
- Consumable supplies

c. Tools and technical materials
- Replacement of tools
- Purchase of new tools and technical materials
- Lease of devices

d. Outsourcing-related matters

6.1 Overview of Rolling Stock Maintenance Costs
The operational costs are the ones that are incurred during the service life of rolling stock in order to maintain their performance in accordance with the technical requirements, and to help ensure they continue to operate as expected. In the case of an urban railway currently managed by Tokyo Metro, the maintenance costs are as shown below.

Operational cost

In the above, (b) represents the total costs of replacement devices at the Workshop, and (d) represents the total costs of function inspections, materials and consumable supplies. According to the experience at Tokyo Metro, annual costs of the above items are as described below when the purchase costs of a new 1 train is set as 100%.

\[
b = 10\% / \text{year} \quad ("b" \text{ is the annual cost of Workshop inspection for a 13 train sets, and this cost corresponds to 10\% of the purchase cost of a new 1 train.})
\]

\[
a+c+d = 12\% / \text{year}
\]

(Currently c is outsourced at Tokyo Metro. At HMC, this item will be directly conducted by the company.)
Capital costs (Major items)

- Costs of equipment and devices for maintenance
  - Operational cost of equipment: It is the maintenance cost for maintaining the operation of the equipment and devices for maintenance. It includes the following.

  In the above, the total cost of (i+ii+iii) items is about 10% of the new purchase cost of the equipment (assumed based on the experience at Tokyo Metro).

- Capital cost
In the above, i is about 1/2 of the new purchase cost (ii) of the equipment (assumed based on the experience at Tokyo Metro).

6.2 Maintenance Budget

a. Periodic inspection
   - Replacement devices
   - Estimation will be prepared based on the demand for the types and number of devices and equipment to be replaced according to the periodic inspection period, equipment service life, maintenance procedure and manual. The above estimations are summarized. The above includes the number of devices to be replaced according to the annual, monthly and daily inspections. (In the new operating company, demand for the initially replaced devices shall be calculated based on the periodic inspection period, the service life of equipment, case examples of devices in the similar projects and the data provided by contractors.) In the initial phase of operation of Line-2A (for two years from start of the operation), the type of inspection that requires disassembly of the equipment installed on the rolling stock is not basically conducted. Thus, the demand for the devices to be replaced is depend mostly on the monthly and daily periodic inspection. (At this stage, it is not necessary to refer to the devices to be replaced in the medium-scale and large-scale repairs.)
   - The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.
   - Number of spare of these equipment and devices
   - Consumable supplies and fuel:
     - Consumable supplies that are replaced in most of the inspections (brake pads, collector shoes, etc.)
     - Oil, lubricant and fuel
     - Other materials: Welders and comprehensive electronic devices

   Demand for these shall be determined based on the inspection period, frequency of inspection and maintenance during the planned period, condition and operating state of the equipment, and the company's experience gained in the previous term.
A new operating company should estimate the demand for consumable supplies based on the periodic inspection period, maintenance plan, figures and experiences provided by the contractors, and the demand for consumable supplies observed in the similar projects.

- The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.

- Outsourced inspection items and maintenance: Based on the contract, during the planned period, the payment to be made to the contractor as well as the scheduled workload to be consigned to the contractor and its contract price should be added.

- Number of spare devices and consumable supplies to be prepared for the replacement process.

- Other than the above, circulation spare device should be prepared in order to equalize the workload during the inspection period depending on the actual situation of the company and the maintenance method. This approach is applied to the Workshop. These spare devices will be considered by the company in the next phase, and will be used for periodic inspections and repairs carried out at the Workshop.

b. Other maintenance

- Include the costs for cleaning and wheel grinding.

- Based on the demand for the equipment and consumable supplies that were purchased with the previous budgets, prepare appropriate budgets for the work to be implemented.

- The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.

- Outsourcing of works relevant to this work must be carried out based on the contract and unit price.

- Additional matters

c. Repair and replacement

- Replacement devices for repairing failures.

- Replacement devices and equipment for failures.

- To do so, it is necessary to estimate the type and quantity of the equipment that will be replaced during the planned period.

- It is necessary to estimate the quantity of devices and equipment to be replaced for dealing with failure.

- Decisions on the demand for devices and equipment during the planned period must be made based on the company's train operation, frequency of failure and demand for replacement in the previous period. (Generally, the last 3 to 10 years are the reference period.)

- According to our experiences in Japan, the devices to be replaced is mainly consumable supplies. (Devices installed on bogie such as valves and bearings, and electric wires and consumable supplies that can not be reused.)
At a new company, results of the actual operation are not available for estimating the demand for the equipment replacement. Therefore, estimates of the demand for the spare equipment should be made based on the experiences in operation in similar projects, and the contractors' experiences and data reflecting the current status and requirements in Vietnam. For the initial 1 to 2 years, the failures corresponding this item may not occur, and the cost for this item may not be incurred. Since the equipment procurement contract of each line contains the warranty, a failure within the warranty period (Line-2A and Line-3: Two years, Line-2: Five years) will be treated by the contractor.

The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.

- Troubleshooting budget: The troubleshooting budget consists of the following two blocks.
  - Repair work carried out by the company personnel, such as welding and riveting, will not require a lot of costs basically.
  - In the case of a large-scale repair work, the company cannot directly deal with it. Therefore, it is necessary to prepare a budget for outsourcing the troubleshooting. The method of calculating the budget for this item corresponds to that of the additional maintenance cost of the previous year, or it may be determined as a percentage of the prepared budget. Currently in Japan, the method based on the average of the last three years is employed. A new company may choose the cost of this item to be within 10% of the total cost since the company has no experience of the operation or the previous data. 10% is the reserve fund of the construction budget in Vietnam. The size of the budget for this item depends on the frequency of failure, technical specifications of rolling stock, and the company's policy regarding maintenance and train operating methods.

- In an emergency, the troubleshooting cost is reported to HQs of the company for their review.

- Improvement cost of devices and equipment for a failure
  - In the process of dealing with failures, the company should understand the necessity that improvement and enhancement of equipment quality is important in order to prevent failures. This kind of budget is reviewed and allocated to each equipment in order to secure the operation plan and safe operation while taking the company's financial standing into consideration.

In this case, functions and performance to be added are considered based on causes of failures, and the technical specifications and budget of the target equipment of purchase are finalized.

The budget for equipment replacement for the purpose of improvement is allocated based on the company's operation-related experience in the previous term.

- Practices at Tokyo Metro
  8 to 10 years after launch: Replacement of electronic devices (these devices are improved)
  20 to 25 years after launch: Most the equipment (most of the electronic equipment and electronic devices) are replaced. This cost is included in this kind of budget.

d. Renovation of Rolling Stock and Procurement of New Rolling Stock
  - New purchase or additional purchase of rolling stock
In the planned period, the number of rolling stock to be replaced is considered based on the service life, and the operating period and travel distance of the rolling stock. In many countries, the rolling stock replacement cycle is about 50 years. Therefore, it is not necessary for the company to consider this replacement in the initial phase.

If it becomes apparent during the planned period that more rolling stock are necessary to meet operational demands, this issue should be considered. (Based on the new rolling stock purchase request by the company)

The cost shall be determined based on the unit price that issued by the government agency or that issued from the similar project, or that provided by the contractor.

Renovation and remodel of rolling stock

This cost should include the following matters.

- To confirm the number of train sets and trains to be renovated based on the renovation cycle and operating period.
- Then, confirming the type and the number of equipment, and consumable supplies to be replaced.
- The type and number of equipment are confirmed based on the specifications of the rolling stock and the service life of the equipment to be replaced. At the same time, the planned renovation should be compared with the similar train sets and trains renovated the last time, or should be studied based on the suppliers' experience, or data from the similar project or company.
- The unit price of equipment shall be based on that issued by the government agency or that used in the similar project, or that provided by the contractor.
- As needed, the remodeling work should be outsourced.
- Outsourcing costs for removing the equipment (when needed).
- It is not necessary to remodel rolling stock for HMC for some time after the start of operation (generally speaking, the above remodeling will take place after about 20 year operation.); however, the timing may become earlier in accordance with passengers' needs, addition of new equipment or technical innovation of the equipment.

e. Costs for maintenance facilities and equipment

- Installation of new facilities or equipment
  The quantity of facilities and equipment to be newly purchased or improved is decided during the planned period based on the facilities’ service life and current condition. The above should include the facilities and equipment that are used for the inspection, periodic maintenance, dealing with failure, remodeling of rolling stock, cleaning and wheel grinding.
  The unit price of equipment shall be based on that issued by the government agency or that used in the similar project, or that provided by the contractor.
- Fuel cost and grease consumption cost
- Repair cost (material and outsourcing)
Decide the budget for this work during the planned period based on the facilities and equipment inspection period, or the contract concluded with the contractor.
- Cost for removing unnecessary facilities and equipment, and cost for moving them to another place, when such is necessary.
- Other outsourcing costs, as needed.

f. Maintenance personnel training cost
   Maintenance personnel training cost should be prepared based on the training program. This cost should be included as the common expense along with the office management cost, operation cost, etc. The cost must include cost for outsourcing lecturers and device.

7) Training of Rolling Stock Maintenance Personnel

7.1 Principle of Training
- The contents and format of the education must be practical, enhance the quality of leadership, management and operation in the company business, and improve quality of work of the workers who are innovative and developmental.
- The training program should be rational and appropriate in the framework of the company's work plan.
- The company improves the environment to enable the administrators and workers to learn themselves and improve their capabilities so that they are able to implement their assignments effectively using their actual business expertise and high working standards.

7.2 Types of Maintenance Personnel Training
- Training for new personnel at respective sections
  - Training for new employees
  - Training for the personnel who has moved in from other section
- Periodic training:
  - Training for drivers at depots
  - Training for maintenance personnel to enhance their capabilities and skills
  - Training on safety and health
  - Training for an emergency
  - Training for management capabilities
- Supplementary training: It will be conducted when required.
- Other training
  - Attending a lecture held by an external organization

7.3 Training at Site
- Training is implemented on the basis of actual activities on site.
- During implementation of daily work, the head of each section must confirm the capabilities of their personnel and, if judged necessary, the head should plan to provide additional training for such personnel.

- The head of each section is responsible for improving the capabilities of inexperienced personnel, and allocating an experienced personnel to such personnel in order to train and educate them and help them meet the requirement of the assignment. The company introduces the following to promote the training and education.
  
  - Exhibition of actually failed devices
  - Exhibition of explanations why and how the failure occurred, what countermeasures were taken, and how should we act against a failure.
  - Experience in using tools
  - Experience of getting injury due to wrong use of tool

7.4 Training on Emergency Response

The maintenance personnel must receive training on emergency response.

7.4.1 Contents of training

a. The way of using emergency equipment
b. Training on restoring from an accident in hypothetical situations (training on derailment, failure of wheelset, failure of bogie, recovery of a separated trains)
c. Information reporting training

7.4.2 Requirements of training

d. Training for relevant personnel (every personnel in the Inspection Yard must receive the training)
e. Training on handling emergency machinery and materials, restoring of accidents in hypothetical situations, and making calls and reporting must be conducted annually on a regular basis.
f. Comprehensive training against accidents (handling of the emergency machinery and materials, information communication, restoration work and cooperation with relevant departments) must be conducted once a year.

7.5 Training Period

Form of training: The period of training depends on its purpose and requirements. Head of each section is responsible for considering and preparing the training period and plan appropriately.

Maintenance personnel training period at Tokyo Metro as a reference

- Training at Tokyo Metro's Inspection Yard

Maintenance personnel is educated so that they can implement every item at the Inspection Yard including the rolling stock inspection and driving train.

Training on theories including confirmation of capability of the personnel: 1 month (25 business days)
Practical training on 3-month inspection: 6 months to 1 year
Practical training on 10-day inspection, dealing with failure response and repairs: 6 months to 1 year
Training at Tokyo Metro’s Workshop

**Appendix 8-6-6-1-B**

<table>
<thead>
<tr>
<th>1年目 1st year</th>
<th>2年目 2nd year</th>
<th>3年目以降 3rd year or later</th>
<th>10年目以降 After 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>入社研修 Training after joining</td>
<td>随時教育 At any time</td>
<td>鐘電業作業 3-month inspection</td>
<td>随時教育 At any time</td>
</tr>
<tr>
<td>職場配属 Assign to Industry</td>
<td>練習実習 3-month inspection</td>
<td>動力車検作業 10-day inspection</td>
<td>動力車検作業 10-day inspection</td>
</tr>
<tr>
<td>3-month inspection</td>
<td>10-day inspection</td>
<td>(all-day shift)</td>
<td>(all-day shift)</td>
</tr>
<tr>
<td>新入就業 Training for new comer</td>
<td>新入就業 Training for new comer</td>
<td>運転試験 Driving test</td>
<td>新入就業 Training for new comer</td>
</tr>
<tr>
<td>3-month inspection</td>
<td>3-month inspection</td>
<td>Driving training incl. taking a driving license</td>
<td>Driving training incl. taking a driving license</td>
</tr>
<tr>
<td>Check the ability</td>
<td>Check the ability</td>
<td>Driving training incl. taking a driving license</td>
<td>Driving training incl. taking a driving license</td>
</tr>
<tr>
<td>3-month inspection</td>
<td>3-month inspection</td>
<td>Driving training incl. taking a driving license</td>
<td>Driving training incl. taking a driving license</td>
</tr>
<tr>
<td>三検作業 (製作業) Driving training (incl. taking a driving license)</td>
<td>運転試験 Driving test</td>
<td>運転試験 Driving test</td>
<td>運転試験 Driving test</td>
</tr>
</tbody>
</table>

### Training of Line-2A Maintenance Personnel

<table>
<thead>
<tr>
<th>Dept.</th>
<th>Staff</th>
<th>Dept., center</th>
<th>Q'ty of staff</th>
<th>Training course (date)</th>
</tr>
</thead>
</table>

Normally, actual training duration for each position is about 1 year. For personnel carrying out the inspection and maintenance, when equipment is disassembled, they will be trained intensively about each of their own in-charge parts.

**7.6 Evaluation of Result of Training**

When a part or entirety of a training program is finished, it is necessary to evaluate the program to evaluate its degree of attainment.

**7.7 Training of Line-2A Maintenance Personnel**

*東京メトロの工場では3〜4班ある。 (制御・ブレーキ、台車、運転整備等)*

There are 3-4 site section in Tokyo Metro (such as Controller & Brake equipment, Bogie, General inspection)
### Appendix 8-6-1-B

<table>
<thead>
<tr>
<th>Categories</th>
<th>RS maintenance center</th>
<th>Theory</th>
<th>Practice</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deputy Manager</td>
<td>RS maintenance center</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixing technique chief</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixing technicians</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixing technique assistant</td>
<td>Safety dept.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety supervisor for technical equipment</td>
<td>Safety dept.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management of electricity on the train</td>
<td>RS department</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management of on-board machines and equipment</td>
<td>RS department</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixing controlling staff</td>
<td>RS maintenance center</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management of Train control, inspection</td>
<td>RS maintenance center</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior inspector for electrical equipment on train</td>
<td>RS maintenance center</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspector for electrical equipment on train</td>
<td>RS maintenance center</td>
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<td></td>
<td></td>
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<tr>
<td>On-board machines senior inspector</td>
<td>RS maintenance center</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>On-board machines inspector</td>
<td>RS maintenance center</td>
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<td></td>
<td></td>
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<tr>
<td>Management of monthly maintenance and repairs</td>
<td>RS maintenance center</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Senior staff of monthly electricity maintenance and fixing</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff of monthly electricity maintenance and fixing</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior staff of monthly machines maintenance and fixing</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff of monthly machines maintenance and fixing</td>
<td>RS maintenance center</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Management of Equipment</td>
<td>RS maintenance center</td>
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<td></td>
</tr>
<tr>
<td>Worker on Equipment type B (wheel lathe)</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker on Equipment type C (Train washing machine)</td>
<td>RS maintenance center</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Supervisor of equipment type B (small train, maintenance car)</td>
<td>RS maintenance center</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Theory: Entire car body, arrangement of electronic equipment, main motor, auxiliary power supply, braking devices, air conditioning devices, bogie, piping, doors, announcement system and display devices.

Practical skill: Work outline, operating procedures, implementation procedures, repair of failure, work flow, job classification and duty assignment.

(For details, see the attached Line-2A Maintenance Staff Training Plan.)

### 8) Revision and Changes of Rolling Stock Maintenance Rules

#### 8.1 Major Cases that Require Revision and Changes of Maintenance Rules

a) When an accident or failure occurred: In order to prevent recurrence of the similar accident or failure, the inspection and maintenance methods must be reviewed again. When implementing inspections or maintenance work, compliance with the rules and manuals must be ensured to
prevent the similar accident or failure from recurring. However, an accident or a failure can occur during service operation due to various reasons.

- Therefore, it is indispensable to identify the cause of an accident or failure.
- Thus, reviewing and revising rules and manuals in order to adjust and revise the recovery measures and maintenance method based on the identified causes.
- After revisions or changes are conducted on the rules and manuals, each section must generalize the new rules and train all maintenance personnel based on the new regulations so that they will be able to execute the assignment in accordance with the new rules and manuals.
- An example as a reference: It was unnecessary in the maintenance procedure of a contractor to remove a certain device during the operating period. However, several trouble (ignition, smoke generation, etc.) occurred on the device due to various causes including climate-related conditions. Thus, it became necessary to revise the rules and manuals to conform them to the actual condition. (Such as adding contents of inspection at periodic.)
- Causes of accidents and failures include an error due to maintenance personnel being unsure of the workflow (human error). In such a case, considering and revising the specific workflow were required in order to prevent a recurrence.
- An example as a reference: During train operation, several failures were detected that can affect the safe operation. An investigation into the cause has determined that certain incomplete work flow instructions had been issued to the maintenance worker. Thus, it became necessary to review the rules and manuals in order to determine the necessity of the revision.

Example:

b) When an equipment on a rolling stock or facility for inspection is changed: It is necessary to revise the rules and manuals in accordance with the change.
An example that a brake system was changed

An example that the working method was changed

c) When organization of the working unit is changed: When improving the work by changing the working method, requirements and workload to the maintenance personnel are changed. Therefore, the number of personnel and organization are changed, too, (increased or decreased). As a result, the rules and manuals related to the personnel arrangement and division of duties must be revised to conform to the new organization system.

8.2 Requirements for Revision and Change in Rules and Manuals

- Revisions and changes in the rules and manuals must ensure improvement over the existing rules and manuals. The maintenance personnel must accept the revisions and changes, and work in accordance with them.
- Revisions and changes must be compatible with the existing rules, manuals and other relevant regulations.
- When a unit proposes revisions or changes, the unit must specifically explain the reasons why and the expected effect.
Every revision and change in the rules and manuals must be reported to HQs in order to enable them to consider and grant the necessary approval.

HQs shall hold a meeting with relevant departments and contractors to consider the revisions and changes.

Every revision and change must be appropriately checked and verified in the consideration. When revising or changing the maintenance rules or manuals, it may be necessary to make certain adjustments with regard to the implementing organization and personnel as well as implementation timing.

The related units and sections must explain, within the unit or section, the contents of the revisions and changes specifically to the personnel and train them in accordance with the revisions and changes.

9) Management of Activity of Maintenance Center

9.1 Daily Working Procedure from Start of Day of Duty

+ For the maintenance personnel, supervisors and management personnel who carry out monthly inspections.
  - The supervisor or management personnel have responsibility to call out the names of every personnel before start of work in the day.
  - The supervisor or management personnel assigns work to every maintenance personnel. Only maintenance personnel who meet the health and capacity requirements are allowed to carry out work.
  - All management personnel, supervisors and maintenance personnel get together to do some gymnastics. Precautions or instructions, if any, will be announced there before the work starts.
  - The total time for the above shall be within 30 minutes.

+ For drivers and maintenance personnel for daily inspection and maintenance
  - Before a shift starts, the supervisor or management personnel must call out the names of all maintenance personnel who will work the coming shift.
  - The supervisor or management personnel assigns work for the day. Every maintenance personnel who drives trains in the depot is required to take an alcohol test before starting work.
  - The supervisor or management personnel informs every maintenance personnel about the matters necessary to implement the work, precautions and other information handed over from the personnel of the previous shift.

+ Matters to be handed over and matters to be received between one shift and another
  - Prior to the end of a shift, the supervisor or management personnel of the current shift must hand over the work to the supervisor or management personnel of the next shift.
  - The above personnel in the current shift must convey information about events that occurred, instructions issued and restoration policies taken, if any, in the current shift to the new shift.

9.2 Hand-Over Process

a. Maintenance personnel to hand over the work
The head of each section allocates the shift at Inspection Yard as follows.
Supervisor or Sub Supervisor in charge of the day of duty (daytime inspection shift)
Supervisor or Sub Supervisor in charge of dealing with failures during operation

Place for hand over: Select an appropriate place for hand over in consideration of the work of each section.
Normally, the business office under the supervision of the section or Inspection Yard is used so that the work plan and business operations may be carried out smoothly. Hand over during operation time should ideally be carried out at the work place because many trains are operated.

b. Implementation time
15 to 30 minutes though it depends on the details of the matter and type of information to be handed over.

c. Details of matter to be handed over
- Changes in the train allocation and maintenance personnel, failures and other relevant matters occurred during the shift.
- The work plan to be implemented in the next shift such as additional inspection and cleaning.
  The above includes information about a mistake or accident that forces the work plan to be changed.
  For example, if an accident which suspends train operation occurs, the next shift must review the previously prepared plan, report about the accident to relevant personnel, and make necessary adjustments in consideration of the given situation. For example, when the inspection and restoration of a rolling stock failure have not been completed in the current shift, the current shift must hand over details about the failure and relevant countermeasures to the next shift.
- Change or adjustment of an equipment installed on the rolling stock, disassembly or assembly of an equipment, change due to improvement purposes, etc.
- Other information

9.3 Locations to be managed by Inspection Yard and by Workshop
The boundary between the Inspection Yard and Workshop must be made clear in order to ensure a smooth flow of management tasks, and facilitate clearer responsibility sharing between them when implementing the work. The above includes making it clear in the work where the trains are to be handed over between the two work places.

The trains must be handed over between these work places in accordance with the maintenance plan. Both sides should confirm train hand-over time and notify it each other based on rules. When a scheduled delivery of trains is not possible due to an emergency, the parties should notify each other of it and report relevant information to their senior personnel to review and solve the situation.

9.4 Rolling Stock Inspection before Operation
For the trains that have been parked at the depot, maintenance personnel has responsibility of inspecting it before start of operation. (The inspection should focus on the communication system and lighting.)

For the trains that have been parked at any other location, the driver has responsibility of carrying out the above inspection.

9.5 Driving Train at Depot
Driving train at depot includes the following matters.

- Driving trains from the location where they are parked in the depot to the service line is carried out mainly in the early morning.
- Driving trains from the service line to the parking location in the depot is carried out mainly during the night of the operation day.
- Trains are moved within the depot for the purpose of inspecting the electric equipment and signal equipment, cleaning, wheel grinding, trial run, large-scale Workshop repairs, and maintenance of rolling stock or equipment at the depot.

The following describes the difference in driving between in depot and on service line.

- Generally speaking, CBTC signal is applied on service line, while the depot is not.
- The train operation on service line is managed and controlled by OCC, while the depot is not.

Examples at a depot of Tokyo Metro:

- Outbound and inbound trains at the depot: Weekday: 37 train sets, Holidays: 13 train sets
- Operation within the depot: 10 train sets

Characteristics of driving at depot

- Most of the train driving work are concentrated in a short period in the early morning and nighttime.
- Frequency of driving within the depot is fewer than that for the inbound and outbound.

Types of personnel assignment for driving within depot are as follows;

- Driver who drives train on the service line and in the depot.
- Driver who drives train only in the depot.
- Maintenance personnel who drives train in the depot.

Advantages and disadvantages of driving train at the depot carried out by Operation Department and Maintenance Department

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### Advantages

- The time required for the train hand-over process between the Maintenance Department and Operation Department can be reduced. The time required to walk back to the maintenance location after the driving can be reduced.
- Train operation as planned is available (risks involving on-time delivery by the other party can be reduced)
- It is easier to prepare and adjust the train allocation plan in order to secure both operation and maintenance work.
- The Maintenance Department understands the courses and signals in the depot and, thus the train shunting operations are implemented and necessary instructions can be given more efficiently and easily by this department. In addition, they can efficiently and easily arrange and shunt the trains for maintenance purposes.
- This department is more suited to securing safety since they can utilize results of the daily inspection and rolling stock maintenance. (Inspection that is implemented prior to service operation.)
- More efficient maintenance is assured. (Maintenance personnel can both drive trains and carry out maintenance.)

### Disadvantages

- It is difficult to revise and adjust the train allocation plan when an emergency occurred while operation and maintenance work is being carried out.
- It is difficult to move the trains in order to carry out maintenance or issue instructions for that purpose.
- Effect of the daily rolling stock inspection before operation is lower. (Inspection carried out by Operation department personnel, not by maintenance personnel).
- More drivers who have licenses for the service line will be necessary.
- Hand over time is required, and time for returning to the maintenance location after hand over is also required.
- A close confirmation is required so that the trains may be handed over as scheduled.

### 10) Manual for Dealing with Accident

#### 10.1 Principle for Dealing with Accident

- Secure safety of human and property thoroughly, and make quick and timely responses.
- If an accident occurs, the organizations and individuals who engage in urban railway have responsibility of dealing with an accident together.
Appendix8-6-6-1-B

- Rescue evacuees immediately, and protect the accident site, national property and evacuees.
- Notify and report an accident to the relevant organizations and individuals timely.
- All organization and individuals who have been informed of the accident must rush to the site of the accident and take appropriate actions.
- Resume train operation on the affected line as soon as possible. Make effort to operate trains as planned. ( Depending on the accident situation, ensure smooth train operation by allocating spare trains through consideration.)
- Take measures to prevent recurrence of the accident.

10.2 Requirements
In case of accident – natural disaster, the personnel of rolling stock management maintenance division shall join force with one another and other personnel to take action with the best method to ensure safety of passenger and personnel, paying special attention the following important contents.

a. To rescue and evacuate the passengers and maintenance personnel.
b. To ensure their own safety and that of other maintenance personnel.
c. To prevent disasters and collateral accidents.
d. To report and inform the accident.
e. To safeguard the property.
f. Other important matters
g. The maintenance personnel must wear gloves when engaging in inspections, rescue and restoration.

10.3 Importance of Initial Action
Head of each section (Head of the Inspection Yard, Head of Maintenance Center, Head of Workshop, Station Master, etc.) must be aware that speed of the initial action after an accident occurs determines the success or failure of early restoration. Thus, the head of each work place must notify the importance of speed to their maintenance personnel so that no serious problems caused by delays will occur.

10.4 Reporting of Accident
a. When an accident occurred, OU and the Rolling Stock Maintenance Management division in HQs notify and report on the accident according to the following flow.
The personnel in charge in each section has responsibility of reporting to each relevant maintenance personnel about the accident, so that restoration work immediately starts.

When a train operation-related accident or disaster occurred in the depot, relevant personnel (driver and maintenance personnel) must immediately report about it to the Head of the Inspection Yard (Head of Maintenance Center) and Head of the depot.

In the above:

- Inspection Yard (Maintenance Center): After being informed of the accident, the personnel who is in charge of dealing with accident must immediately report about it to the Head of the Inspection Yard (Maintenance Center) and relevant personnel of the section.

- The personnel in charge of dealing with accident at HQs (Head of Rolling Stock Maintenance Management division or section personnel): In the case of beginning phase of HMC, this personnel in charge may be the personnel of the Rolling Stock Maintenance Management division in HQs. When the number of lines and rolling stock are increased in the future, a personnel dedicated to dealing with accident will be assigned at the Rolling Stock Department in HQs (it is the same as the current Tokyo Metro).

- When the Accident Response Board is established, the Chief of the Rolling Stock Maintenance Management division shall participate in it according to the regulations. If the section chief is not available, the Rolling Stock Maintenance Management division in HQs shall designate a proxy.
b. Maintenance personnel who is dispatched to the site to deal with an accident

If an accident occurs, the relevant personnel in each section must immediately collect relevant information and dispatch necessary personnel to the accident site as shown in the above figure. When requested to attend the site, the maintenance personnel shall go straight to the site with materials and equipment for first aid and restoration.

10.5 Head of the Depot

- When informed of the accident, the Head of the depot of the line concerned must grasp the situation by immediately dispatching the necessary personnel to the site to collect information, and the Head of the depot must go to the site as quickly as possible. At the same time, the Head of the depot shall, as needed, request the support from another Workshop or work place and make necessary adjustments if they request receiving information or support of Inspection Yard or OCC.
- The Head of the depot and Inspection Yard must be familiar with the lines in their charge on a routine basis so that they can take accurate and appropriate measures for the accident site.

10.6 Role of Maintenance personnel of Inspection Yard - Maintenance Center

When an accident occurs, the personnel on duty who is in charge of accident shall, according to requests received from OCC, rush to the site to collect relevant information, or shall dispatch inspection personnel to the site and have them report on the status of the accident to the Head of the Inspection Yard (Maintenance Center). When support from other Inspection Yard is necessary, the Head of the Inspection Yard (Maintenance Center) or an authorized personnel shall contact the other Inspection Yard or section and arrange dispatch of personnel and equipment to the accident site.

10.6.1.1 When informed of an accident, the supervisor who is in charge of dealing with accident, the Head of the Inspection Yard (Maintenance Center), or the relevant personnel defined in the regulations on duty shall rush to the site with the emergency machinery and materials.
10.6.1.2 The Head of the depot and the Head of the Inspection Yard must prepare necessary emergency machinery and materials beforehand in consideration of the specifications and activities of each line.

10.6.1.3 When informed of an accident or requesting support, every department and personnel shall respond to it as much as practicable, and report the results to the personnel requesting them. At the same time, they must promptly implement the necessary measures such as dispatching personnel, emergency machinery and materials to the accident site.

10.7 Role of Inspector

10.7.1.1 When attending the accident site, the inspector must report on circumstances of the accident briefly and accurately to the accident response personnel on duty. (The inspector is responsible for making a prompt report to the Head of the Inspection Yard (Maintenance Center).

10.7.1.2 The inspector at the accident site must secure the safety of passengers and relevant personnel until the restoration unit arrives and, at the same time, must carry out the necessary emergency measures and restoration works.

10.8 Handling upon Arrival at the Accident Site

10.8.1.1 The Head of the depot, the Head of the Inspection Yard (Maintenance Center) or authorized person must immediately consider, develop and propose a restoration policy based on the circumstances of the accident. The Task Force reviews it and decides the policy.

10.8.1.2 The Head of the Inspection yard (Maintenance Center), the personnel in charge of dealing with accident on duty or an authorized personnel must allocate the personnel and equipment according to the request so that accident restoration can be accomplished in accordance with the restoration policy.

10.9 Configuration of Attending Personnel

The Head of the depot and the Head of the Inspection Yard (Maintenance Center) of each line must decide beforehand the configuration of the personnel who will attend the site to help manage the accident taking into consideration the type of assumed accident (collision, derailment, overturn, fire hazards, etc.) and the specifications of each line. (Inspector, restoration personnel, assistant, informer, etc.)

10.10 Basis of Restoration Work

- The Head of the depot and the Head of the Inspection Yard must decide on the basis of restoration work beforehand in consideration of the specifications of each line and type of assumed accidents. (Derailment, train collision, fire hazards, disaster, etc.)
- The maintenance personnel must be trained and have received instruction in the basis of restoration work so that they understand the necessary accident handling procedures and measures.
- The basis of the restoration work must be implemented in compliance with the safety regulations.
- Training must be carried out for accidents that are anticipated on an urban railway line such as derailment, collision, turnover and fire hazards.

10.11 Work Assignment at Site

10.11.1 Organizations to Implement Restoration Work

- The Task Force is immediately set up to implement restoration.
- The Head of Task Force for accidents that occur due to train operation at the depot or fire hazards shall be the Head of the Inspection Yard (Maintenance Center). (Generally speaking, the personnel in charge of the accident area (Station Master) assumes the position of the Head of Task Force to ensure the safe and immediate start of the restoration work.) When a personnel of the duty position is required, the appropriate personnel shall be designated by HQs or the Accident Handling Committee.
- Other maintenance personnel who are ordered to deal with an accident or disaster must rush to the site in line with the request. List and contact information of the maintenance personnel of the Rolling Stock Department must be indicated clearly so that relevant personnel can contact them when necessary.

Other maintenance personnel shall act according to the instructions of the Task Force. The organization is composed of the following duty positions with the functions and assignment as described below.

10.11.2 Responsibility of Each Personnel in Charge

Each department shall allocate personnel appropriately depending on the circumstances of the accident.

- Head of the depot
  The Head of depot shall advise the Taskforce to define restoration policy, instruct the Head of Inspection Yard and related personnel to implement and manage restoration activities.
- Main communicator
This personnel assists the Head of the depot and the Task Force, and acts as mediator between the Task Force and personnel who are not at the site.

The personnel is responsible for communicating necessary information to the relevant departments and, as needed, requests their support.

- Head of the Inspection Yard (Maintenance Center)
  The personnel is responsible for organizing the restoration work according to the agreed upon restoration policy.

- Communicator with the Head of Inspection Yard
  The personnel assists the Head of the Inspection Yard (Maintenance Center) and acts as mediator between the Head of the Inspection Yard (Maintenance Center), restoration personnel and the Task Force. The personnel is responsible for accurately informing the restoration policy-based instructions of the Head of the Inspection Yard (Maintenance Center) and, at the same time, reporting relevant details about the restoration site to the Head of the Inspection Yard (Maintenance Center).

- Associate Inspector
  The personnel assists the Head of the Inspection Yard (Maintenance Center) in direction of restoration and implementation of restoration. Generally, the supervisor on duty in the Inspection Yard who is responsible for accidents becomes in charge.

- Investigator
  The personnel investigates the circumstances of the accident, and retains records and evident of the accident.

- Restorator
  The personnel is in charge of restoring work at the accident site.

### 10.12 Emergency Machinery and Materials

- The emergency machinery and materials used for dealing with an accident are usually deployed in the Inspection Yard.

- Based on the characteristics of each line (derailment, collision, turnover, fire hazards, etc.), respective OU must create a list of emergency machinery and materials necessary for each type of accident, and sort and prepare the equipment beforehand.

- The emergency machinery and materials must be periodically inspected, maintained and kept in good operating condition. Maintenance records of the equipment, machinery and materials must be created.

### 10.13 Restoration Training

The Head of the Inspection Yard (Maintenance Center) must implement restoration training in order to enhance the skills of personnel and give them an experience of accident-related restoration work in preparation for an accident.

Contents of training
- Information reporting training
- The way of carrying and handling the emergency machinery and materials
Training of accident restoration work in hypothetical situations (training on derailment, failure of wheelset, bogie failure, restoration of a separated train)

Comprehensive training against accidents (handling of the emergency equipment, information communication, restoration work and cooperation with relevant sections) must be conducted once a year.

10.14 Training Plan and Record

10.14.1 The plan and record must be in compliance with the company's training regulations.

10.14.2 Training must be implemented, recorded and stored according to the decided plan.

10.15 Emergency Automobile

10.15.1 Emergency automobile should be maintained according to the regulations and kept in good condition so that they can be used at any time.

10.15.2 The drivers of the emergency automobile should be designated beforehand.

10.16 Route

10.16.1 The Head of the Inspection Yard (Maintenance Center) must check routes in the area that can be driven by emergency automobile for restoration or support purposes. The head should hold a training for concerned personnel to grasp the route.

10.16.2 Head of the Inspection Yard (Maintenance Center) must provide necessary training to the drivers of emergency automobiles so that the specified requirements may be met at an accident.

10.17 Restoration of Rolling Stock Failure after Returning to Depot

i. Investigate the failure after observing relevant circumstance.

- Analyze the cause of failure and make a proposal on the restoration measures. Analysis and inspection of a railway accident must be carried out in accordance with the existing regulations.

- For future reference: In the initial stage, HMC does not have experience in dealing with failure and restoration work. Therefore, the participants, who investigates cause of failure and deals with failure, are not only each division in the company but also the contractor which provided equipment and the concerned organizations. OU is in charge of carrying out investigation and restoration of failure. HQs supports investigation and restoration of failure through adjustments made with the contractor.

- Although OU is in charge of dealing with failure, HQs is responsible for requesting technical support from the contractor and other relevant external organizations as needed.

- When investigating a failure, including investigating the cause of the equipment's previous failure and collecting failure-related information from maintenance records and materials, company employees themselves must play leading roles for them.

- As needed, they will collaborate with the manufacturer in order to conduct a more detailed investigation.

- The investigation shall be continued until the cause is accurately identified.
If the cause is not able to be identified, it is permissible to use the same or spare devices after it has been confirmed as safe.

ii. Take Measures against the Cause of Failure

Based on condition and failure cause, maintenance personnel in charge must promptly carry out restoration or must report to senior personnel in order to restore failure quickly. It is required to check the same failure or the risk of failure on the rolling stock in other sections.

Several types of failure, and countermeasures:

iii. Preparation of Materials (Records of dealing with failure)

- Records of all failures shall be prepared. These records will become a foundation which can be used for analysis, cause investigation and development of restoration measures. Summarized results, which are accumulated of dealing with failure, can help managers in each division to ensure safety.
- The section in charge of investigation and restoration of failure, is responsible for preparing a detailed record of circumstances and causes of failures, and relevant countermeasures.
- The section in charge of investigation, as well as OU and the Rolling Stock Maintenance Management division in HQs, are responsible for storing records on failures.

iv. Reporting to HQs on Failures and Proposals and Recommendations from OU

- The section in charge of investigation and restoration must prepare detailed records on causes and countermeasures, and report it to HQs.
- In all cases, OU must report to HQs on circumstances of failure, including train delay time (if any).

v. Sharing information of cause and countermeasure to concerned organizations

The materials that explain the circumstances, causes of failures and countermeasures shall be shared with and notice to relevant employees in order to prevent recurrences of similar failures.

vi. General Handling and Meeting System

- Information on failures and accidents must be stored and statistically processed periodically (quarterly and annually). Each OU must grasp circumstance of the failures. Each OU must
predict failure-related trends by statistically processing and analyzing the data. OU must develop restoration measures based on information and materials on actual conditions of lines, and present it to HQs. Based on the countermeasures for failure, and on the statistical processing and investigation on the failure-related trends, OU shall develop measures that prevent the trends, and propose the measures.

✓ HQs and personnel in each concerned OU shall hold meetings periodically every month in order to report and discuss failures and other matters that happened during the month. Another meeting may be held at the end of the month in order to receive reports on various subjects from each unit, including causes of train delays, recently detected failures, and accidents that resulted from mistakes made by maintenance personnel. The meeting will study measures to preventing recurrence of such troubles. Members attendees will be personnel of the Rolling Stock Department in HQs and management personnel of each OU.

✓ If a large failure occurs that requires urgent measures, an emergency meeting will be held.

✓ If necessary, the company shall consider changing, adjusting the contents and methods of maintenance, repair, or replacement, improvements and equipment throughout the company to prevent recurrence of failure. In such a case, each OU requests HQs to allocate a budget for repairs and/or implementation of improvement measures. Depending on the seriousness of the given failure, it is necessary to consider which is more appropriate - making a company-wide urgent response, or preparing a countermeasure plan.

10.18 Restoration of Failure in the Process of Inspection and Maintenance (Periodic Inspection)
- If an error or failure is detected in the inspection or maintenance processes, the personnel in direct charge of inspection or maintenance should restore the trouble as soon as possible. If the personnel is not able to identify the cause or countermeasures, they must immediately report it to the senior personnel. The detected failure shall be handled as follows:

1. Tentative Measures:
   ✓ Reinforcing inspections.
   ✓ Enhancing maintenance quality.
   ✓ Replacing devices of failed equipment, or entire equipment.

2. After the Cause is identified:
   ✓ Improving the equipment with design changes and other methods.
   ✓ Replacing the equipment or its devices.
   ✓ As needed, revising the inspection method and period.

11) Procedure of Periodic Maintenance

The maintenance procedure shall include the following.
- Preparation and approval of the rolling stock maintenance procedure.
- Preparation of maintenance plan and budget.
- Approval of maintenance plan and budget.
11.1 Preparation and Approval of Rolling Stock Maintenance Procedure (See law No.114/2004 Maintenance Procedure in Civil Engineering Work)

- Equipment supplying contractors are responsible for preparing and handing-over the maintenance procedures for rolling stock equipment.
- Basis for preparing rolling stock maintenance procedures:
  a) Applicable standards, regulations.
  b) Similar maintenance procedures if any.
  c) Instructions of equipment manufacturers.
  d) Respective suitable natural conditions.
  e) Related regulations of government’s competent authorities.
- Rolling stock maintenance procedures shall be prepared in order to ensure overall covering for rolling stock devices, as the following:
  a) Regulations on technical, technology specifications.
  b) Regulations on objects, methods and frequency of inspection.
  c) Regulations on contents and instructions of maintenance implementation.
  d) Regulations on timing and instruction of periodical replacement.
  e) Instructions of repairing methods for failures; regulations on conditions to ensure labor safety and environmental hygiene during implementation of maintenance;
  f) Other instructions relating to the maintenance.
- Approval
  OU submits the maintenance procedure to HQs for evaluating and approving
  Evaluating of procedures: Rolling Stock Department in HQs
  Approve: General Director

11.2 Preparation of Maintenance Plan

- OU is responsible for preparing rolling stock annual, monthly, daily maintenance plans for respective lines, in order to guarantee safe and effective operation and maintenance plans. Based on maintenance plan, OU shall prepare annual specific cost estimate to submit HQs for assessment, decision making for conducting next steps.
- Contents of annual rolling stock maintenance plan shall include sufficient items as followings:
  contents of maintenance work and main items, unit, maintenance implementing duration, implementing methods, priority level, quantity/amount of workload and cost estimate;
- Inputs for preparing maintenance plan will include the following:
  - Rolling stock maintenance procedures following the standards in design of OU
  - Train operation plan of OU
  - Human resource plan of maintenance division in OU
  - Failures, problems occurred during operation
• Safety policy
• Training, education plan

- Inputs for calculating annual cost estimate:
  Forecast of the maintenance cost is obtained from the workload finalized in the maintenance plan to follow and the unit price of the maintenance to be implemented for the workload.
  • Annual maintenance plan
  • Estimate of unit price, quantity, devices and equipment
  • Backup plan

- Maintenance plan can be amended, supplemented during the implementation. General Director of the Company or authorized personnel can make decision on amendment, supplement of maintenance plan.

11.3 Approval of Maintenance Plan and Maintenance Budget

Approval of the rolling stock maintenance plan is classified as described below:

- HQs approves the annual rolling stock maintenance plan and the annual budget of OU.
+ ) Maintenance plan
  • Assessment: The Rolling Stock Department is responsible for evaluating the annual maintenance plan of OU.
  • Approval: Company’s General Director
+ ) Annual maintenance budget
  • Assessment: The Rolling Stock Department evaluates the budget items in collaboration with the Financial Department, and then hands them over to the Financial Department for a final evaluation.

The following are included in the evaluation:

a) Check the compliance between major amount/quantity in the cost estimation with implementing amount.

b) Check the reasonability of application of unit price using for rolling stock, rate of expenses, cost estimation for consulting services and cost estimation for other expenses in maintenance.

c) Defining value of maintenance cost estimation.
  • Approval: Company’s General Director

- Based on approved annual maintenance plan, OU shall develop detailed maintenance plan for the real date and month of implementation.

11.4 Implementation of Maintenance

- OU organizes the implementation of the inspection, maintenance and repairing of rolling stock in accordance with procedures and maintenance plan if they have sufficient capability. If not, OU studies and proposes to hire capable organizations to implement.

- Maintenance works shall be specifically regulated by steps towards respective related devices in rolling stock.
- Inputs for implementing rolling stock maintenance:
  - Annual, monthly and daily maintenance plan
  - The approved rolling stock maintenance procedure

11.5 Maintenance Records
- The implementation, inspection results, maintenance and repairing works for rolling stock must be recorded and archived for management and tracking.
- Individuals directly implementing maintenance works, technical management, as well as individuals and organizations relating to inspection works, repairing and maintenance works are responsible for taking records.
- Input
  - Implementation of works
  - Inspection result

11.6 Maintenance Completion Report
- OU must report on rolling stock maintenance work annually or when incidents possible to cause disasters may occur.
- OU is responsible for reporting to HQs on results of inspection, maintenance and repairing works for rolling stock after medium-scale repair (4 years), large-scale repair (8 years) and un-scheduled repairs.

12) Implementing Organization

a. Rolling Stock Maintenance Management division in HQs
   - This division gives advice to and evaluate the rolling stock maintenance plan and the accident response plan in compliance with the national and company regulations.
   - This division inspects and audits execution of the approved maintenance plan by each unit.
   - This section prepares the rolling stock maintenance work procedure and the manual for each unit.

b. Maintenance Implement division (Maintenance Center)
   - Preparation of rolling stock maintenance plan.
   - Implementation of maintenance based on the approved plan.
   - Finalizing regulations. This division reviews the work of the implementing organizations in order to give guidance to them.
13) **Forms**

   a. Form of train allocation plan
### Long term Inspection & Improvement plan for Workshop Inspection (Workshop)

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# Yearly & Monthly Inspection Plan

**Year:** 2015

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| Day of week | | Wed | Thu | Fri | Sat | Sun | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Mon | Tue | Wed | Thu |
| Inspection Train No. | | Train No. 01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| The elapsed days from last time inspection | | Train No. 02 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Train No. 06 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Train No. 07 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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**Note:** The table is repeated for different months, May, June, July, August, September, October, and November. Each month has the same format with the day of the week and inspection dates.
Yearly Monthly Inspection plan for Daily inspection (Inspection Yard)

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Daily operation plan 〈Inspection Yard → OCC, Operation Dept.〉

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<td>Mon</td>
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<td>8-years</td>
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<tr>
<td>4-years</td>
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<tr>
<td>3-months</td>
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</tr>
<tr>
<td>6-days</td>
<td></td>
</tr>
<tr>
<td>cleaning</td>
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<tr>
<td>wheel grinding</td>
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Form of Daily Inspection<Inspection Yard>

Date 02/May
Day of the week Mon

<table>
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<tr>
<th>In charge</th>
<th>Work Shift</th>
<th>A</th>
<th>B</th>
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<tbody>
<tr>
<td></td>
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<tr>
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Daily inspection

<table>
<thead>
<tr>
<th>Limit value</th>
<th>Thickness</th>
<th>Stroke</th>
<th>Thickness</th>
<th>Disconnection of mesh wire</th>
<th>Size of wheel flat</th>
<th>In charge</th>
<th>Remark</th>
<th>Required time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>more than 5mm</td>
<td>(120mm)</td>
<td>more than 17mm</td>
<td>less than 30%</td>
<td>less than 50mm at 2part, or less than 75mm at 1part</td>
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<table>
<thead>
<tr>
<th>Inspection method</th>
<th>Limit check</th>
<th>(Seeing)</th>
<th>Limit check</th>
<th>Seeing</th>
<th>Seeing</th>
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<tbody>
<tr>
<td>Train No.</td>
<td>Current collector</td>
<td>Brake cylinder</td>
<td>Brake Pad</td>
<td>Mesh wire</td>
<td>Tread of wheel</td>
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Other maintenance (replacement of consumable parts, repair)

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<th>Train No.</th>
<th>Situation</th>
<th>Cause and treatment</th>
<th>In charge</th>
<th>Remark</th>
<th>Required time</th>
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In charge
Form of Monthly Inspection<Inspection Yard>

Date 02/May
Day of the week Mon
Train No.

Code No. Inspection

In charge

Compressor
1st car

<table>
<thead>
<tr>
<th>Inspection item</th>
<th>Reauried time to store compressed air</th>
<th>Safety valve function</th>
<th>Pressure regulator(turn on)</th>
<th>Pressure regulator(turn off)</th>
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<tbody>
<tr>
<td>Limit value</td>
<td>less than 4 minutes</td>
<td>880kpa(+0,—20)</td>
<td>640kpa(+20,—0)</td>
<td>780kpa(+20,—0)</td>
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<tr>
<td>Measured value</td>
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Brake test
1st car

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<th>Load condition</th>
<th>Empty</th>
<th>Full</th>
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<tr>
<td>Brake position</td>
<td>Neutral</td>
<td>4th steps</td>
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<tr>
<td>Command voltage(standard)</td>
<td>1.47V</td>
<td>3.07V</td>
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<tr>
<td>Measured value</td>
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<td></td>
</tr>
<tr>
<td>Brake cylinder pressure(standard)</td>
<td>0kpa</td>
<td>155kpa</td>
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<tr>
<td>Measured value</td>
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**Other remarks**

- Current collector/ Electric equipment
- Air brake equipment/ Motor and compressor
- Door/ Car body
- Other maintenance

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c. Form of budget preparation
### Budget contents for 'regular maintenance' (for 1 year)
(OPEX: every periodical inspection)

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<th>Line-2A</th>
<th>Work Place name/</th>
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- **Material cost for inspection & maintenance (Rolling stock)**
  - **Monthly inspection**
  - **Daily inspection**
  - **Other maintenance**
  - **Total**

- **Outsource cost for inspection & maintenance (Rolling stock)**
  - **Inspection (incl. repair air)**
  - **Other maintenance**
  - **Total**

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<th>Type of inspection</th>
<th>Number of cars/facilities to be</th>
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**Contents**

- **Category**
- **Name of parts**
- **Quantity**
- **Unit price**
- **Sub total**
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Year/  2015
Line name/  Line-2A
Work Place name/  (Workshop)
### Budget contents for 'rolling stock maintenance' <mid term>
(OPEX: not every periodical inspection)

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| Wire-off | Outsource|                         |      |      |      |      |      |      |            |         |        |

Appendix8-6-6-1-B
## Budget contents for 'rolling stock Maintenance' (mid term)

(CAPEX: Spare equipments & parts)

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Total

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|     |      |        |               |                      |                 | total                 |      |      |      |      |      |      |          |            |

## Appendix 8-6-1-B
### Budget contents for 'Facilities maintenance' <mid term>

(CAPEX: New car&improvement, cost of wire-off removal)

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**Total**

| CAPEX Materials | Outsource total       |      |      |      |      |      |
| Wire-off Materials | Outsource total   |      |      |      |      |      |
## Budget contents for 'rolling stock Maintenance' (mid term)
(CAPEX: Equipments for inspection)

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Total

- Quantity
- Unit price
- total
Budget contents for 'other expense' <for 1 year> 2015

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Total
d. Form of situation report for accident and failure
# Situation Report

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<th>Month:</th>
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<tr>
<td>3. Work place name</td>
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</tbody>
</table>
| 4. Type | A 1. failure 2. accident 3. disaster 4. other  
          | B 1. rolling stock 2. facility 3. driving 4. other |
| 5. Date and time of occurrence | Year: | Month: | Date: | Day of the week: | Weather: |
| 6. Place of occurrence | Line: | – | Line: | Time |
| 7. Operation No. | No.: | Line: | – | Line: |
| 8. Train No.      | Train set: | Starting station: | Destination station: |
| 9. Delay time | Delay: (min) | Stop operation: | – | Number: |
|                  |       | Deadhead train: | – | Number: |
| 10. Specific date information of the train | Start operation | Recent improvement | Workshop improvement | Monthly inspection | Daily inspection |
| 11. Occurrence situation |       |        |       |
| 12. Contents of investigation |       |        |       |
| 13. Treatment for the time being |       |        |       |
| 14. Cause and analysis |       |        |       |
| 15. Measures to prevent recurrence | Preventive measures against recurrences: | Confirmation method of the effect: | Date of effect confirmation: |
| 16. Application of same measures to similar trains | Necessity: (Y or N) | Responsible work place: | Performed date: |
14) Attachment

Attachment- 1 : Train allocation plan for Line-2A

1. Operation plan

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- Departure from Depot
- Arrival to Depot
- Operating time
## 2. Inspection plan

### Inspection plan (Monthly - train No. base)

| Train No. | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1 | A (M) | A | A | K | A | K | A | (L) | A | A | A | A | A | A | A (M) | A | A | A | A | A | A | A | A (L) | A | A | A | A | A | A | A | A | A |
| 3 | A | B | A | C | C | C | C | L | M | (M) | B | C | C | C | C | B | (L) | K | C | C | C | C | C | C | C | C | C |
| 4 | 5 | C | (L) | C | C | C | B | L | C | (L) | A | C | B | C | D | K | D | D | C | (M) | A | D | D | D | L | (L) | B |
| 7 | E | C | (L) | E | E | D | B | E | K | (L) | E | E | E | B | E | C | (L) | K | D | E | F | E | E | E | E | E | E |
| 8 | F | D | D | (M) | F | E | C | F | C | K | (M) | F | F | C | F | D | K | (M) | E | F | G | F | F | C | (M) | F | K | D | F |
| 10 | H | F | F | F | (M) | G | M | G | E | E | F | (M) | H | E | E | E | E | (M) | H | L | H | E | E | K | (M) | G | F | H | F |
| 11 | K | G | G | K | (L) | H | F | F | H | F | F | G | (L) | K | F | L | F | F | F | (L) | K | K | M | F | F | F | (L) | H | G | M | G | K |
| 13 | M | K | H | H | A | (L) | H | K | H | H | K | H | (L) | H | H | H | H | H | H | (L) | K | H | H | H | H | (L) | K | K | H | H |

### Kinds of maintenance

- 5-year inspection
- 3-month inspection
- 10-day inspection
- Creaning
- Wheel grinding
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### Calculation of the number of maintenance personnel of Line-2A

1. **Maintenance staff of Line-2A according to training plan**

Train check and repair department of Line 2A: 53 person

In the train check and repair department of Line 2A, there are 6 Management Staff and 47 Working staff. It includes 4 persons in Check and repair supervision team, 28 persons in Check teams by segment, 7 persons in Monthly maintenance team and 8 persons in General equipment. For detail, see following table.

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<th>Department</th>
<th>Staff classification</th>
<th>Position classification</th>
<th>Standard of staff arrangement</th>
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<td></td>
<td>Deputy chief of check and repair department</td>
<td>1 person/department</td>
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<tr>
<td></td>
<td>Senior Technical Manager of check and repair</td>
<td>1 person/department</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chief engineer of check and repair</td>
<td>1 person/department</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assistant of check and repair</td>
<td>1 person/department</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Check and repair supervision team</td>
<td>Check and repair supervision staff</td>
<td>1 person/shift, 4 teams 2 shifts</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Check teams by segment</td>
<td>Main segment check supervisor</td>
<td>1 person/shift, 4 teams 2 shifts</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior electrification check</td>
<td>1 person/shift, 4 teams 2 shifts</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrification check</td>
<td>2 person/shift, 4 teams 2 shifts</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior Equipment check</td>
<td>1 person/shift, 4 teams 2 shifts</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment check</td>
<td>2 person/shift, 4 teams 2 shifts</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Monthly maintenance team</td>
<td>Monthly maintenance leader</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior monthly electrification maintenance</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly electrification maintenance</td>
<td>2 person</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior monthly Equipment maintenance</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly Equipment maintenance</td>
<td>2 person</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>General equipment</td>
<td>Main supervisor to equipment</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operator of machine type A (Crane truck)</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operator of machine type B (Roller)</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operator of machine type C (Train washing machine)</td>
<td>1 person</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supervision of Equipment Type A (Measurement tool)</td>
<td>2 person</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supervision of Equipment Type B (small train, train repair)</td>
<td>2 person</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>
2. Verification of the number of maintenance personnel of Line-2A

**Premise**

- Inspection is carried out as proposed by contractor.
  - Monthly inspection (working shift: day-time)
    - Contents of inspection is same as 3-months inspection (conducted by Tokyo Metro)
  - Daily inspection (working shift: 3 shifts/day (Ban-san’s 4-group idea))
    - Contents of inspection is same as 10-days inspection (conducted by Tokyo Metro)
  - Number of train sets: 13 train sets

<table>
<thead>
<tr>
<th>Assumption for adequate number of staffs</th>
<th>Classification</th>
<th>Management staff</th>
<th>Working staff</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance in office</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly inspection</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In Tokyo Metro (6 cars/1 day → about 15 staffs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In this case (4 cars/2 day → about 5 staffs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;calculation 15 staff * 4/6 cars * 1/2 day&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>※There are 13 train sets, and 26 weekdays (mon~sat) in one months, so it is sufficient to inspect 1 train set/2 days</td>
<td></td>
</tr>
<tr>
<td>Daily inspection</td>
<td></td>
<td>2*4 group = 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4*4 group = 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>It is implementated with 3-shifts. It is necessary to have 4 team for 3-shits. And it is necessary to have 4 staffs for 1 shift.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;calculation: 4 staffs * 4 teams&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>※All 13 train sets are inspected everyday.</td>
<td></td>
</tr>
<tr>
<td>Other maintenance</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General equipment</td>
<td>1</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>18</td>
<td>33</td>
<td></td>
<td>51</td>
</tr>
</tbody>
</table>
Attachment-3: Overview of Rolling Stock of Line-2A

- There are 52 cars / 13 trains. Propulsion systems, braking systems, train signaling equipment, radio equipment etc. are included under supply of equipment for the trains.
- Spare equipment and corrective maintenance tools (connection tools, assembly tools, etc).
- Replace perishable and easily worn components once during the warranty period.
- Including the cost of installing and testing the system propulsion system, braking system etc.
- Technical documentation and drawings.

The main dimensions of the train requirements table (calculated unit: mm)

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>The train length (The length between Coupler connection surfaces)</td>
<td>Tc rolling stock: 19520 + 500 (Temporary)</td>
</tr>
<tr>
<td>M rolling stock: 19520</td>
<td></td>
</tr>
<tr>
<td>Train length (the length between Coupler connection surfaces of two sides in the Four-Rolling stock train)</td>
<td>79080 (Temporary)</td>
</tr>
<tr>
<td>Body train length</td>
<td>Tc rolling stock: 19500 (Temporary)</td>
</tr>
<tr>
<td>M rolling stock: 19000</td>
<td></td>
</tr>
<tr>
<td>Rolling stock height (From the track surface to the top of the train, new wheels)</td>
<td>3800</td>
</tr>
<tr>
<td>The maximum width of the Rolling stock</td>
<td>2800</td>
</tr>
<tr>
<td>Central height of the inside Rolling stock (Non-dynamic height in the passenger rolling stock):</td>
<td>2100</td>
</tr>
<tr>
<td>The minimum height of the standing area in the passenger rolling stock</td>
<td>1900</td>
</tr>
<tr>
<td>Air spring is inflated, the floor surface to the height of the rail surface</td>
<td>1100</td>
</tr>
<tr>
<td>Bogie center distance</td>
<td>12600</td>
</tr>
<tr>
<td>Bogie fixed wheelbase</td>
<td>2200</td>
</tr>
<tr>
<td>The coupler centerline from the height of the rail surface</td>
<td>660 + 10</td>
</tr>
<tr>
<td>Wheel diameter:</td>
<td></td>
</tr>
<tr>
<td>New car</td>
<td>840 + 10</td>
</tr>
<tr>
<td>Half-worn wheel</td>
<td>805</td>
</tr>
<tr>
<td>Abrasion wheel</td>
<td>770</td>
</tr>
<tr>
<td>Wheel on the inside pitch</td>
<td>1353 ± 2</td>
</tr>
<tr>
<td>Passenger compartment side doors</td>
<td>4 pairs / side rolling stocks</td>
</tr>
<tr>
<td>Side door logarithm</td>
<td>1200</td>
</tr>
<tr>
<td>Side door opening width</td>
<td>1200</td>
</tr>
<tr>
<td>Open the side door, the height above the threshold of the top surface</td>
<td>1800</td>
</tr>
<tr>
<td>Cab side door</td>
<td>2600</td>
</tr>
<tr>
<td>Net cab side door open width</td>
<td>≥1800</td>
</tr>
<tr>
<td>Cab side door is open, the threshold above the top surface height</td>
<td>≥1800</td>
</tr>
<tr>
<td>Through Road (no partition doors)</td>
<td>≥1200</td>
</tr>
<tr>
<td>Through the channel width</td>
<td>≥1850</td>
</tr>
</tbody>
</table>

Through the channel height
# Contents of training for Maintenance Personnel of Line-2A

## Train maintenance class (theory 25 days)

<table>
<thead>
<tr>
<th>Week</th>
<th>Day</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td>Morning</td>
<td>General about train</td>
<td>Train electric equipment layout</td>
<td>Train electric equipment layout</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>General about train</td>
<td>Train electric equipment layout</td>
<td>Train electric equipment layout</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td>Day</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td></td>
<td>Morning</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
<td>Auxiliary system</td>
<td>Auxiliary system</td>
<td>Braking system</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
<td>Tractive and leading system</td>
<td>Auxiliary system</td>
<td>Auxiliary system</td>
<td>Braking system</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td>Day</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td></td>
<td>Morning</td>
<td>Braking system</td>
<td>Braking system</td>
<td>Braking system</td>
<td>Braking system</td>
<td>Air condition and heating system</td>
<td>Bogie</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>Braking system</td>
<td>Braking system</td>
<td>Braking system</td>
<td>Braking system</td>
<td>Air condition and heating system</td>
<td>Bogie</td>
</tr>
<tr>
<td><strong>Week 4</strong></td>
<td>Day</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td></td>
<td>Morning</td>
<td>Bogie</td>
<td>Bogie</td>
<td>Through line</td>
<td>Statement of using door next to passenger chamber</td>
<td>On-board braking system</td>
<td>Passenger information system</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>Bogie</td>
<td>Bogie</td>
<td>Statement of using door next to passenger chamber</td>
<td>Statement of using door next to passenger chamber</td>
<td>On-board braking system</td>
<td>Reviewing</td>
</tr>
<tr>
<td><strong>Week 5</strong></td>
<td>Day</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td></td>
<td>Morning</td>
<td>Reviewing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>Taking an exam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Practical timetable of vehicle maintenance

<table>
<thead>
<tr>
<th>Week</th>
<th>Time</th>
<th>Training method for positions</th>
<th>No. of days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Management staff</td>
<td>Maintenance and monthly inspection</td>
</tr>
<tr>
<td>Week 1</td>
<td>9:30～16:00</td>
<td>Education before practice</td>
<td>6 days</td>
</tr>
<tr>
<td>Week 2</td>
<td>9:30～16:00</td>
<td>Practice at inspection</td>
<td>Practice at monthly inspection</td>
</tr>
<tr>
<td>Week 3</td>
<td>9:30～16:00</td>
<td>Practice at monthly inspection</td>
<td>Practice at monthly inspection</td>
</tr>
<tr>
<td>Week 4</td>
<td>9:30～16:00</td>
<td>Practice at monthly inspection</td>
<td>Practice at monthly inspection</td>
</tr>
<tr>
<td>Week 5</td>
<td>9:30～16:00</td>
<td>Practice at equipment</td>
<td>Practice at monthly inspection</td>
</tr>
<tr>
<td>Week 6</td>
<td>9:30～16:00</td>
<td>Practice at technical team of maintenance center</td>
<td>Practice at monthly inspection</td>
</tr>
<tr>
<td>Week 7</td>
<td>9:30～16:00</td>
<td>Reviewing, taking an exam</td>
<td>4 days</td>
</tr>
</tbody>
</table>
Hanoi City People's Committee

Socialist Republic of Vietnam

Hanoi Railway One-Member Limited Liability Company

Independence Freedom Happiness

Regulation on Civil Structure Maintenance

Chapter 1: Purpose

Chapter 2: Applicable Scope and Target

Chapter 3: Definition of Terms and Abbreviations

Chapter 4: Legal Foundation and Reference Materials

4.1 Legal Foundation

4.2 Reference Materials

Chapter 5: Responsibility for Implementation

Chapter 6: Structure of Implementation and Management Organization

6.1 Management Organization Structure of Civil Structure Maintenance Section at HQ and OU

6.2 Stratification of Implementation of Work

Chapter 7: Regulations on Document Storage

Chapter 8: Forms and Appendices
Chapter 1: Purpose

This document has been edited to describe regulations concerning civil structure maintenance procedures for various types of equipment and systems that comprise an urban railway.

Maintenance of an urban railway to keep it in constant good operational condition so that it does not stop for any unexpected reasons. In addition, it is important for the urban railway to continue high-density operation without delays. However, the equipment inevitably deteriorates due to repeated use. This is an unavoidable fact that should always be kept in mind by maintenance staff. Despite the above, the urban railway must continue operations according to the plan once operations are started. This method of business will enhance users’ recognition of the urban railway as a trustworthy means of transportation, and will most possibly increase the number of users.

Among the various types of urban railway equipment, this document focuses on maintenance of civil structures, and classifies related work into three categories: inspection, planning, and repairs.

Every item related to civil structures must be maintained in good condition, every potential failure must be prevented using appropriate measures, and necessary repairs must be carried out on a timely basis using suitable measures in order to ensure safe and continued urban railway operations, and to maintain the relevant structures in sound condition.

Chapter 2: Applicable Scope and Target

- This regulation stipulates the requirements for maintenance of civil structures of the respective urban railway lines in the city of Hanoi.
- This regulation applies to the organizations and individuals who are directly engaged in maintenance of civil structures in respective urban railways in the city of Hanoi.
- Applicable scope: The applicable shall be the respective urban railways administered by Hanoi Metro Company.

Chapter 3: Definition of Terms and Abbreviations

The Regulation on Civil Structure Maintenance covers the procedures for inspection, planning and repair work, the contents of this work, and the guidance on implementation of the work.

- Maintenance denotes the respective activities (inspection, follow-up, planning and repair) that are implemented regularly or irregularly according to the design requirements in order to maintain civil structures in conditions suitable for normal operation and use.
- Inspection refers to checking of relevant structures for signs of failure either visually or by use
of special equipment in order to judge the acceptability of the current state.
- **Planning** means formulating appropriate repair plans based on the inspection results to ensure safe train operation and safe use of the civil structures.
- **Repair** denotes the act of recovering from a failed state in order to ensure the safety of the relevant civil structures while trains are in operation or in use. In this case, maintenance shall be executed appropriately in accordance with the formulated maintenance plan.
- **Upgrading** denotes replacing an existing item of equipment with a new one, or adding a new item of equipment to an existing one when it is not possible to completely recover its functionality by repeated repairs alone.

**Chapter 4: Legal Foundation and Reference Materials**

**4.1 Legal Foundation**

- National Law on Civil Engineering Work No. 50/2014/QH13 dated 2014/6/18
- Decree No. 114/2010/ND-CP on Maintenance of Civil Structure dated 2010/12/06
- Traffic and Transportation Ministry Circular No. 20/2013/TT-BGTVT on Management and Maintenance of Railway Facilities dated 2015/08/16
- Decree No. 46/2015/ND-CP on Quality Control of Civil Structure dated 2015/05/12
- Decree No. 32/2015/ND-CP on Management of Construction Investment Costs dated 2015/03/25
- Labor Law by Diet No. 10/2012/QH13 dated 2012/06/18

**4.2 Reference Materials**

- Documents and materials from 2A Line work
- Basic Standard No. TCCS 01: 2010/VNRA on Maintenance Procure of Railway Viaducts and Tunnels
- Our experience gained from maintaining civil structures of subways in Tokyo

**Chapter 5: Responsibility for Implementation**

- Staff who maintain civil structures shall receive the necessary education that will equip them with the necessary knowledge and skills to carry out their assignments.
- Staff who maintain civil structures shall carry out their assignments unfailingly to maintain reliable and safe operations that are not stopped due to unexpected reasons.
- When concluding an agreement on inspections or repairs with a subcontractor, the maintenance
staff shall confirm that the subcontractor has sufficient capabilities to execute the assigned business.
Chapter 6: Structure of Implementation and Management Organization

- While the train is in operation or in use, civil structures shall be maintained according to regulations.
- The civil structure maintenance procedure shall be formulated, along with the design standard, based on the maintenance regulation herein.
- Maintenance of civil structures shall assure safety of those who engage in the work as well as the property.
  (The maintenance staff must prepare suitable protective gear, tools and machines before starting the inspection or repair.)

6.1 Management Organization Structure of Civil Structure Maintenance Section at HQ and OU

**Headquarters (HQ)**

- Section manager
- Deputy Section manager 1 person
- In charge of inspection 1 person
- In charge of planning 1 person
- In charge of repairs 1 person
- In charge of technology 1 person
- In charge of general affairs 1 person

**Operation Unit (OU)**

- Section manager 1 person
- Deputy Section manager 1 person
- In charge of inspection 12 people
- In charge of planning 2 people
- In charge of repairs 16 people
- In charge of general affairs 1 person
6.2 Stratification in Implementation of Work

a. Headquarters (HQ)

HQ shall assume the management function.
- Manages the inspection work of OU
- Checks the civil structure maintenance plan of OU
- Formulates the civil structure maintenance plan of all lines
- Implements the operations related to the bid tender and outsourcing agreement for civil structures of respective lines.
- Formulates the personnel program for civil structure maintenance work at OU.
- Checks the civil structure maintenance procedure of OU.
- Checks the design and the civil structure maintenance costs of OU.
- Administrers the material supply and parts use plan of OU.
- Implements administration, auditing and acceptance inspections on every civil structure maintenance job carried out on respective lines.
- Formulates the rules, technical standard system and technical procurement for civil structure maintenance.
- Submits approval request forms related to civil structure maintenance work to the regulatory authority.
- Formulates accident processing measures by analyzing and verifying the given accident.
- Studies how to improve the maintenance methods.
- Implements the work related to design and improvement of the maintenance equipment for civil structures.

b. Operation Unit (OU)

OU shall assume the role of implementing the actual work.
- Carries out the inspection work from the OU standpoint.
- Formulates the civil structure maintenance plan of the assigned project, reports and submits the related approval request form.
- Creates the bid tender plan and the outsourcing agreement concerning maintenance of civil structures, and submits the approval request form for these.
- Makes suggestions and proposals related to the bid tender and outsourcing agreement for civil structures of respective lines in quality of OU.
- Proposes the personnel program for civil structure maintenance work in quality of OU.
- Finalizes necessary civil structure maintenance jobs and calculates maintenance costs.
- Finalizes OU's demand for materials to be supplied, and use of parts.
- Implements civil structure maintenance, and conducts internal audit and acceptance inspections
on the maintenance work.
- Conducts acceptance inspections of completed or uncompleted civil structure maintenance work in collaboration with HQ.
- Tabulates and analyzes accidents, and submits comments on the accidents to HQ.
- Proposes improvements for equipment used for civil structure maintenance.

c. Hanoi Metro maintenance staff
- Inspections and repair work are carried out in three shifts.
  1st shift: 6:00 start - 15:00 end
  2nd shift: 14:00 start - 23:00 end
  3rd shift: 22:00 start - 7:00 end
  + Workers work 8 hours in each shift. (1-hour break period is included in the above. This 1-hour period not be included in the duty period.)
  + 1-hour is duplicated between each shift for the hand-off from the preceding to the succeeding unit. (The last 1-hour of the preceding unit and the first 1-hour of the succeeding unit is used for the hand-off.)
- The Unit Chief of each shift shall judge any work-related defects according to the Defect Judgment Criteria. He shall record details of the judgment on the Inspection Record.
- The Unit Chief of the preceding shift hands off the completed and uncompleted jobs as well as necessary tools, if any, to the Unit Chief of the succeeding shift. The above matters shall be described in the Hand-off Record.
- When the maintenance plan is not executable as scheduled due to the reasons such as missing staff, bad weather, etc., Unit Chief of each shift shall choose the location where the work can be done referencing the monthly plan, or adjust the workload of the day's maintenance plan.
- Hand-off between shifts
  + The preceding shift hands off the implemented work to the succeeding shift (completed and uncompleted jobs in the day's maintenance plan).
  + The preceding shift hands off the machines and tools to the succeeding shift (when they are used by the succeeding shift, too).
  + After the work is completed, the shift that used the machines and tools must return them to the specified places.

● Inspection and Repair staff
- Inspection staff

| The person responsible for the inspection results [Unit chief] | I person |
When a visual inspection is not possible for the given location, a service vehicle for high-elevation work shall be used.

| Person in charge of inspection (staff) | 2 people |

- **Inspection staff when a service vehicle for high-elevation work is used**

| Worker to drive service vehicle used for high-elevation work control the up-and-down movement and lighting | 1 person |
| The person responsible for the inspection results | 1 person |
| Person in charge of inspection | 1 person |

- **Repair staff**

| Driver | 1 person |
| The person responsible for safety | 1 person |
| Person in charge of maintenance | 2 people |
d. Staff for Formulation of Plan

Based on the inspection results, the person in charge of planning formulates the maintenance plan and sends it to the person in charge of repairs. The person in charge of repairs checks its feasibility. If not feasible, the person in charge of planning must revise it as appropriate.

- [Person in charge of planning] is responsible for formulating the annual and monthly maintenance plans.
- [Unit chief] is responsible for formulating the day's maintenance plan.

Defects that are not included in the maintenance plan shall be updated in the next monthly or annual maintenance plan.

**Application procedure**

**HQ**
- HQ Section manager: Responsible for everything concerning the plans developed at HQ and OU. When not available, the duty may be delegated to HQ Deputy Section manager.
- HQ Deputy Section manager: Responsible for each person in charge at HQ and OU, and summarizes the jobs in progress and reports them to the Section manager. When not available, the duty may be delegated to each person in charge.
- Each person in charge at HQ: Responsible for the jobs at HQ and OU, and reports them to the Section manager and Deputy Section manager.
- Person in charge of general affairs at HQ: Responsible for retention of the documents and general affairs.

**OU**
- OU Section manager: Responsible for everything concerning the plans developed at OU. When not available, the duty may be delegated to OU Deputy Section manager.
- OU Deputy Section manager: Responsible for work of each unit of OU, and summarizes the jobs in progress and reports them to the OU Section manager. When not available, the duty may be
delegated to the Unit Chief of each unit of OU.
- Unit Chief of each unit in charge at OU: Responsible for each unit he is in charge of, and reports them to the Section manager and Deputy Section manager of OU.

• **Plan and Work Reporting and Approval Procedure (From OU to HQ)**
- Each person in charge at OU submits the report to the senior office of the section. After gaining approval, the above person sends it the senior officer of HQ. Then, the above person sends it to the unit in charge at HQ for verification. After inspection and confirmation, the above unit in charge sends the document to the senior officer of HQ for approval. Then the above unit sends it to OU for implementation.
- If any revisions are needed, HQ requests the senior officer of OU to revise the document or conduct a re-inspection. Then, HQ sends the request again to each OU unit for revision.

- **List of Portion that Require Maintenance**
  
  - Portions that belong to structure
    + Building, stations and equipment that belong to civil structure
    + List of fire extinguishing equipment
  
  - Portions that belong to civil structures
    + Viaducts and tunnels

- **Inspection Cycles (Application to Hanoi Metro Company is proposed)**
  
  - Viaducts inspection cycle

<table>
<thead>
<tr>
<th>Inspection cycle</th>
<th>Inspection method</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 times/month</td>
<td>Check viaducts by walking quickly with the rest of the patrol.</td>
<td></td>
</tr>
<tr>
<td>Once/2 years</td>
<td>Check the target locations using a service vehicle for high-elevation work and, if cracks are detected, record their details.</td>
<td>Finalize the evaluation of the following items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Inspection of area in the vicinity of the viaducts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Place and dimension</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Cause</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Crack progress state</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Judgment on influence of cracks</td>
</tr>
</tbody>
</table>
When the following accidents occurred, OU and HQ shall collaborate in inspecting and evaluating the current state and promptly developing countermeasures. Such events may include unexpected accidents that affect safe use of structures or safe train operations, accidents due to disasters such as typhoons, floods, earthquakes and fire hazards, and sudden train-related accidents.

Results of the above inspection are recorded and reported to the person who has formulated the maintenance plan.

### Tunnel inspection cycle

<table>
<thead>
<tr>
<th>Inspection cycle</th>
<th>Inspection method</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every month</td>
<td>Check the tunnel visually while walking through it during the time period when trains are not running. No lighting.</td>
<td></td>
</tr>
<tr>
<td>Once/1 years</td>
<td>Check the tunnel visually using the lamp during the time period when trains are not running.</td>
<td>Finalize the evaluation of the following items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Place and dimension</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Cause</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Crack progress state</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Judgment on influence of cracks</td>
</tr>
<tr>
<td>Once/10 years</td>
<td>Check the tunnel in detail using the lamp during the time period when trains are not running. Inspect the tunnel ceiling using the service vehicle for high-elevation work.</td>
<td></td>
</tr>
<tr>
<td>Extraordinary inspection</td>
<td>When the following accidents occurred, OU and HQ shall collaborate in inspecting and evaluating the current state and promptly developing countermeasures. Such events may include unexpected accidents that affect safe use of structures or safe train operation, accidents due to disasters such as typhoons, floods, earthquakes and fire hazards, and</td>
<td></td>
</tr>
</tbody>
</table>
sudden train-related accidents.

Results of the above inspection are recorded and reported to the person who has formulated the maintenance plan.
Chapter 7: Regulations on Document Storage

- The following describes the burden sharing and implementation procedures concerning storage of the documents and materials (materials related to inspection, plan and repair) for civil structure maintenance.
- The materials to be saved must be originals (described on papers, and in movies and photos). When the original is not available, a legitimate copy shall be saved.

Retention period

(Documents are retained in accordance with Interior Ministry Circular No.09/2011/TT-BNV on the retention period of documents and materials dated 2011/06/03.)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Retention period</th>
<th>Department in charge of maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documents on basic construction to be sent to the authority concerned.</td>
<td>Up to expiration date of effect and force</td>
<td>- OU</td>
</tr>
<tr>
<td>(In document form as a general rule)</td>
<td></td>
<td>- HQ</td>
</tr>
<tr>
<td>Documents for system formulation, regulations on basic policy formulation of the authority concerned and documents related to guidance.</td>
<td>No set duration</td>
<td>- OU</td>
</tr>
<tr>
<td>Plan documents and reports of the basic construction investments.</td>
<td></td>
<td>- HQ</td>
</tr>
<tr>
<td>- Long period, Fiscal year</td>
<td>- No set duration</td>
<td>- OU</td>
</tr>
<tr>
<td>- Six months, Nine months</td>
<td>- 20 years</td>
<td>- HQ</td>
</tr>
<tr>
<td>- Quarter term, Monthly</td>
<td>- 5 years</td>
<td></td>
</tr>
<tr>
<td>Documents related to basic civil structures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Documents related to structures of A group, structures that introduce unprecedented architecture, construction, technology, equipment and materials, structures that are erected in special geological conditions or on special geological forms, and structures that are recognized as</td>
<td>- No set duration</td>
<td>- OU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- HQ</td>
</tr>
</tbody>
</table>
cultural and historical assets.

<table>
<thead>
<tr>
<th>Documents related to structures of B and C groups and documents related to large-scale repairs.</th>
<th>Dependent on the life of the given civil structure</th>
<th>- OU - HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documents related to small-scale repair of structures.</td>
<td>15 years</td>
<td>- OU - HQ</td>
</tr>
<tr>
<td>Conference documents on basic construction.</td>
<td>10 years</td>
<td>- OU - HQ</td>
</tr>
</tbody>
</table>

**Forms that must be prepared**

<table>
<thead>
<tr>
<th>Order</th>
<th>Form name</th>
<th>Number (When assigned)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Table of contents of a submitted/preserved document</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Record of a submitted/preserved document</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Table of contents of a document</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Request for disposal of preserved documents</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Letter of introduction</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Request for use of preserved edition</td>
<td></td>
</tr>
</tbody>
</table>
# Chapter 8: Forms and Appendices

## Defect Judgment Criteria

<table>
<thead>
<tr>
<th>Class</th>
<th>Structure soundness judgment criteria</th>
</tr>
</thead>
</table>
| A     | Existence of an abnormality that threatens the following.  
- Operational security  
- Normal train operations  
- Public safety  
Or an abnormality that potentially threatens to compromise the above. |
| AA    | Existence of an abnormality that threatens the following.  
- Operational security  
- Normal train operations  
- Public safety  
- An abnormality that requires emergency measures  
Repair period: Train must be stopped immediately. |
| A1    | - An ongoing abnormality is deteriorating the performance of a structure.  
- Structural performance can be completely lost due to heavy rains or flooding.  
Repair period: Must be repaired immediately during the night of the day it occurred. |
| A2    | - An existing abnormality threatens to deteriorate performance of a structure in the future.  
Repair period: Within a year from the day of inspection |
| B     | - Existence of an abnormality that threatens to grow to soundness A in the future. |
| C     | - A portion of a structure that has a slight abnormality. |
| S     | - Sound portion of a structure |
## Inspection Record Form

**Hanoi Railway One-Member Limited Liability Company**  
**Civil Structure Preservation Section**  
**Inspection Record**

<table>
<thead>
<tr>
<th>Line</th>
<th>Station</th>
<th>Place</th>
<th>Defect judgment</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Type of inspection</th>
<th>Contents of inspection</th>
<th>Number</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Inspection method</th>
<th>(Hammering, visual inspection, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>(Crack, peeling, bulge)</td>
</tr>
<tr>
<td>Cause</td>
<td></td>
</tr>
<tr>
<td>Processing method</td>
<td>(Repair or further monitoring)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Defect state</th>
<th>Defect judgment</th>
<th>Deadline of defect repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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</tr>
</tbody>
</table>

Supervisor

Unit Chief

---

**Defect state**
Hand-off Record

Hanoi Railway One-Member Limited Liability Company
Civil Structure Preservation Section

(Year and date)

Unit to hand off the work: ……………… A/Hanoi Metro Civil Structure Preservation Section

Unit to take over the work: ……………… B/Hanoi Metro Civil Structure Preservation Section

<table>
<thead>
<tr>
<th>Line</th>
<th>Place</th>
<th>Hand-off duration</th>
<th>Number of staff (Unit to hand off the work)</th>
<th>Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Contents of handed-off work
- Assignment

<table>
<thead>
<tr>
<th>Assignment name</th>
<th>Maintenance plan</th>
<th>Completed</th>
<th>Not completed</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Machines and tools

<table>
<thead>
<tr>
<th>Name of machines</th>
<th>Number of machines</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hanoi City People's Committee  
Japan International Cooperation Agency

Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Track Maintenance Regulations

Prepared by:  
Hoang Tuan Dat

TA Specialist:  
Mr. Fujioka
Contents

1. Purpose
2. Scope of Application
3. Definition of Terms and Interpretation of Abbreviation
4. Legal Foundation and Relevant Materials
5. Responsibility for Implementation
6. Details of Regulations
7. Regulations on Document Retention Period
8. Forms and Appendices
1. Purpose

This document provides requirements for track maintenance to assure the quality and structure of tracks, ensure safety operations, reduce the number of failures, and provide economic benefits.

2. Scope of Application

This document shall apply to any workplace that is involved in operational and maintenance activities of urban railways.

3. Definition of Terms and Interpretation of Abbreviation

- "Gauge" is the minimum distance between the rail heads in a section in which the track center line is straight.
- "Main track" is a track on which a train runs to provide passengers with service according to a train operation schedule.
- "Side track" is a railroad track (including a depot), not a main track.
- "Station" is a place where trains load or unload passengers where trains can be moved from one track to another using turnouts and crossings. A depot is also referred to as a "station".
- "Car" is a railway passenger that is mainly used for railway operations, or a dedicated car (a track geometry car, an electrical inspection car, a relief car, or a car with a special structure or facilities) with the exception of a track maintenance car.
- "Train" is a series of connected railroad cars that satisfies all critical conditions for safe train operations from a station to another station according to a transport plan, including the number of connected vehicles and braking force.
- "Railway signaling" refers to a signal, a sign, or sign markers.
- "Signal" is a railroad facility used to indicate the operating condition of a train or car to a driver or other people involved in operations.
- "Sign" is way to communicate among the railway staff via geometry, coloring, voice, etc.
- "Sign markers" are signs that indicate locations, directions, conditions, or the like to relevant crews, workers or the like.
- "Outside the Station" refers to the outside of the station limit.
- "Station limit" is a section situated between the outer-most sign marker (direction in which a train approaches) in a station yard and the outer-most sign marker (direction in which a train departs) in the station yard.
- "Track maintenance" is the upkeep of track functions and efficiency. It involves technical work to appropriately restore functions and efficiency that are degraded due to use of tracks.
- The basic components of track include (1) rails, (2) joints, (3) sleepers, (4) rail fastening system, (5) antivibration devices, (6) ballast track beds, (7) concrete beds, (8) turnouts and crossings, (9) stoppers, and (10) sign markers.
- Track maintenance is carried out through the following stages: (1) inspection of tracks, (2) development of maintenance plan, and (3) implementation of track maintenance (daily maintenance, frequently occurring repairs repairs, moderate scale repairs, large scale repairs, renewal).

4. Legal Foundation and Relevant Materials

4.1 Legal Foundation

The provisions in the Regulations shall be in compliance with the laws and regulations of Vietnam. MOT is currently preparing the regulations and standards concerning operation and maintenance of urban railways. When these regulations and standards have been established, the Regulations must be updated.

4.2 Relevant Materials

- Vietnam Railway Act 2005
- Circular No.20/2013/TT-BGTVT dated August 16, 2013 on Regulations on Management and Maintenance of Installation of Railway
- Ordinary Railway Structures Maintenance Standard TCCS 02:2014/VNRA
- Seamless Railway Facilities Maintenance Standard TCCS 03:2014/VNRA
- Standard TCCS 05:2014/VNRA on Resources, Materials and Accessory Items used in Railway
5. Responsibility for Implementation

Each HMC workplace and each HMC personnel involved in the track maintenance is responsible for complying with the regulations.

6. Details of Regulations

6.1 Regulations on Track Inspections

6.1.1 Inspection Services

- Train patrol
- Patrol on foot
- Inspection of structure gauge
- Inspection of tracks
- Inspection of turnouts and crossings
- Guardrail inspection
- Joint inspection
- Expansion joint inspection
- Inspection of sleepers
- Inspection of fastening system
- Inspection of vibration
- Inspection of track bed
- Car stop inspection
- Sign marker and indicator inspection

6.1.2 Regulations on Inspections and Inspection Periods

- Train patrol
  The main tracks must be patrolled at least once per month to check for train noise and abnormal vibrations.
- Patrol on foot
  A patrol on foot must be carried out in all sections of the main tracks and side tracks at least three times per month to check the conditions of track maintenance.
- Inspection of structure gauge
  The inspection of structure gauge must be carried out at least once per year in all sections of the main tracks and side tracks to ensure that there are no facilities that exceed the structure gauge.
- Inspection of tracks
  + Measurement of a distance of both tracks
    The measurement of a distance of both tracks must be carried out at least once per year at predetermined measurement points for both the main tracks and side tracks to ensure that the required track spacing is as specified.
  + Gauge measurement
    Gauge measurement must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the gauge has neither increased nor decreased over a specified limit.
  + Measurement of cross level
    Measurement of cross level must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the cross level has neither increased nor decreased over a specified limit.
  + Measurement of alignment
    Measurement of alignment must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the alignment has neither increased nor decreased over a specified limit.
  + Measurement of longitudinal level
    Measurement of longitudinal level must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the longitudinal level has neither increased nor decreased over a specified limit.
  + Measurement of twist
Measurement of twist must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that twist has neither increased nor decreased over a specified limit.

+ **Inspection of rail**
  - Inspection of rail must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to check top surfaces of rails for damage, including wearing depth, flaking and shelling, and to check welded joints of rails for irregularities.

+ **Inspection of turnouts and crossings**
  - **Inspection of parts**
    - The Inspection of turnouts and crossings parts must be carried out at least twice per year for all turnouts and crossings of the main tracks and at least once per year for all turnouts and crossings of the side tracks to check tongue rails for engagement, to check top surfaces of rails for damage, including wear, flaking and shelling, and to check welded joints of rails for irregularities.
  - **Measurement of spacing between parts**
    - Measurement of spacing between turnout and crossing parts must be carried out at least twice per year for all turnouts and crossings in the main tracks and at least once per year for all turnouts and crossings in the side tracks to ensure that neither the guard face gauge nor check gauge has increased or decreased over a specified limit.

+ **Guardrail inspection**
  - **Inspection of guardrail conditions**
    - Inspection of guardrail conditions must be carried out at least once per year in all sections of the main tracks and side tracks to verify the spacing between guardrails and rails and fastening of attachments.

+ **Joint inspection**
  - **Joint gap inspection**
    - Joint gap inspection must be carried out at least twice per year for all joints of main tracks and at least once per year for all joints of side tracks to ensure that no joint gap has either increased or decreased over a specified limit.
  - **Inspection of joint conditions**
    - Inspection of joint conditions must be carried out at least twice per year for all joints of the main tracks and at least once per year for all joints of the side tracks to check for joint depressions, rail misalignment at joints, and unevenness in height at joints.
  - **Joint parts inspection**
    - Joint parts inspection must be carried out at least once per year for all joints of the main tracks and side tracks to ensure that joint bars and joint bar bolts have not been damaged.

+ **Expansion joint inspection**
  - **Inspection of expansion joint conditions**
    - Inspection of expansion joint conditions must be carried out at least twice per year for all joints of the main tracks and side tracks to ensure that none of the gauge, cross level, longitudinal level and alignment has increased or decreased over specified limit, and to verify the condition of stroke and contact.
  - **Expansion joint parts inspection**
    - Expansion joint parts inspection must be carried out at least twice per year for all joints of the main tracks and side tracks to check top surfaces of rails for damage, including wear, flaking and shelling, and to check welded joints of rails for irregularities.

+ **Inspection of sleeper**
  - **Inspection of sleeper conditions**
    - Inspection of sleeper conditions must be carried out at least once per year in all sections of the main tracks and side tracks to verify the spacing between sleepers and laying of accessories.
  - **Sleeper parts inspection**
    - Sleeper parts inspection must be carried out at least once per year in all sections of the main tracks and side tracks to ensure that there are no cracks or any other type of damage that may negatively affect sleepers.

+ **Inspection of fastening system**
  - **Inspection of rail fastening system conditions**
    - Inspection of rail fastening system conditions must be carried out at least once per year in all sections of the main tracks and side tracks to check the rail fastening system for looseness, loss, and any protruding track pads.
  - **Rail fastening system parts inspection**
Rail fastening system parts inspection must be carried out at least once per year in all sections of the main tracks and side tracks to check for breakage, corrosion and any other damage.

+ Measurement of carbody vibration
  Measurement of carbody vibration must be carried out at least four times per year in all sections of the main tracks to ensure that the lateral and vertical acceleration has not exceeded a specified limit.

+ Inspection of track bed
  • Inspection of ballast conditions
    Inspection of ballast conditions must be carried out at least once per year in all sections of the main tracks and side tracks to verify the maintenance of cross section with ballast layer in ballast sections.
  • Ballast parts inspection
    Ballast parts inspection must be carried out at least once per year in all sections of the main tracks and side tracks to ensure that ballasts are not abraded over a specified limit and to ensure that there are no dangerous cracks or any other type of damage in the sections of concrete beds.

+ Inspection of car stop
  • Inspection of parts
    Inspection of parts must be carried out at least once per year for all car stops of the main tracks and side tracks to ensure that there are no cracks or any other type of damage that may negatively affect car stops.
  • Functional inspections
    Functional inspections must be carried out at least once every seven years for all hydraulic car stops of the main tracks and side tracks to ensure that hydraulic car stops function normally.

Note:
Extra inspections must be carried out when it is necessary to urgently verify the conditions of tracks in the event of a disaster, such as a fire, earthquake, and flood or an abnormal accident, and when it is necessary to inspect the tracks in greater detail through regular inspections.

6.1.3 Inspection Results
- Inspection results shall be documented.
- The inspection document shall be created on the record forms in the Appendix in the Track Maintenance Manual.
- Inspection results shall be used to develop a track maintenance plan and shall be correctly stored in a document that identifies the conditions of facilities.

6.1.4 Tolerances
Tolerances are defined in detail in the track maintenance manual.

6.2 Regulations on Development of Track Maintenance Plans
The person in charge of planning shall formulate a maintenance plan based on inspection results and shall send it to the person in charge of repairs. The person in charge of repairs shall verify its feasibility. If not feasible, the person in charge of planning shall revise it appropriately.

The person in charge of planning shall be responsible for formulating annual and monthly maintenance plans. Unit Chief in charge of repairs shall be responsible for formulating day's maintenance plan.

6.2.1 Classification of Track Maintenance Plans
The track maintenance plans include a long-term plan (30-year plan), a medium-term plan (5-year plan) and a plan for the next year (annual plan).

30-year plan
A 30-year plan shall be formulated to spread enormous upgrade costs across the entire business without threatening safety urban railway operations. In the process of formulation, we can gain an understanding of the trends in the repair and upgrade costs within the entire business. We must also prepare a long-running employment policy based on the long-term plan.

Every item of urban railway equipment must eventually be replaced. If, however, replacement of a large number of items of equipment is required at the same time, we must prepare an enormous amount of funds. Therefore, in addition to the size of annual repair costs, we must coordinate and clearly describe the size of
investment costs for equipment upgrades in the long-term plan based on the durable years of each item of equipment being set during the design phase, and the current state of the equipment checked in the daily inspection.

5-year plan

The goal of the 5-year plan is to grasp the actual costs needed by specifically sorting out repairs and investment. "Specifically sorting out" means that repairs and renewals are to be sorted out based on the 30-year plan, inspection-based judgment, and assumed actual work.

As mentioned above, comprehensive discussions and adjustments must be made between the department in charge of the budget and the department that requests the budget in order to create a feasible business plan.

The 5-year plan provides information on what businesses are specifically scheduled during the said period, as well as the required order of preference. Therefore, the 5-year plan becomes a guide for obtaining a clear view of the management situation, not only for the departments requesting budgets but also for all employees, including those in management. In the 5-year plan, the portion that covers the coming year becomes the plan for the next year.

The 30-year plan and 5-year plan should desirably be revised annually. In particular, the 5-year plan must be revised annually.

Although the maintenance plan is a reference that indicates maintenance work to be carried out during the relevant fiscal year, it is not possible to bring maintenance work into effect according to this plan alone. In order to implement the work without delay, we must divide the business into detailed maintenance work schedules, and decide specifically who does what and when. Every maintenance staff member must share the information regarding this situation. Therefore, it is necessary to further divide scheduled maintenance work in an annual plan into monthly and daily plans.

Changes in actual maintenance work normally occur because we sometimes need to urgently address the sites that are affected by climate and natural conditions. Changes in the maintenance plan also occur when the scheduled work is not finished on time due to utilization of inexperienced workers. As seen in the above, the work plan is normally repeatedly revised due to various factors.

When implementing maintenance, we need the daily plan that allocates the day's work to each shift based on the monthly plan. The daily plan tells the maintenance staff what they are supposed to do in the day's shift. It also ensures a complete hand-off between the shifts in order to prevent any oversight.

Every maintenance task carried out during each shift during the day is recorded in the daily plan. These records are very important information for formulating future plans. Namely we can formulate feasible plans only by analyzing and grasping these records. These records also provide effective information for developing a human resource cultivation plan and an employment plan. Thus, we must accumulate this information and analyze them on a daily basis.

6.2.2 Annual Maintenance Plan

6.2.2.1 Basis for Developing Annual Maintenance Plan

- 5-year plan
- Results of annual maintenance plan implemented in the previous year
- The equipment and machinery data necessary for maintenance and change-related rules that have been accumulated in the past maintenance.
- Results of track inspections
- Regulations on track maintenance work and related regulations
- Resources (personnel, machinery and equipment) held by the company

6.2.2.2 Requirements for Developing Annual Maintenance Plan

- It is necessary to consider developing an annual maintenance plan in consideration of workload to be carried out and supply of budget, personnel and materials held by the company.
- Should a new maintenance task arise from the results of track inspections, the annual maintenance plan should be appropriately modified.
- When developing an annual maintenance plan, it is necessary to equalize monthly maintenance tasks.

6.2.3 Monthly Maintenance Plan

6.2.3.1 Basis for Developing Monthly Maintenance Plan
– Annual maintenance plan approved by the company
– Results of track inspections
– Results of monthly maintenance plan implemented in the previous month
– Regulations on track maintenance work and related regulations
– Resources (personnel, machinery and equipment) held by the company

6.2.3.2 Requirements for Developing Monthly Maintenance Plan
– It is necessary to consider developing a monthly maintenance plan in consideration of workload to be carried out and supply of personnel and materials held by the company.
– Should a new maintenance task arise from the results of track inspections, the monthly maintenance plan should be appropriately modified.

6.2.4 Daily Maintenance Plan
Daily maintenance plan forms the basis to complete a monthly maintenance plan. Therefore, it is necessary to specifically organize a daily task, to define work items, and to establish the goal of their work.

6.2.4.1 Basis for Developing Daily Maintenance Plan
– Monthly maintenance plan
– Results of track inspections
– Results of the plan for the preceding shift (in the 3-shift per 1-day system. Each shift engages in the development of a daily maintenance plan.)
– Resources (personnel, machinery and equipment) held by the company
– Weather

6.2.4.2 Requirements for the development of the day's maintenance plan
– Tasks in day's maintenance plan comply with those tasks in monthly maintenance plan.
– Should a new maintenance task arise from the results of track inspections, the day's maintenance plan should be appropriately modified.

6.3 Regulations on Implementation of Track Maintenance
6.3.1 Basic Track Maintenance Tasks
– Rail renewal
– Rail grinding
– Lubrication to top surfaces of curved rails
– Fastening system renewal
– Sleeper renewal
– Tamping after adjustments of four parameters (gauge, cross level, alignment, and longitudinal level)

The details on these track maintenance tasks are defined in the track maintenance manual.

6.3.2 Requirements for Track Maintenance
6.3.2.1 Requirements for Preliminary Step to Implement Track Maintenance
– Daily maintenance plan
– Personnel and machines for performing repair work defined in a daily maintenance plan
– Personnel who perform any maintenance or repair work must fully understand the requirements for safety and quality of repair work.
– Personnel who uses machines is responsible for keeping them in good condition.
– Dispatching materials are to be registered with a material manager by filling out a ledger.
– Implement the appropriate registration process for confirmation according to the regulations. For repair, contact relevant authorities and ask them for their cooperation.
– For repair work, security personnel must be positioned as appropriate to perform the work safely.

6.3.2.2 Requirements for Implementation Phase of Track Maintenance
– Perform repair work according to the guidance received from the unit chief and according to the regulations.
– For repair work, security personnel must be positioned as appropriate to perform the work safely.
- Personnel who perform repair work ensure quality and workplace safety by observing applicable laws and regulations and by following prescribed steps.

6.3.2.3 Requirements for Completion Phase of Track Maintenance
- After track maintenance is completed, the track must be inspected to make sure that safe and stable urban railway operations are able to be carried out on and after the following day.
- According to the regulations, put the sign markers for ensuring safety back into place.
- Adjust machines and put materials in order before returning them to the warehouse. Arrange them neatly in position.
- Based on the amount of work completed, count the materials used and workers and record the completion status of day's maintenance plan.
- Make an analysis of and calculate the day's safety, condition of quality and work efficiency, and then enter comments.
- Based on the results of an investigation into practices, develop a maintenance plan for the following day.

7. Regulations on Document Retention Period (to be added later)

8. Forms and Appendices
**Common Inspection Record Form**

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>A line/ B line</th>
<th>Kilometrage (Km)</th>
<th>Left rail/ Right rail</th>
<th>Inner rail/ Outer rail</th>
<th>Inspection result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contents of inspection</td>
</tr>
</tbody>
</table>

**Four-item Measurement Record Form (parameters are to be measured every 5 meters)**

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>A line/ B line</th>
<th>Kilometrage (Km)</th>
<th>Left rail/ Right rail</th>
<th>Gauge</th>
<th>Cross level</th>
<th>Alignment</th>
<th>Longitudinal level</th>
<th>Twist</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TK</td>
<td>TT</td>
<td>CL</td>
<td>TK</td>
<td>TT</td>
<td>CL</td>
</tr>
</tbody>
</table>

TK: Design value; TT: Measured value; CL: Magnitude of irregularity

**Document Containing Characteristics of Railway Line**

<table>
<thead>
<tr>
<th>Order</th>
<th>Design element of railway line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kilometrage</td>
</tr>
<tr>
<td>2</td>
<td>2D plan</td>
</tr>
<tr>
<td>3</td>
<td>Longitudinal gradient</td>
</tr>
<tr>
<td>4</td>
<td>Type of roadbed</td>
</tr>
<tr>
<td>5</td>
<td>Locations of joints and fastening system</td>
</tr>
</tbody>
</table>
### Rail Head Wear Inspection Record Form

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>Date of manufacture</th>
<th>Kilometrage</th>
<th>Straight line/Curved line</th>
<th>Track Type</th>
<th>Date of laying of rails</th>
<th>Monitored wearing depth of top surface of rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>1st year</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Depth of wear</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Passed tonnage</td>
</tr>
</tbody>
</table>

### Rail Damage Record Forms

<table>
<thead>
<tr>
<th>Date failure occurred</th>
<th>Between stations</th>
<th>A line/B line</th>
<th>Kilometrage</th>
<th>Curve radius</th>
<th>Inner/outer rails</th>
<th>Type of crack</th>
<th>Date rail was laid</th>
<th>Passed tonnage</th>
<th>Type of rail</th>
<th>Manufacturer</th>
<th>Date of manufacture</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ballast track bed</th>
<th>Type of fastening system</th>
<th>Type of joint</th>
<th>Joint clearance between rails (mm)</th>
<th>Longitudinal level at joint (mm)</th>
<th>Rail wear depth</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Top surface… mm</td>
<td>Running surface… mm</td>
<td></td>
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</tr>
</tbody>
</table>

Description of processing method: ..........................................................
Replacement timing
### Rail Surface Damage Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Monitored defects on rail surfaces (history)</th>
<th>Description concerning progress of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Addition of vertical projection view of rail</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of vertical projection view of rail</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of vertical projection view of rail</td>
<td></td>
</tr>
</tbody>
</table>

### Damage Described on Rail Bottom Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Monitoring of state of damages to rail surface (History)</th>
<th>Description concerning progress of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Addition of the end view of the rail bottom</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of the end view of the rail bottom</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of the end view of the rail bottom</td>
<td></td>
</tr>
</tbody>
</table>

### Turnout and Crossing Wear Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Date of laying of rails</th>
<th>Tongue rail</th>
<th>Crossing</th>
<th>Guard rail</th>
<th>Lead rail</th>
<th>Stock rail</th>
<th>Running rail</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
**Turnout and Crossing Damage Record Form** (for a mechanical installation other than for turnouts and crossings, results are to be recorded on the Rail Inspection Form)

<table>
<thead>
<tr>
<th>Date failure occurred</th>
<th>Site of occurrence</th>
<th>Turnout and crossing number</th>
<th>Type of turnout and crossing</th>
<th>Type of track bed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of laying of rails</th>
<th>Passed tonnage</th>
<th>Manufacturer</th>
<th>Date of manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of finder</th>
<th>Commendation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Repair procedure</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Repair timing</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Changes in the failed portion over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st time</td>
<td>No description</td>
</tr>
<tr>
<td>2nd time</td>
<td>First description</td>
</tr>
<tr>
<td>3rd time</td>
<td>Description of each of the previous times.</td>
</tr>
<tr>
<td>4th time</td>
<td>Description of each of the previous times.</td>
</tr>
<tr>
<td>5th time</td>
<td>Description of each of the previous times.</td>
</tr>
<tr>
<td>6th time</td>
<td>Description of each of the previous times.</td>
</tr>
</tbody>
</table>

**Four-item Measurement at Turnout and Crossing Record Form**

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Gauge</th>
<th>Cross level</th>
<th>Alignment</th>
<th>Longitudinal level</th>
<th>Check gauge</th>
<th>Difference between tongue rail and stock rail</th>
<th>Clearance between tongue rail and stock rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>2’</td>
<td>5’</td>
<td>6’</td>
</tr>
<tr>
<td>Design value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference between measured and design values</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Difference between before and after repair</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Design value</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>On-site measurement</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Difference between measured and design values</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Difference between before and after repair</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### Tongue Rail Heel and Crossing Toe Joint Clearance Measurement Recording Form

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>Kilometrage (km)</th>
<th>Measurement of tongue rail heel</th>
<th>Measurement of crossing toe</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Design value</td>
<td>Left side</td>
<td>Right side</td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>

### Rail Joint Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Between stations</th>
<th>A line/ B line</th>
<th>Kilometrage</th>
<th>Type of rail</th>
<th>Type of track bed</th>
<th>Longitudinal level of joints (Yes/No)</th>
<th>Defect on rail surface (Yes/No)</th>
<th>Deviation of longitudinal level at the top surface of rail</th>
<th>Rail misalignment at joint</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

### Rail Joint Parts Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Between stations</th>
<th>A line/ B line</th>
<th>Kilometrage</th>
<th>Inner rail/ Outer rail</th>
<th>Type of track bed</th>
<th>Contents of inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>Type of joint bar and bolt</td>
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</tbody>
</table>

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14
### Damage on Joint Bar Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Between stations</th>
<th>A line/ B line</th>
<th>Kilometrage</th>
<th>Straight line/Curved line</th>
<th>Left/Right</th>
<th>Inner/Outer</th>
<th>Type of track bed</th>
<th>Type of crack</th>
<th>Outline drawing</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

*Image of joint bar added*

*Image of joint bar added*

### Expansion Joint Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Gauge</th>
<th>Cross level</th>
<th>Alignment</th>
<th>Longitudinal level</th>
<th>Travel distance</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
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<td>2</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Tongue rail</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stock rail</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Tongue rail</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Stock rail</td>
<td></td>
</tr>
</tbody>
</table>

*Left rail*

*Right rail*

*Remark*
Civil Structure Maintenance Manual

Chapter 1: Legal Foundation and Reference Materials

1.1 Legal Foundation

1.2 Reference Materials

Chapter 2: Types of Maintenance

2.1 List of Structures That Require Maintenance

2.2 Types of Maintenance

2.3 Inspection Method

Chapter 3: Maintenance Facilities

Chapter 4: Requirements for Maintenance Staff

Chapter 5: Inspection and Judgment

5.1 Inspection

5.2 Treatment of Failure and Accident

Chapter 6: Plan Development

6.1 Business Plan

6.2 Human Resource Cultivation Plan

6.3 Plan Development Procedure

Chapter 7: Implementing Organization

7.1 Maintenance Staff

7.2 Repair Method

7.3 Implementation Procedure for Repair Works

Chapter 8: Acceptance Inspection, Quality Evaluation and Monitoring
Chapter 1: Legal Foundation and Reference Materials

1.1 Legal Foundation

- National Law on Civil Engineering Work No. 50/2014/QH13 dated 2014/6/18
- Decree No. 114/2010/ND-CP on Maintenance of Civil Structure dated 2010/12/06
- Traffic and Transportation Ministry Circular No. 20/2013/TB-BGTVT on Management and Maintenance of Railway Structures dated 2015/08/16
- Decree No. 46/2015/ND-CP on Quality Control of Civil Structure dated 2015/05/12
- Decree No. 32/2015/ND-CP on Management of Construction Investment Costs dated 2015/03/25
- Labor Law by Diet No. 10/2012/QH13 dated 2012/06/18

1.2 Reference Materials

- Documents and materials from 2A Line work
- Basic Standard No. TCCS 01: 2010/VNRA on Maintenance Procure of Railway Bridges and Tunnels
- Our experience gained from maintaining civil structures at Tokyo Metro
Chapter 2: Types of Maintenance

Urban railways must continue to function efficiently without unexpected delays or problems. However, equipment inevitably deteriorates due to repeated use. Therefore, urban railway maintenance staff must check equipment on a daily basis and repair any deteriorated sections that are found on a timely basis so that urban railway operation will not be affected.

We must abandon the idea of repairing an object after it breaks. If we find a deteriorated section, we must repair it before it causes an entire structure to collapse, thereby forcing us to stop operations.

2.1 List of Structures That Require Maintenance

Check and confirm deterioration of the structure and equipment by comparing them against the design documents.

a. Parts of buildings

<table>
<thead>
<tr>
<th>Order</th>
<th>Structure and equipment</th>
<th>Inspection frequency/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall surfaces</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Ceiling</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Window</td>
<td>1 - 2</td>
</tr>
<tr>
<td>4</td>
<td>Roof</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Drainpipe</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Soil tank</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Water-purifier tank</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Pressure tank</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Booster feed tank</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Water receiving tank</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Elevated reservoir</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>Hot water supply system</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>Gas powered hot water heater</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>Automatic door</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>Shutter</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>Direction board</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>Drainpipe</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>Garden tree</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>Disaster control equipment</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Automatic fire alarm</td>
<td>1</td>
</tr>
</tbody>
</table>
b. List of fire extinguishing equipment (Inspection according to Vietnam's fire protection regulations)

<table>
<thead>
<tr>
<th>Automatic fire alarm</th>
<th>Fire extinguishing equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Automatic fire alarm</td>
<td>- Fire hydrant, water intake and nozzle</td>
</tr>
<tr>
<td>- Heat detector</td>
<td>- Water tube system to supply water to extinguish fires</td>
</tr>
<tr>
<td>- Smoke detector</td>
<td>- Fire pump (Diesel powered)</td>
</tr>
<tr>
<td>- Sprinkler</td>
<td>- Hydrant valve</td>
</tr>
<tr>
<td>- Fire alarm</td>
<td>- Fire hose (water is put in)</td>
</tr>
</tbody>
</table>

| - Emergency lamp, fire lamp, accident alarm lamp and indicators for fire-fighting equipment |

c. Portion of civil structure

<table>
<thead>
<tr>
<th>Viaducts</th>
<th>- Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Beam and related parts</td>
</tr>
<tr>
<td></td>
<td>- Beam joint and telescopic joint</td>
</tr>
<tr>
<td></td>
<td>- Bridge face and related parts</td>
</tr>
<tr>
<td></td>
<td>- Bearing</td>
</tr>
<tr>
<td></td>
<td>- Abutment, landing pier, hand rail, soundproof wall, etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tunnel</th>
<th>- Tunnel lining</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Telescopic joint and coupling</td>
</tr>
<tr>
<td></td>
<td>- Dewatering in and out of tunnel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil road bed</th>
<th>- Soil road surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Welded part of bridge and road</td>
</tr>
</tbody>
</table>

2.2 Types of Maintenance

Maintenance of urban railway equipment is divided into repairs and upgrading.

+ Repairs (Implementation on a daily basis)

Repairs denotes restoration of deteriorated portions based on inspection results. Although
repair costs are increasing each year, annual repair costs should be equalized.

+ **Upgrade**

Upgrading denotes replacing an existing item of equipment with a new one, or adding a new item of equipment to an existing one when it is not possible to completely recover its functionality by repeated repairs alone.

<table>
<thead>
<tr>
<th>Large category</th>
<th>Middle category</th>
<th>Small category</th>
<th>Repair</th>
<th>Upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>Platform</td>
<td>Roof</td>
<td>- Repair of a hole in a roof</td>
<td>- Replacement of an entire roof</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Repair of a corroded pillar supporting a roof</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Platform surface</td>
<td></td>
<td>- Repair of a broken tile on the surface</td>
<td>- Replacement of all tiles on the surface</td>
</tr>
<tr>
<td></td>
<td>Staircase</td>
<td>Surface of footsteps</td>
<td>- Repair of a broken surface of a footstep</td>
<td>- Replacement of entire surface of a footstep</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handrail of staircase</td>
<td>- Repair of a broken handrail</td>
<td>- Replacement of every handrail of a footstep</td>
</tr>
<tr>
<td></td>
<td>Station compartments</td>
<td>Door</td>
<td>- Repair of a broken door</td>
<td>- Replacement of every door</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Window</td>
<td>- Repair of broken window glass</td>
<td>- Replacement of broken window glass</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Repair of a broken sash</td>
<td>- Replacement of a broken sash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wall</td>
<td>- Repair of a cracked wall</td>
<td>- Refurnish and replace an entire wall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ceiling (plaster)</td>
<td>- Repair of a damaged, cracked or peeler plaster jacket</td>
<td>- Replacement of ceiling system of plaster jacket</td>
</tr>
<tr>
<td>Living space</td>
<td>Roof</td>
<td>- Repair of a hole in a roof</td>
<td>- Replacement of an entire roof</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Repair of a corroded pillar supporting a roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surface of footsteps</td>
<td>- Repair of a broken surface of a footstep</td>
<td>- Replacement of entire surface of a footstep</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Handrail of staircase</td>
<td>- Repairs required</td>
<td>- Replacement of every handrail of a footstep</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Door</td>
<td>- Repairs required</td>
<td>- Replacement of every window</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Window</td>
<td>- Repair of broken window glass</td>
<td>- Replacement of broken window glass</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Repair of a broken sash</td>
<td>- Replacement of a broken sash</td>
<td></td>
</tr>
</tbody>
</table>
2.3 Inspection Method

a. Inspection of concrete (Frequently observed failures)

- When inspecting concrete-related cracks, you must accurately check how many cracked portions there are on the viaducts, where they develop, and what causes the cracks to occur. Follow up and record the inspection results, and then develop a maintenance plan with appropriate cycles and methodology.

- Crack size measuring method: Use a measuring scale for the inspection.

+ It is very important to identify the size of cracks, where they are, and conditions of reinforcing bars.

- Cracks are categorized into two types.

+ Dangerous cracks (They develop on bridge pier and beams)

  This refers to cracks larger than X-cross type or nearby cracks, or rusty cracks. Dangerous

<table>
<thead>
<tr>
<th>Water supply and water discharge systems</th>
<th>Wall</th>
<th>- Repair of a cracked wall</th>
<th>- Refurnish and replace an entire wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Water supplying pipe</td>
<td></td>
<td>- Repairs of water leakages</td>
<td>- Replacement of a water supplying pipe system</td>
</tr>
<tr>
<td>- Water supplying pipe for fire-fighting</td>
<td></td>
<td>- Repairs required</td>
<td>- Replacement of a water supplying pipe system for fire-fighting</td>
</tr>
<tr>
<td>- Water discharge pipe</td>
<td></td>
<td>- Repairs of water leakages</td>
<td>- Replacement of a water discharge pipe system</td>
</tr>
<tr>
<td>- Water feed tank</td>
<td></td>
<td>- Cleaning of a water feed tank to improve its level of hygiene</td>
<td>- New construction of a water feed tank, water tank for fire-fighting, or a drain tank</td>
</tr>
<tr>
<td>- Water feed tank for fire-fighting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Drain tank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Soil water valve</td>
<td></td>
<td>- Repairs of water leakages</td>
<td>- Replacement of an entire valve system</td>
</tr>
<tr>
<td>- Pump for clear water, and pump for fire-fighting</td>
<td>- Repairs required</td>
<td>- Replacement of a pump</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Viaducts</th>
<th>Pier</th>
<th>- Repair of large cracks</th>
<th>- Improvement to suppress cracks and rust on reinforcing bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam</td>
<td></td>
<td>- Repair of large cracks</td>
<td>- Improvement to suppress cracks and rust on reinforcing bars</td>
</tr>
</tbody>
</table>
cracks can be further divided into two additional types.
   a. Cracks that require immediate repair
   b. Cracks whose repair may be done within two- or three-year time frame
You must propose repairs for identified cracks on a timely basis.

Cracks that do not pose a problem when identified
Cracks that are generated as part of the concrete hardening process are not dangerous. These cracks are not a problem at this point. These cracks, however, can become a problem in 10 or 20 years namely over a long-term time frame.

(Cause)
A possible cause may be that the load was heavier than anticipated (Example: A train was longer or heavier than that assumed in the initial design). However, such cases are rare. Alkaline properties of concrete are lost over time.

Since concrete in the initial stage has sufficient alkaline properties, immersion in water does not rust reinforcing bars. However, when concrete loses its alkaline properties, water rusts the reinforcing bars. Rust on reinforcing bars will cause them to expand, which can cause cracks to develop in concrete. At this point, cracks develop not only inside the concrete but also on the concrete surface.
Specifically, the diameter of reinforcing bars shrinks and, as a result, the performance of the structure they are in will be reduced in the following process of falling surface of concrete -> Exposure of reinforcing bars -> Rusting of reinforcing bars due to water.

b. Building and Equipment Inspection
Check and confirm deterioration of the structure and equipment by comparing them against the design documents.

2.4 Defect Judgment Criteria

<table>
<thead>
<tr>
<th>Class</th>
<th>Structure soundness judgment criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Existence of an abnormality that threatens the following.</td>
</tr>
<tr>
<td></td>
<td>- Operational security</td>
</tr>
<tr>
<td></td>
<td>- Normal train operations</td>
</tr>
<tr>
<td></td>
<td>- Public safety</td>
</tr>
<tr>
<td></td>
<td>Or an abnormality that potentially threatens to compromise the above.</td>
</tr>
<tr>
<td>AA</td>
<td>Existence of an abnormality that threatens the following.</td>
</tr>
<tr>
<td></td>
<td>- Operational security</td>
</tr>
<tr>
<td></td>
<td>- Normal train operations</td>
</tr>
</tbody>
</table>
### Chapter 3 Maintenance Facilities

- **Public safety**
  - An abnormality that requires emergency measures
  
  **Repair period:** Train must be stopped immediately.

| A1          | - An ongoing abnormality is deteriorating the performance of a structure.  
|             | - Structural performance can be completely lost due to heavy rains or flooding.  
|             | **Repair period:** Must be repaired immediately during the night of the day it occurred. |

| A2          | - An existing abnormality threatens to deteriorate performance of a structure in the future.  
|             | **Repair period:** Within a year from the day of inspection |

| B           | - Existence of an abnormality that threatens to grow to soundness A in the future. |

| C           | - A portion of a structure that has a slight abnormality. |

| S           | - Sound portion of a structure |

- **Inspection tools**
  + Flashlight
  + Binoculars
  + Inspection hammers, etc.

- **High-elevation work**
  + Ladder
  + Vehicle for high-elevation work

- **Materials in storage**
  + You must repair urban railway equipment at the appropriate timing. "Appropriate timing" as used herein may be the moment you detect the deteriorated portion or after the last train of the day. Or it can be a month or six months later. The basic premise in selecting an "appropriate timing" for repair is that it does not stop our business operations. In addition, compatibility with Workload Planning is also an important factor in deciding the timing. You should not choose a timing when the materials necessary for repair are out of stock or unavailable.

  + Therefore, you must keep a certain volume of materials necessary for repairs in storage. The railway business operator himself must decide at their own risk the materials and respective quantities to be stored. Over time from the launch of business operations, deteriorating portions change on a constant basis. Despite ongoing daily inspections and repair, the number of deteriorated portions will inevitably increase over time. Therefore, you must reexamine the materials and respective quantities to be stored once a year.
A monthly stock-take is also necessary. You should determine the quantities of the stored materials referencing the following three types as a guideline.

a. Minimum storage quantities to be maintained  
b. Storage quantities to be maintained at the start of the procurement procedure  
c. Maximum storage quantities to be maintained

Chapter 4: Requirements for Maintenance Staff

- Staff who maintain civil structures must be appropriately educated and possess the necessary knowledge and skills to work on civil structures.
- When concluding an inspection or repair agreement with a subcontractor, maintenance staff shall confirm whether the subcontractor has the necessary capabilities to carry out the said inspections or repairs.
- Capability Requirements for Maintenance Staff (To be updated when upon reception of 2A Line education materials).

Chapter 5: Inspection and Judgment

5.1 Inspection (Inspection unit: 3 people/shift)

a. Appearance inspection of viaducts and tunnels: 3 times/month
- Inspection tools
  + Flashlight
  + Inspection hammers
  + Air whistle
  + Binoculars (As needed)
- Inspection staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 2 people

(Inspection Method)

1) The walking direction of every staff member must be opposite to the direction the train is traveling in.
   (Staff members must walk in the direction opposite to the direction the train is traveling in. The range that can be checked by the staff in one observation is half way through an viaducts or
2) Every staff member must walk at normal walking speed.
3) During the inspection, [Unit chief] and [Staff] must detect defective portions that adversely affect train movement.
4) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
5) If suspicions remain about a location that has already been inspected, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work. Alternatively, they must observe conditions of the suspected portion while the train is traveling.
6) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop the train immediately.
7) Since the inspection will take place during the normal train operation time period, one inspection [Staff member] must carefully be on the lookout for approaching trains. This staff member must walk 20 to 40 m ahead of [Unit chief] and other [Staff] because he is responsible for identifying any approaching trains.
8) If a train is approaching, this staff member must notify [Unit chief] and [Staff] of it using an air whistle. When the air whistle is heard, [Unit chief] and [Staff] must stop the inspection temporarily.
9) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

b. Appearance inspection of viaducts and tunnels: Once/2 years
   - Inspection tools
     + Flashlight
     + Binoculars
     + Inspection hammers
     + Ladder
     + Tools for high-elevation work (as needed)
   - Staff assignment
     + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
     + People in charge of inspection [Staff]: 2 people

   (Inspection Method)
   1) Every staff member must walk at a leisurely pace.
   2) [Unit chief] and [Staff] must detect defective portions (cracks, water leakages, exposed reinforcing plates, etc.) that adversely affects train movement.
3) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
4) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
5) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop the train immediately.
6) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

c. Appearance inspection of tunnels: Once/10 years
- Inspection tools
  + Flashlight
  + Binoculars
  + Inspection hammers
  + Tools for high-elevation work
- Staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 1 person
  + Inspection car [Driver]: 1 person

(Inspection Method)
1) [Unit chief] and [Staff] must detect defective portions (cracks, water leakages, exposed reinforcing plates, etc.) near to a structure that adversely affects train movement.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop the train immediately.
4) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)
5. When [Unit chief] and [Staff] started the work, [Driver] of the inspection car must stop the tool being used for high-elevation work.

d. Buildings appearance inspection: Once/year
- Inspection tools
  + Flashlight
  + Binoculars
Appendix 8-6-7-3-A(CTC)

- Inspection hammers
- Ladder
- Tools for high-elevation work (as needed)

Staff assignment

- Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
- People in charge of inspection [Staff]: 2 people

(Inspection Method)

1) [Unit chief] and [Staff] must detect defective portions (cracks, water leakage, stains, etc.) that adversely affect the soundness of buildings.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
4) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the building.
5) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

e. Inspection of building's equipment function: 1 to 3 times/year

- Inspection tools
  - Inspection tools appropriate for the target equipment must be used.

- Staff assignment
  - Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  - People in charge of inspection [Staff]: 2

(Inspection Method)

1) [Unit chief] and [Staff] shall inspect whether each item of equipment meets the specified function criteria.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the equipment.
4) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)
f. Inspection of building's equipment materials:  1 to 3 times/year

**Inspection of outside of building and station** (Walls, windows, roofs, water pipes, lightning protection system, etc.)
- Inspection tools
  + Binoculars
  + Inspection tools appropriate for the target equipment must be used.
  + Ladder and tools for high-elevation work (as needed)

(Inspection Method)
1) [Unit chief] and [Staff] must detect defective portions (cracks, water leakages, etc.) that adversely affect use of the building.
   - Door: Check it for cracks and breakages. Staff members must make sure there are no problems opening and closing the door.
   - Water pipe system: Staff members must check whether the system operates normally when a faucet is opened. They must also check the system for water leaks and flooding of the lower levels.
   - Staff members must make sure that disaster-prevention signs and regulation indication boards are set in the specified positions.
   - The staff member makes sure that evacuees can get to the basement via the emergency stairs.
   - The staff member checks that the fire-fighting system equipment operate as specified.
   - Electric pump, diesel pump, water supply system for firefighting, automatic fire alarm system (smoke and temperature detection tools, sprinklers, etc.)
   - The staff member checks that the exhaust and ventilation systems operate as specified.
   - Lightning protection system: Lightning rod, grounding wires, earth resistance measurement system, etc. are checked to ensure they are operating normally.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
4) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the equipment or structure. When the equipment or structure can affect safe travel of the train, [Unit chief] shall issue an instruction to stop the train immediately.
5) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)
Inspection of inside of structures and stations (Wall, ceiling, lighting system, entrance door, water supply and drainage system, fire protection sign, emergency guidance lamp, water stop door, etc.)

- Inspection tools
  - Inspection tools suited for each type of equipment must be used.
  - Ladder and tools for high-elevation work (as needed)

(Inspection Method)

1) [Unit chief] and [Staff] must detect defective portions (cracks, penetration of water, water leakages, etc.) that affect use and soundness of the building.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
4) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the equipment.
5) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

5.2 Treatment of failure and Accident

This item describes responses to be taken to accidents and failures, responsibility sharing up to recovery, and utilization of accident and failure information.

a. Responsibility sharing up to recovery

Urban railway equipment must be maintained in such a way that its high-density operation may be continued in good condition without delay. Its operation must be protected to prevent cancellations occurring due to unexpected reasons. However, the equipment inevitably deteriorates due to repeated use, and will fail if we miss carrying out timely repairs. In addition, other types of accidents may occur including a car colliding against pier of viaducts, and accidental contact between a moving train and a person that are not attributable to the train company.

Urban railway operations are forced to stop if an accident or failure occurs. In order to resume operations at an earliest possible timing, the train company must make the necessary preparations on a daily basis to recover from accidents and failures. Preparation for accidents and failures involves making clear who engages in what type of recovery work and with what level of responsibility. Generally speaking, the organizations involved in field work are responsible for recovery steps. They must designate a person responsible and workers in advance in order to make decisions necessary for the recovery including selection of the recovery work method and check of results of recovery efforts.
The above-mentioned preparation includes designating in advance a department for central control of the information, and forming of a consensus on retention of materials necessary for recovery steps in order to avoid delays in the recovery work due to mixed intelligence upon the occurrence of an accident or failure.

b. Utilization of information on accidents and failures

We must utilize the information about accidents and failures that have occurred in order to prevent recurrence of similar problems. There are two approaches to utilizing such information.

The first is to share the intelligence, which is obtained from a thorough investigation of causes, immediately among the organizations involved in field work, and start an emergency check for signs of occurrence of similar accidents or failures. In this way, we can not only prevent occurrence of similar accidents or failures but also help ensure the people in the organizations involved in field work have the same level of awareness regarding the work. This is a very effective approach when the HQ organization is aiming to standardize maintenance quality levels.

Secondly, accumulating accident and failure information provides the chance for us to recognize the necessity of reviewing daily maintenance methods, and also the chance to identify the type of information to be reflected in the design when upgrading an item of equipment. Analysis of the accumulated accident and failure information clearly visualizes the meaning of individual information that might have been overlooked in response to a single accident or failure. Such information presents us, for instance, the fact that a specific part deteriorates more frequently than others, and equipment deterioration becomes more evident depending on the number of years that have passed since its introduction. The above information is also an effective means of preventing recurrence of similar accidents and failures.

Therefore, we must utilize the accident and failure information after recovery, too, without discarding them. In general, the HQ organization gathers, store and analyze them.

(Response Procedure at Occurrence of an Accident/Failure)

If an accident/failure occurred, OU shall check the side immediately.

- OU Manager
  - Upon receiving the report, OU Manager shall visit the site to check the situation.
  - The Manager shall designate a person responsible for inspection work and a person responsible for repair work (of the day).
  - The Manager shall designate a liaison with OCC.
  - The Manager shall review the reports from the person responsible for inspection work and the person responsible for repair work to determine acceptability of the reports.
  - The Manager shall notify the liaison with OCC of the approved matters.
- Person responsible for inspection work
  + This person makes a judgment at the accident site whether continuous safe train operations can be ensured (whether immediate repairs are needed).
  + When immediate repairs are needed, he must present an appropriate repair method (a method that ensures work can be carried out safely in the shortest time in order to reduce adverse effects on passengers).

- Person responsible for repair work
  + He shall be responsible for everything necessary for repair work including materials and staff.
  + After repairs are completed, he shall check safety. He approves resumption of operations when there are no safety-related problems.
    (At first, a test run is carried out at reduced speed in order to make sure there are no problems with the repaired portion. If it is not clear whether any problems still exist, he should not permit train operations to resume.)

- Liaison with OCC
  + He shall immediately report to OCC on the situation of accident/failure (including photos), state of repairs, and security verification.
  + OU shall report to HQ on the accident/failure.
    (The report shall be made on the following day at the latest. If the report cannot be made within the above-mentioned time frame, OU shall confer with HQ regarding a due date for the report.

- The report from OU to HQ shall contain the following information.
  + Detailed accident/failure states
  + Inspection record of the accident/failure site
  + Analysis of cause of the accident/failure
  + Measures to prevent the accident/failure

- HQ
  + HQ checks whether OU's report is sufficient, and if so, approves it.
  + HQ provides the information to other lines to prevent similar accidents/failures from occurring through information sharing.
  + HQ shall conduct internal inspection.
    • HQ checks that the periodic inspection is implemented correctly and completely.
    • HQ checks that the maintenance is implemented correctly on a timely basis.
    • HQ checks that training of OU staff is fully implemented (grasp of the regulations and manuals of OU).
Preparation for response on a daily basis is important to help ensure a guaranteed response to detected accidents/failures.

Training in the case of an accident/failure is necessary (training should be carried out several times a year as a countermeasure against possible accidents/failures).

Repair materials must be prepared.

- Materials should be grouped based on specific purpose of repair, and their quantity should also be specified.
- These repair materials must be stored separately from those used for ordinary repairs.
Chapter 6: Plan Development

6.1 Business Plan

Businesses, including the railway business and other businesses, usually consist of several different fields. In such a case, each department that runs some aspect of the business requests, at the appropriate time, a budget for repairs/upgrades of equipment in its field of charge in consideration of the timing and contents of the repair/upgrade. This is called a budgetary request.

The department in charge of the budget (generally the financial department) adjusts the budget size from a company-wide standpoint after coordinating the budget request amounts requested by each department. The term adjustment as used here refers to the negotiations between the department in charge of the budget and each department regarding the assuredness of budget request details, reconfirmation of budget size, and timing of the budgetary request to be issued. The adjustment, particularly adjustment of timing, must be done between the department in charge of the budget and the department that submitted the budgetary request on the condition that safe urban railway operations can be assured based on their technical rationales.

A business plan is usually formulated for three different periods: long-term, mid-term and next year.

a. Long-term plan: 30 years

A long-term plan is formulated in such a way that enormous upgrade costs may be equalized over the entire business without threatening safe urban railway operations. In the process of formulation, we can understand the trends in the repair and upgrade costs for the entire business. We must also prepare a long-running employment policy based on the long-term plan.

Every item of urban railway equipment must eventually be replaced. If, however, replacement of a large number of items of equipment is required at the same time, we must prepare an enormous amount of funds. Therefore, in addition to the size of annual repair costs, we must coordinate and clearly describe the size of investment costs for equipment upgrades in the long-term plan based on the durable years of each item of equipment being set during the design phase, and the current state of the equipment checked in the daily inspection.

- The long-term maintenance plan (30 years) shall be developed based on the maintenance plan developed in the initial year of establishment of the business.
+ HQ: HQ functions as the investigation and planning organization of the long-term plan.
+ OU: It is the organization that implements the plan and delivers the results.
- We must verify four points before developing the long-term plan.
  2. Identifying how fast broken portions can be fixed based on past records.
3. Investigating how many staff will be required to carry out specific repairs based on past records.
4. Investigating repair costs based on past records.

b. Mid-term plan: 5 years

Its goal is to grasp the actual costs needed for investment by making aspects concerning repairs and investment more manageable. Making things clear means to organize aspects related to repairs and upgrades based on the long-term plan, inspection-based judgments, and assumed actual work. As mentioned above, comprehensive discussions and adjustments must be made between the department in charge of the budget and the department that requests the budget in order to create a feasible mid-term business plan.

The long-term plan and the mid-term plan should desirably be revised each year. The mid-term plan provides information on what businesses are specifically scheduled during the said period, as well as the required order of preference. In the mid-term plan, the portion that is related to the coming year becomes the next year plan.

- The five years maintenance plan is formulated based on the inspection plan and the business plan formulated during the business' first year of operation.
  + This plan is updated once a year.
    (Example: Five-year plan covers the period of 2013 to 2018. When it is updated in the next year, the five-year plan covers the period from 2014 to 2019.)
- The mid-term plan shall contain the following items.
  + Period (from when to when)
  + Classification of businesses
  + Budget
  + Business No., name of the person who created the plan
  + Place of work
  + Purpose of the work
  + Description of the work implemented
  + Requirements to be met (machines, human resources, electricity and water)
  + List of items for which difficulties are anticipated during the work
  + Relevant departments whose cooperation is solicited for the work

c. Annual plan

Although the annual plan describes the work to be implemented during the said year, it is not possible to actually execute the work according to this plan alone. In order to implement the work
without delay, we must divide the business into detailed maintenance work schedules, and decide specifically who does what and when. Accordingly, all maintenance staff members must share the information regarding this situation. Therefore, usually two types of Workload Planning are created. One is the annual plan that allocates the work to each month, and the other is the monthly plan that allocates staff members to each task and sets down the working days.

When implementing maintenance, we need the daily plan that allocates the daily work to each shift based on the monthly plan. The daily plan tells the maintenance staff what they are supposed to do in the day's shift. It also ensures a complete hand-off between the shifts in order to prevent any oversight.

Every maintenance task carried out during each shift during the day is recorded in the daily plan. These records are very important information for formulating future plans. These records also provide effective information for developing a human resource cultivation plan and an employment plan. Thus, we must accumulate this information and analyze them on a daily basis.

Changes in the workload plan normally occur when maintenance work is actually being carried out because we sometimes need to urgently address the sites that are affected by climate and natural conditions. Changes in the workload plan also occur when the scheduled work is not finished in time due to utilization of inexperienced workers.

6.2 Human Resource Cultivation Plan

The number of staff calculated in the above is the minimum required to carry out the business in the initial phase of operations. In order to prevent our business operations from being interrupted due to staff resignations, holidays and age-limit retirement of employees as well as time-dependent workloads, we must have an employment and cultivation plan.

We need to establish an education system that includes classroom lectures and practical training in order to help new employees clearly understand their assignments because their level of experience and knowledge were not uniform when they joined the company. Maintenance plan varies over time, so contents of the education programs must be periodically updated, too.

(Human Resource Cultivation)

a. The purpose of this is to give the employees a broad understanding of the job in their charge and power to carry it out.

Knowledge
- Every inspection and repair job
- To acquire a good understanding of what they have been instructed to do by the unit chief

Experience
- To perform every inspection and repair job
- Capable of selecting the most appropriate approach in case of emergency
Skill in issuing instructions and education
- To teach know-how and knowledge for inspections and repairs.

b. Job requirements
In order to process the inspection and repair jobs smoothly:
- Employees of OU (in charge of repairs) must have experience and knowledge regarding inspections.
- Employees of OU (in charge of inspection) must have experience and knowledge regarding repairs.

c. Cultivation type
Class for new employees
- Target
  + New employees
- Purpose
  + To acquire basic knowledge required by OU employees at the given duty position.
- Instruction method
  + Classroom lectures
- Contents
  + Understanding of the Civil Structure Maintenance Manual and relevant regulations.
  + Understanding of the theories related to maintenance methods in each specific job.
- Appraisal
  + Test of knowledge acquired the above education.
  + Assessment by unit chief

Class for employees
- Target
  + All employees (except unit chiefs)
- Purpose
  + To ensure smooth execution of assignments by OU employees.
- Instruction method
  + Direct teaching on site.
- Contents
  + Development of technical knowledge.
  + To experience maintenance work in different environments.
- Appraisal
6.3 Plan Development Procedure

Based on a review of the data provided by respective sections of OU, the sections at HQ formulate the long-term plan and the detailed plan according to the following table.

<table>
<thead>
<tr>
<th>Assignment name</th>
<th>OU</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate of defects</td>
<td>In charge of inspection (5)</td>
<td>In charge of technology (4)</td>
</tr>
<tr>
<td>Survey of number of workers and costs</td>
<td>In charge of planning (6)</td>
<td>In charge of planning (2)</td>
</tr>
<tr>
<td>Repair speed</td>
<td>In charge of planning (6)</td>
<td>In charge of planning (2)</td>
</tr>
</tbody>
</table>

**a. Update of Long-term Plan**

The section in charge of planning at HQ is responsible for updating the long-term plan based on the data provided by the section in charge of planning at OU and the section in charge of technology at HQ.

Section in charge of planning (6) [OU] -> Section in charge of planning (2) [HQ] <- Section in charge of planning (4) [HQ]

**b. Development of Annual and Monthly maintenance plans based on inspection results**

- Preparation of Annual plan and Monthly maintenance plan
  + [Section in charge of planning]: Responsible for formulating the maintenance plan.
  + ([Section in charge of planning] updates the day's plan to formulate the next monthly plan by
the end of this month.

- Formulation Daily maintenance plan
  + [Unit chief] is responsible for formulating the day's maintenance plan.
  + [Unit chief] shall formulate the day's maintenance plan in consideration of the monthly plan and the matters handed to him from the preceding shift or shift of the previous day.
  + He shall previously check the portions that require inspection or repair. As needed, he shall contact the section in charge of planning to have a common understanding on the above.

- Annual maintenance plan development method
  1) [Section in charge of planning] shall review the documents of up to the last inspection. (Judgment, repair period, etc.)
  2) If any question arises about a document, [Section in charge of planning] shall consult with [Unit chief] until a common understanding is reached. As needed, [Section in charge of planning] may request [Unit chief] to re-inspect the matter.
  3) [Section in charge of planning] may formulate the maintenance plan ahead of the repair commitments described in the inspection result.
  4) [Section in charge of planning] must decide the repair method for a defective portion.
  5) When [Section in charge of planning] is unable to decide the repair method, the section may employ a specialized consultant to carry out research and design.
  6) [Section in charge of planning] must prepare repair budgets on a defective portion basis.
  7) [Section in charge of planning] shall formulate the repair plan in accordance with the above procedures.
Chapter 7: Implementing Organization

7.1 Maintenance Staff

- Work shift: 3 shifts
  
  - 1st shift: 6:00 start - 15:00 end
  - 2nd shift: 14:00 start - 23:00 end
  - 3rd shift: 22:00 start - 7:00 end

+ Workers work 8 hours in each shift. A 1-hour break period is included in the above. (This one hour shall not be included in the duty period of 8 hours.)

+ One hour overlaps between the preceding and succeeding shifts. Hand-off of the work shall be completed within this hour.

+ The number of working hours per week is 40 to 48 hours.

<table>
<thead>
<tr>
<th>Shift</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

(Number of staff)

<table>
<thead>
<tr>
<th>Group</th>
<th>Inspection unit</th>
<th>Repair unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3 people</td>
<td>4 people</td>
</tr>
<tr>
<td>B</td>
<td>3 people</td>
<td>4 people</td>
</tr>
<tr>
<td>C</td>
<td>3 people</td>
<td>4 people</td>
</tr>
<tr>
<td>D</td>
<td>3 people</td>
<td>4 people</td>
</tr>
</tbody>
</table>

- Observation of staff during normal inspection: Visual inspection on foot. A lamp is used by the night shift.

<table>
<thead>
<tr>
<th>The person responsible for the inspection results [Unit chief]</th>
<th>1 person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>Number</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Person in charge of inspection [Staff]</td>
<td>2 people</td>
</tr>
</tbody>
</table>

An elevating service vehicle is used for inspection of a suspected portion.

- The number of staff members required when a service vehicle for high-elevation work is used

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The person responsible for the inspection results [Unit chief]</td>
<td>1 person</td>
</tr>
<tr>
<td>Person in charge of inspection [Staff]</td>
<td>1 person</td>
</tr>
<tr>
<td>Worker to drive service vehicle used for high-elevation work, operation of the elevating platform and control of lighting</td>
<td>1 person</td>
</tr>
</tbody>
</table>

- Repair staff

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The person responsible for safety [Unit chief]</td>
<td>1 person</td>
</tr>
<tr>
<td>Person in charge of repairs [Staff]</td>
<td>2 people</td>
</tr>
<tr>
<td>Worker to drive service vehicle used for high-elevation work [Staff]</td>
<td>1 person</td>
</tr>
</tbody>
</table>

- Staff to formulate the maintenance plan

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>In charge of planning</td>
<td>2 people</td>
</tr>
</tbody>
</table>

7.2 Repair Method (Defects that tend to occur)

This section introduces a typical repair method for viaducts and open-cut tunnels. There is a wide range of variations in the target of repair and, on the other hand, repair technology progresses day by day. Thus, we must study the cause of deterioration carefully before choosing an appropriate approach.

a. Viaducts
Falling surface of concrete due to corrosion of reinforcing bars inside reinforced concrete is a deterioration-related phenomenon often observed on viaducts. Falling surface side of the concrete is the portion that does not have to support the generated stress from the design standpoint. Therefore, the repair approach should be selected in consideration of the following.

- A sufficiently alkaline environment must be provided in the periphery of reinforcing bars to prevent any further corrosion.
- Repair materials must be closely adhered to the base material to prevent them from falling again.

Polymer cement mortar is an effective repair material for protecting reinforcing bars since it retains sufficient alkalinity, excels in adhesion to the base material, and also has excellent waterproof properties. Therefore, polymer cement mortar should be used to repair viaducts. When the depth to be repaired by polymer cement mortar is large, it can cure in layers during prolonged repair work. To avoid such problems, a continuous fiber sheet is sometimes inserted between the upper and lower layers. This reduces adhesion between polymer cement mortar layers.

![Figure 1: General Drawing of Repair of Elevated Concrete Bridge](image)

**b. Open-cut tunnel**

Water leakage from the back of a tunnel is a deterioration phenomenon observed in open-cut tunnels. A tunnel is not only constantly exposed to pressure from the ground but it is also subject to water pressure when built below groundwater level. Although a tunnel is designed to sufficiently resist the assumed pressure and great care is paid to its construction, some irregularities resulting from construction work are unavoidable. Then, water with high flow property flows inside the tunnel with water pressure from the locations that are vulnerable to pressure.

Since a tunnel has a reinforced concrete (RC) structure, reinforcing bars must be protected from corrosion as I have previously mentioned repeatedly. Reinforced bars corrode when exposed to water and air. Water leakage in a tunnel creates an environment that corrodes reinforcing bars. Thus, we must
eliminate this cause of deterioration. You must choose a repair method in consideration of the following.

- In order to protect reinforcing bars from being exposed to water, we need to inject water-stop materials into cracks positioned below reinforcing bars.
- A sufficiently alkaline environment must be provided in the periphery of reinforcing bars to prevent them from corroding further.

Polymer cement mortar retains sufficient alkalinity, excels in adhesion to the base material, and also has excellent waterproof properties. Thus, after checking that water-stop material is effectively working to stop water, we create a groove using polymer cement mortar to bury the seal material, and add the finishing touch to the water stop effect by using epoxy resin sealing material.

![Figure 2: General Drawing of Repair of Open-cut Tunnel](image)

c. Soil road bed

Road bed

1) At the depot, track is in many cases directly installed on the improved ground. The ground in this case is called a soil road bed.

Many abnormalities on the soil road bed are caused by water or consolidation. Therefore, before constructing the track, you should take a range of measures including improving soil properties by forcible water discharge and replacing soil, as well as to increase consolidation pressure by applying a uniform load to the ground for a long period. Despite such measures, abnormalities can occur after operations start. The following three major measures can be taken against such abnormalities.
- Start your visual check from the track on the top surface of the soil road bed. When mud water is spouting out on the ballast bed or any traces of it remain, the soil road bed just below the ballast bed will have in many cases been hollowed out after being turned to sludge by sump water.

- Check the drainage from the previously installed drain trench. If a large volume of water is drained from part of the drain trench when there is no rain, you may suspect in many cases that a huge amount of water has accumulated, or there is sump water in the section between the front and rear drain trenches.

- Or the track is repeatedly sagging at the same position. If sagging continues after the track is repaired, the soil road bed will be hollowed out by sump water or consolidation in many cases.

Such detected abnormalities on the soil road bed require appropriate repairs. I will not mention the repair methods here because they are not unique to railway technology but used as part of general civil engineering work. The only thing you should note in terms of applying the methods to a railway is that it is rather difficult to repair the soil road bed independently. Since the track is laid on the soil road bed, you must scrape out the ballast before starting repairs. Or, sometimes you must remove the track itself before starting repairs. Namely, the Civil Engineering Work Department cannot plan and execute repairs of the soil road on its own. In this case, it is imperative that the Track Department is consulted. When use of the soil road bed is not possible for a prolonged period, consultation with the Rolling Stock Department in the depot will also be necessary to help ensure that train operations are not significantly affected.

When checking earth structures, visual inspection becomes the basis. Check cracks, deformation and flush on the earth structure by visual inspection.

Checks are usually carried out with the naked eye on the track or from the road. However, binoculars are also used when it is not possible to carry out checks with the naked eye due to the distance to the target earth structure.

2) On earth structures that retain the ground with retaining wall made of stones or concrete

If the ground is unstable due to earthquakes or heavy rain, the force acting on an earth structure becomes unbalanced. If the force acting on the earth structure becomes unbalanced, the ground collapses due to downward movement of the soil at a higher position due to gravity. Therefore, in the visual inspection of earth structures, you must detect cracks and spouting of large quantities of water on a daily basis.

Through these inspections, you should not only record detailed information of the accident site but also the conditions under which the earth structure failed. Detailed information on the failed location and the judgment at the point of inspection are important for identifying the target location of repair, and also for grasping the extent of progress prior to the next inspection.
In addition to this information, studying the information concerning the failed part enables us to reflect the recurrence protection measures in the future design.

7.3 Implementation Procedure for Repair Works

a. Removal of peeler concrete (for viaducts and tunnels)
   - Tools
     + Inspection hammers
     + Chisel
     + Concrete cutter
     + Chalk for marking
     + Ladder
     + Tools for high-elevation work (as needed)
   - Materials
     + Rust inhibitor (for when reinforcing bars are exposed)
   - Repair staff assignment
     + [Unit chief]: 1 person responsible for inspection
     + [Staff]: 3 people
   - Repair procedure
     1) [Staff] decides the repair location using the inspection hammer and marks it using chalk.
     2) [Unit chief] shall check that the above repair location coincides with the inspection result and the maintenance plan.
     3) After 2) above, [Staff] shall remove all the flaked concrete.
     4) After 3) above, [Unit chief] shall check that all the flaked concrete is removed.
     5) If any reinforcing bars are exposed, [Staff] shall apply a sufficient volume of rust inhibitor to them.

b. Repair of water leakage (for tunnels)
   - Tools
     + Hammer
     + Chisel
     + Concrete cutter
     + Steel brush
     + Ladder
     + Tools for high-elevation work (as needed)
   - Materials
     + Pipe for injection
Cement-based quick setting water-stop material
+ Water dilatable rubber
+ Urethane-based medical solution
+ Epoxy resin
- Repair staff assignment
  + [Unit chief]: 1 person responsible for inspection
  + [Staff]: 3 people
- Repair procedure
  1) [Staff] shall clean the area using a steel brush and decide on the repair location.
  2) [Unit chief] shall check that the above repair location coincides with the inspection result and the maintenance plan.
  3) After 2) above, [Staff] shall prepare a groove for caulking using the concrete cutter and chisel.
  4) After 3) above, [Staff] shall assemble the injection pipe for the cement-based quick setting water-stop material.
  5) After 4) above, [Staff] shall install the cement-based quick setting water-stop material at the location of the crack.
  6) After 5) above, [Staff] shall inject the urethane-based medical solution through the assembled pipe.
  7) After 6) above, [Unit chief] shall check that no water leaks occur.
  8) After 7) above, [Staff] shall inject epoxy resin along the constructed groove.
  9) After 8) above, [Staff] shall remove the pipe, and install the water dilatable rubber and pour epoxy resin into this location.
  10) In the last, [Unit chief] shall check that no water leaks occur.

- Repair of structure (for viaducts and tunnels)
  - Tools
    + Hammer
    + Chisel
    + Concrete cutter
    + Steel brush
    + Inspection hammer
    + Ladder
    + Tools for high-elevation work (as needed)
  - Materials
    + Polymer-based primer
    + Polymer cement-based mortar
Aramid continuous fiber sheet

Repair staff assignment

[Unit chief]: 1 person responsible for inspection
[Staff]: 3 people

Repair procedure

1) [Staff] shall decide on the repair location by cleaning the place with a steel brush. If the side face of the repair location is protruding, [Staff] shall cut it off using the concrete cutter.

2) If reinforcing bars are exposed, [Staff] shall process the rusted portions using the steel brush, and apply rust inhibitor to them.

3) [Unit chief] shall check that the above repair location coincides with the inspection result and the maintenance plan.

4) After 3) above, [Staff] shall clean the repair location using water.

5) After 4) above, [Staff] shall apply polymer-based primer to the repair location.

6) After polymer-based primer is dried, [Staff] shall fill the repair location with polymer-based mortar (1st layer). At this point, polymer cement-based mortar must be evenly filled in and adhered to the base metal.

7) After 6) above, [Staff] shall set the continuous fiber sheet on the first layer.

8) After 7) above, [Staff] shall fill the continuous fiber sheet with polymer cement-based mortar (2nd layer).

9) In the last, [Unit chief] shall check that polymer cement-based mortar has adhered firmly to the base material.

Chapter 8: Acceptance Inspection, Quality Evaluation and Monitoring after Completion of Work

When the given maintenance work is executed by OU, HQ shall check the documents and current conditions after the work is completed. (Including results of the inspection and repairs.)

When executed by a subcontractor

The work must be implemented in conformance with the Vietnam Law, namely Decree No. 46/2015/ND-CP on Quality Control of Civil Structure dated 2015/05/12.
Track Maintenance Manual

1. Adjustable Range and Applicable Target

The Track Maintenance Manual herein applies to carry out maintenance work on the track administered by the company.

2. Compliance with Regulations of Vietnam

Our maintenance work shall strictly observe applicable laws in Vietnam concerning track maintenance.

3. Track Maintenance Work

(1) Inspection of tracks

Inspection of tracks is a key phase in track maintenance. Track inspection work provides the grounds for understanding information about the state of tracks and regularity of damage, grounds for creating a maintenance plan, grounds for failure analysis, and grounds for countermeasure development.

(2) Preparation of track maintenance plan

Preparation of the track maintenance plan forms the foundation for assuring orderly and accurate maintenance work, and clarifying the purpose of maintenance. The track maintenance plan consists of a long-term maintenance plan (5 years and 30 years), an annual maintenance plan, a monthly maintenance plan, and a daily maintenance plan.

(3) Implementation of track repairs

Repairs are the second most important type of work included in the preparation of the maintenance plan. This work must include the maintenance and investment in the maintenance plan created previously.
## 4. Inspection of Tracks

The following 12 types of inspections are defined as shown below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Contents of inspection</th>
<th>Staff</th>
<th>Inspection tools</th>
<th>Method of implementation</th>
<th>Inspection result Record form</th>
<th>Allowable error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Train patrol</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + A staff member stands in the driver's cabin along with the unit chief. + Two of the staff who carry out the inspection stand behind the unit chief in the passenger car instead of in the driver's cabin.</td>
<td>+ Train in operation + Flashlight</td>
<td>- All the unit staff stand in the train subject to the operation inspection. - The unit chief and a staff stand by the driver in the driver's cabin. - The other two staff stand in the passenger car. - These four inspect the track by observing the front track. - When a failure is found, the chief of the inspection unit tells the driver to stop the train. After the train is stopped, two staff in the passenger car get off the train to carefully inspect the tracks.</td>
<td>Common Inspection Record Form 5.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Patrol on foot</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Number of workers: 2 + Worker responsible for safety checks: 1 person</td>
<td>Inspection hammer - Pen - Measurement Results Recording File - Flashlight - Whistle</td>
<td>- When inspecting the track, all staff walk along the track in the direction opposite to the direction the train is traveling in. They check the track visually for any abnormalities. - Two inspection workers walk along the outside of the track. Each of them inspects a single rail. - The unit chief walks inside the tracks, and confirms and records the inspection results. - The worker responsible for safety checks stands some 50 meters ahead of the inspection team and warns them if a train is approaching. - He warns of an approaching train using a flashlight and whistle. Upon hearing the warning signal, all the inspection unit staff move to a safe train shelter.</td>
<td>Common Inspection Record Form 5.2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Inspection of structure gauge</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Worker responsible for driving the structure gauge measurement car: 1 person + Workers responsible for the expanded track tolerance volume: 2 people</td>
<td>Structure gauge measurement car - Pen - Memo pad - Flashlight</td>
<td>- One of the workers drives the measurement car. - When passing a curve, two workers expand the track tolerance. - The unit chief stands behind the two, and confirms and records the inspection results on a memo pad.</td>
<td>No special form is required for use as a memo pad. If a location exceeding the track tolerance is found, the unit chief records the kilometrage of the location and takes its picture.</td>
<td>The track tolerance shall not be exceeded.</td>
</tr>
</tbody>
</table>
### 4. Inspection of tracks

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
<th>Number of Staff</th>
<th>Measurement</th>
<th>Special Measurement</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>4-item measurement (Gauge, alignment, longitudinal level and cross level)</td>
<td>4</td>
<td>- This measurement takes place in a location where a straight track turns into a curve. - The unit chief checks the measurement results. - One of the workers records the measurement result.</td>
<td>- Tape - Pen - Memo pad - Flashlight</td>
<td>Widen: &lt; 6 mm Narrow: Limit value &gt; Design value</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Measurement of a distance of both tracks</td>
<td>4</td>
<td>- Workers measure the gauge every 5 m. - The unit chief checks the measurement results and records them in the file.</td>
<td>- Special measure - Tape - Pen - Measurement Results Recording File - Flashlight</td>
<td>1/1000</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Gauge measurement</td>
<td>4</td>
<td>- Workers measure the gauge every 5 m. - Two workers stretch the string and another worker measures the alignment. - The unit chief checks the measurement results and records them.</td>
<td>- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight</td>
<td>+6/-3 mm</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Measurement of cross level</td>
<td>4</td>
<td>- Workers measure the gauge every 5 m. - Two workers stretch the string straight, and another worker measures the height from the string to the rail surface. - The unit chief checks the measurement results and records them.</td>
<td>- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight</td>
<td>&lt;±5/-5 mm</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Measurement of alignment</td>
<td>4</td>
<td>- Two workers measure wear of the right side and left side rails every 5 m. - The unit chief checks the measurement results and record them.</td>
<td>- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight</td>
<td>10/-10</td>
</tr>
<tr>
<td>4.1.5</td>
<td>Measurement of longitudinal level</td>
<td>4</td>
<td>- All members of the unit walk along the track. Two workers inspect the track. - The unit chief checks the inspection results. - One of the workers records the inspection result.</td>
<td>- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight</td>
<td>&lt; 12 mm</td>
</tr>
<tr>
<td>4.1.6</td>
<td>Measurement of twist</td>
<td>4</td>
<td>- All members of the unit walk along the track. Two workers inspect the track. - The unit chief checks the inspection results. - One of the workers records the inspection result.</td>
<td>- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight</td>
<td>&lt; 12 mm</td>
</tr>
<tr>
<td>4.2</td>
<td>Inspection of rail</td>
<td>4</td>
<td>- Two workers measure wear of the right side and left side rails every 5 m. - The unit chief checks the measurement results and record them.</td>
<td>- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight</td>
<td>Rail Head Wear Inspection Record Form 5.4</td>
</tr>
<tr>
<td>4.3</td>
<td>Inspection of rail crack</td>
<td>4</td>
<td>- All members of the unit walk along the track. Two workers inspect the track. - The unit chief checks the inspection results. - One of the workers records the inspection result.</td>
<td>- Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight</td>
<td>Rail Damage Record Forms 5.5, 5.6, 5.7</td>
</tr>
<tr>
<td>4.4</td>
<td>Inspection of rail damage</td>
<td>4</td>
<td>- All members of the unit walk along the track. Two workers inspect the track. - The unit chief checks the inspection results. - One of the workers records the inspection result.</td>
<td>- Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight</td>
<td>The following events are observed on the rail head. Width: &lt; 15 mm Length: &lt; 100 mm Depth: &lt; 10 mm</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Number of Staff</td>
<td>Special Measures</td>
<td>Measurement Results</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>----------------</td>
<td>------------------</td>
<td>--------------------</td>
<td>-------</td>
</tr>
<tr>
<td>5.1</td>
<td>4-item Measurement at Turnout and Crossing</td>
<td>4</td>
<td>Tape, Pen, Memo pad, Flashlight, Steel clearance gauge, String, Pen</td>
<td>Measurement Results Recording File</td>
<td>Add the items after confirming the design.</td>
</tr>
<tr>
<td>5.1.1</td>
<td>Gauge measurement</td>
<td>4</td>
<td>其中长官1人</td>
<td>Tape, Pen, Memo pad, Flashlight, Steel clearance gauge, String, Pen</td>
<td>Measurement Results Recording File</td>
</tr>
<tr>
<td>5.1.2</td>
<td>Measurement of cross level</td>
<td>4</td>
<td>Workers responsible for measurement: 2 people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.3</td>
<td>Measurement of alignment</td>
<td>4</td>
<td>Workers responsible for recording measurement result: 1 person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.4</td>
<td>Measurement of longitudinal level</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.5</td>
<td>Measurement of back gauge</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.6</td>
<td>Measurement of spacing between tongue rail and stock rail</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.7</td>
<td>Measurement of clearance between tongue rail and stock rail</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Wear inspection of turnouts and crossings</td>
<td>4</td>
<td>Workers responsible for inspection work: 3 people</td>
<td>Steel clearance gauge, Pen, Measurement Results Recording File, Flashlight</td>
<td>Turnout and Crossing Wear Inspection Record Form 5.8</td>
</tr>
<tr>
<td>5.3</td>
<td>Flaw inspection of turnout and crossing rails</td>
<td>4</td>
<td>Workers responsible for inspecting cracks/rail damage: 3 workers</td>
<td>Measure for clearance measurement, Pen, Measurement Results Recording File, Flashlight</td>
<td>Turnout and Crossing Damage Record Form: Crossing and Tongue rail: Form 5.9 Other locations: Form 5.5</td>
</tr>
<tr>
<td>5.4</td>
<td>Measurement of joint clearance between tongue rail heel and rail</td>
<td>4</td>
<td>Workers responsible for recording inspection results: 1 person</td>
<td>Measure for clearance measurement, Pen</td>
<td>Tongue Rail Heel and Crossing Toe Joint Clearance</td>
</tr>
</tbody>
</table>

The following values are observed in the rail bottom:
- Reduction in width: < 15 mm
- Reduction in thickness: 7 mm

<table>
<thead>
<tr>
<th>Tabulation</th>
<th>Description</th>
<th>Number of Staff</th>
<th>Special Measures</th>
<th>Measurement Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Inspection of Turnouts and crossings</td>
<td>4</td>
<td>Among them</td>
<td></td>
<td>Four-item Measurement at Turnout and Crossing Record Form 5.10</td>
</tr>
<tr>
<td>5.1</td>
<td>Gauge measurement</td>
<td>4</td>
<td>Unit chief: 1 person, Workers responsible for measurement: 2 people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.1</td>
<td>Measurement of cross level</td>
<td>4</td>
<td>Workers responsible for recording measurement result: 1 person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.2</td>
<td>Measurement of alignment</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.3</td>
<td>Measurement of longitudinal level</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.4</td>
<td>Measurement of back gauge</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.5</td>
<td>Measurement of spacing between tongue rail and stock rail</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.6</td>
<td>Measurement of clearance between tongue rail and stock rail</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Wear inspection of turnouts and crossings</td>
<td>4</td>
<td>Unit chief: 1 person, Workers responsible for inspection work: 3 people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Flaw inspection of turnout and crossing rails</td>
<td>4</td>
<td>Unit chief: 1 person, Two workers responsible for inspecting cracks/rail damage, Workers responsible for recording inspection results: 1 person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td>Measurement of joint clearance between tongue rail heel and rail</td>
<td>4</td>
<td>Unit chief: 1 person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>Measurement of joint clearance between rail and crossing front end</td>
<td>+ Workers responsible for joint clearance measurement: 2 people + Workers responsible for recording inspection results: 1 person</td>
<td>- Measurement Results Recording File - Flashlight</td>
<td>Measurement Recording Form 5.11</td>
<td>Add the items after confirming the design.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5.11</td>
<td>Add the items after confirming the design.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Inspection of joint</td>
<td>6.1 Inspection of normal joint</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person</td>
<td>- Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight</td>
<td>- Two workers carry out the inspection. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6.1</td>
<td>+ Joint gap inspection + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person</td>
<td>- Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight</td>
<td>- Two workers carry out the inspection. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.</td>
<td>Rail Joint Inspection Record Form 5.12</td>
<td>Widen: &lt; 10 mm Narrow: 0 mm</td>
</tr>
<tr>
<td>6.1</td>
<td>+ Inspection of joint conditions</td>
<td>Damage on Joint Bar Record Form 5.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>+ Joint parts inspection (joint bar, bolt)</td>
<td>Rail Joint Material Inspection Record Form 5.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>Expansion joint inspection</td>
<td>6.2 Expansion joint inspection</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 3 people</td>
<td>- Special measure - Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight</td>
<td>- Three workers carry out the inspection. - The unit chief checks the inspection results and records them.</td>
</tr>
<tr>
<td>6.2</td>
<td>+ Inspection of expansion joint conditions + Workers responsible for inspection work: 3 people</td>
<td>- Special measure - Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight</td>
<td>- Three workers carry out the inspection. - The unit chief checks the inspection results and records them.</td>
<td>Expansion Joint Inspection Record Form 5.15</td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>+ Expansion joint parts inspection</td>
<td>Rail Joint Material Inspection Record Form 5.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Inspection of sleeper</td>
<td>7 Inspection of sleeper</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person</td>
<td>- Pen - Measurement Results Recording File - Flashlight</td>
<td>- Two workers carry out the visual inspection of sleepers. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.</td>
</tr>
<tr>
<td>8</td>
<td>Inspection of fastening system</td>
<td>8 Inspection of fastening system</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person</td>
<td>- Steel clearance gauge - Hammer for inspection - Pen - Measurement Results Recording File - Flashlight</td>
<td>- Two workers visually inspect the fastening system using a hammer and wrench. Check the marking line provided on the fastening device beforehand. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.</td>
</tr>
<tr>
<td>9</td>
<td>Inspection of carbody vibration</td>
<td>9 Inspection of carbody vibration</td>
<td>Number of staff: 4 Among them + Unit chief: 1 person + Two workers guide the passengers so that they do not come near the vibration indicator. + Workers responsible for operating the vibration indicator: 1 person</td>
<td>- Vibration indicator</td>
<td>- All the unit staff carry out the inspection. - Inspection results shall be assessed after the staff have returned to the office.</td>
</tr>
<tr>
<td>Step</td>
<td>Task Description</td>
<td>Number of Staff</td>
<td>Responsibilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
<td>-----------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 10   | Inspection of track bed | 4 | - Pen
- Measurement Results Recording File
- Flashlight
- All of the unit staff must check the location where the curve starts as well as the place where the ballast track bed collapsed.
- The unit chief checks the inspection results.
- One of the workers records the inspection results in the inspection record file. |
| 11   | Inspection of car stop | 4 | - Pen
- Measurement Results Recording File
- Flashlight
- All the unit staff carry out the inspection and, if any stained or failed portions are identified, they must clean and repair them.
- The unit chief checks the inspection results and records them. |
| 12   | Indicator          | 4 | - Pen
- Measurement Results Recording File
- Flashlight
- All of the unit staff must check the location where the car stop parts must be replaced. |
5. Track Inspection Form

5.1 Inspection of structure gauge: Form not specified

5.2 Common Inspection Record Form

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>A line/ B line</th>
<th>Kilometrage (Km)</th>
<th>Left rail/ Right rail</th>
<th>Inner rail/ Outer rail</th>
<th>Inspection result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contents of inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quantity</td>
</tr>
</tbody>
</table>

5.3 Four-item Measurement Record Form (to be measured every 5 m)

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>A line/ B line</th>
<th>Kilometrage (Km)</th>
<th>Left rail/ Right rail</th>
<th>Gauge</th>
<th>Cross level</th>
<th>Alignment</th>
<th>Longitudinal level</th>
<th>Twist</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TK</td>
<td>TT</td>
<td>CL</td>
<td>TK</td>
<td>TT</td>
<td>CL</td>
</tr>
</tbody>
</table>

:TK Design value; TT: Measured value; CL: Magnitude of irregularity

5.4 Rail Head Wear Inspection Record Form

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>Date of manufacture</th>
<th>Kilometrage</th>
<th>Straight line/ Curved line</th>
<th>Track Type</th>
<th>Date of laying of rails</th>
<th>Monitor wearing depth of top surface of rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Depth of wear</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Passed tonnage</td>
</tr>
</tbody>
</table>

5.5 Rail Damage Record Form
### 5.6 Rail Surface Damage Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Monitoring of state of flaws on rail surface (History)</th>
<th>Description concerning progress of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Addition of vertical projection view of rail</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of vertical projection view of rail</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of vertical projection view of rail</td>
<td></td>
</tr>
</tbody>
</table>

### 5.7 Damage Described on Rail Bottom Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Monitoring of state of damages to rail surface (History)</th>
<th>Description concerning progress of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Addition of the end view of the rail bottom</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of the end view of the rail bottom</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Addition of the end view of the rail bottom</td>
<td></td>
</tr>
</tbody>
</table>
### 5.8 Turnout and Crossing Wear Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Date of laying of rails</th>
<th>Tongue rail (Tongue rail)</th>
<th>Crossing (Crossing)</th>
<th>Guard rail (Guard rail)</th>
<th>Lead rail (Lead rail)</th>
<th>Stock rail (Stock rail)</th>
<th>Running rail (Running rail)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 5.9 Turnout and Crossing Damage Record Form

(Devices other than the turnout shall be recorded on the Rail Inspection Form).

<table>
<thead>
<tr>
<th>Date failure occurred</th>
<th>Site of occurrence</th>
<th>Turnout and crossing number</th>
<th>Type of turnout and crossing</th>
<th>Type of track bed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of laying of rails</th>
<th>Passed tonnage</th>
<th>Manufacturer</th>
<th>Date of manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of finder</th>
<th>Commendation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair procedure</td>
<td>Remark</td>
<td></td>
</tr>
<tr>
<td>Repair timing</td>
<td>Remark</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Changes in the failed portion over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st time</td>
<td>No description</td>
</tr>
<tr>
<td>2nd time</td>
<td>First description</td>
</tr>
<tr>
<td>3rd time</td>
<td>Description of each of the previous times.</td>
</tr>
<tr>
<td>4th time</td>
<td>Description of each of the previous times.</td>
</tr>
<tr>
<td>5th time</td>
<td>Description of each of the previous times.</td>
</tr>
<tr>
<td>6th time</td>
<td>Description of each of the previous times.</td>
</tr>
</tbody>
</table>
### 5. 10 Four-item Measurement at Turnout and Crossing Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Gauge</th>
<th>Cross level</th>
<th>Alignment</th>
<th>Longitudinal level</th>
<th>Check gauge (Check Gauge)</th>
<th>Difference between tongue rail and stock rail</th>
<th>Clearance between tongue rail and stock rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference between measured and design values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference between before and after repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 5.11 Tongue Rail Heel and Crossing Toe Joint Clearance Measurement Recording Form

<table>
<thead>
<tr>
<th>Between stations</th>
<th>Line name</th>
<th>Kilometrage (km)</th>
<th>Measurement of tongue rail heel</th>
<th>Measurement of crossing toe</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design value</td>
<td></td>
<td></td>
<td>Left side</td>
<td>Right side</td>
<td></td>
</tr>
<tr>
<td>Measured value</td>
<td></td>
<td></td>
<td>Left side</td>
<td>Right side</td>
<td></td>
</tr>
<tr>
<td>Difference between measured and design values</td>
<td></td>
<td></td>
<td>Left side</td>
<td>Right side</td>
<td></td>
</tr>
<tr>
<td>Difference between before and after repair</td>
<td></td>
<td></td>
<td>Left side</td>
<td>Right side</td>
<td></td>
</tr>
</tbody>
</table>

### 5.12 Rail Joint Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Between stations</th>
<th>A line/ B line</th>
<th>Kilometrage</th>
<th>Type of rail</th>
<th>Type of track bed</th>
<th>Longitudinal level of joints (Yes/No)</th>
<th>Rail surface damage (Yes/No)</th>
<th>Deviation of longitudinal level at the top surface of rail</th>
<th>Rail misalignment at joint</th>
<th>Remark</th>
</tr>
</thead>
</table>
### 5.1 3 Rail Joint Parts Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Between stations</th>
<th>A line/ B line</th>
<th>Kilometrage</th>
<th>Inner rail/ Outer rail</th>
<th>Type of track bed</th>
<th>Contents of inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type of joint bar and bolt</td>
</tr>
</tbody>
</table>

### 5.14 Damage on Joint Bar Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Between stations</th>
<th>A line/ B line</th>
<th>Kilometrage</th>
<th>Straight line/Curved line R =</th>
<th>Left/Right Inner/Outer</th>
<th>Type of track bed</th>
<th>Type of crack</th>
<th>Outline drawing</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Image of joint bar added</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Image of joint bar added</td>
</tr>
</tbody>
</table>

### 5.15 Expansion Joint Inspection Record Form

<table>
<thead>
<tr>
<th>Inspection date</th>
<th>Gauge</th>
<th>Cross level</th>
<th>Alignment</th>
<th>Longitudinal level</th>
<th>Left rail</th>
<th>Right rail</th>
<th>Travel distance</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>Tongue rail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stock rail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tongue rail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stock rail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Track Maintenance Plan

6.1 Track Maintenance Plan

6.1.1 30-Year Maintenance Plan
The 30-year plan is formulated in such a way that any extremely large investment costs that occur may be spread across the entire business in such a way that does not threaten safe urban railway operations. In the process of formulation, we can gain an understanding of the trends in repair and investment costs within the entire business. We must also prepare a long-running employment policy based on the 30-year plan.

Every item of urban railway equipment must eventually be replaced. If, however, replacement of a large number of items of equipment is required at the same time, an enormous amount of funds will have to be prepared. Therefore, in addition to the size of annual repair costs, we must coordinate and clearly describe the size of investment costs for equipment upgrades in the 30-year plan based on the durable years of each item of equipment being set during the design phase, and the current state of the equipment checked in daily inspections.

6.1.2 5-Year Maintenance Plan
The goal of this plan is to grasp the actual costs needed for repairs and investment by making relevant aspects more manageable. Making relevant aspects more manageable means to organize things around repairs and investment based on the long-term 30-year plan, inspection-based judgment, and the assumed actual work.

As mentioned above, comprehensive discussions and adjustments must be carried out between the department that creates the budget and the department that requests the budget in order to create a feasible midterm business plan.

The 30-year plan and 5-year plan should desirably be revised annually. In particular, the 5-year maintenance plan must be revised annually. The 5-year plan provides information on what businesses are specifically scheduled during the said period, as well as their order of preference. Therefore, the 5-year maintenance plan becomes a guide for obtaining a clear view of the management situation, not only for the departments requesting budgets but also for all employees, including those in management. In the 5-year maintenance plan, the portion that covers the coming year becomes the plan for the next year.

6.1.3 Annual Maintenance Plan, Monthly Maintenance Plan and Daily Maintenance Plan
Although the maintenance plan describes the work to be implemented during the said year, it is not possible to actually execute the work according to this plan alone. In order to implement the work without delay, we must divide large operations into detailed maintenance work schedules, and decide specifically who does what and when. Accordingly, all maintenance staff members must share the information regarding this situation. Therefore, the work described in the annual maintenance plan must be subdivided into monthly and daily maintenance plans.

Changes in actual maintenance work normally occur because we sometimes need to urgently address the sites that are affected by climate and natural conditions. Changes in the maintenance plan also occur when the scheduled work is not finished on time due to utilization of inexperienced workers. As seen in the above, the work plan is normally repeatedly revised due to various factors.

When implementing maintenance, we need the daily maintenance plan that allocates the day's work to each shift based on the monthly maintenance plan. This daily maintenance plan tells the maintenance staff what they are supposed to do during the day's shift. It also ensures a complete hand-off of jobs between shifts in order to prevent any oversights.

Every maintenance work task carried out in each shift during the day is recorded on the daily maintenance plan. These records are very important information for formulating future plans. Namely we can formulate feasible plans only by analyzing and grasping these records. These records also provide effective information for developing a human resource cultivation plan and an employment plan. Thus, we must accumulate this information and analyze them on a daily basis.

6.2 Person in Charge of Plan Preparation
- Regarding the 5-year and 30-year maintenance plan, HQ shall be responsible for conducting surveys for long-term plans and their development, and OU shall be responsible not only for implementing the plans
but also for producing the results.
- The person in charge of plan preparation at OU shall be the creator of the annual and monthly maintenance plans.
- The daily maintenance plan is prepared via discussion between the chief of the repair unit of the preceding shift and the chief of the succeeding repair unit. As necessary, the two chiefs shall consult with the plan preparation engineer.

6.3 Basis for Plan Development

6.3.1 Basis for 30-Year Maintenance Plan Development
- We must estimate how things are broken.
- We must identify from past records how quickly the broken portions are fixed and how many staff are needed to conduct repairs.
- It is also necessary to know from past records the amount of funds required to conduct repairs.

6.3.2 Basis for 5-Year Maintenance Plan Development
- Target fiscal years of the plan
- Classification of businesses
- Budget
- Business number
- Place of work
- Purpose of work
- Description of work implemented
- Request for implementation
- List of items for which difficulties are anticipated during work in the given year.
- Relevant departments whose cooperation is solicited for the work

6.3.3 Basis for Annual Maintenance Plan Development
- 5-year maintenance plan and 30-year maintenance plan
- Results of the annual maintenance plan implemented in the preceding year
- The equipment and machinery data necessary for maintenance and change-related rules that have been accumulated in the past maintenance.
- Results of track inspection
- Regulations on the track maintenance work and other applicable regulations.
- Resources owned by the company (human resources, machines and equipment).

6.3.4 Basis for Monthly Maintenance Plan Development
- Annual maintenance plan
- Results of track inspection
- Results of monthly maintenance plan implemented in the previous month
- Regulations on the track maintenance work and other applicable regulations.
- Resources owned by the company (human resources, machines and equipment).

6.3.5 Basis for Daily Maintenance Plan Development
- Monthly maintenance plan
- Results of track inspections
- Results of the plan for the preceding shift (in the 3-shift a day system. Each shift engages in the development of a day's maintenance plan.)
- Resources owned by the company (human resources, machines and equipment).
- Weather

6.3.6 Precautions for Plan Development
- After the hand-off of the shift every morning, the chief of the repair unit of the morning shift sends the report on the results of the daily maintenance plan executed the previous day to the person in charge of planning. The chief hands off the results of the plan executed the previous day to another unit on the shift.
Results of the plan executed on a Saturday and Sunday shall be handed off to the first morning shift of the following week, and then reported to the person in charge of plan development.

6.4 Plan and Report Approval Request Procedure (From OU to HQ)

- At OU, each person in charge submits the request for approval of report to the senior officer in the department. (Senior officer refers to the department manager or deputy manager.)
- Then the report is sent to the person in charge of the application section at HQ. After the report is checked by the person in charge of the applicable section at HQ, the report is sent to the senior officer of HQ. (Senior person refers to the department manager or deputy manager of HQ.) After the report is approved by the senior officer of HQ, it is sent back to the senior officer of the applicable department at OU.
- When any revisions are needed for the report, the above procedure also applies.

6.5 Maintenance Plan Form

6.5.1 Long-term Maintenance Plan Form (5-year maintenance plan and 30-year maintenance plan)

<table>
<thead>
<tr>
<th>No.</th>
<th>Year implemented</th>
<th>Split of work</th>
<th>Classification of businesses</th>
<th>Budget</th>
<th>Place of work</th>
<th>Purpose of work</th>
<th>Description of work implemented</th>
<th>Difficult points</th>
<th>Relevant departments whose cooperation is solicited for the work</th>
</tr>
</thead>
</table>

6.5.2 Annual Maintenance Plan Form

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Types of work (Repair/upgrade)</th>
<th>Monthly workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>January</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Repair</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Upgrade</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Upgrade</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Repair</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.5.3 Monthly Maintenance Plan Form

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Types of work (Repair/upgrade)</th>
<th>Daily workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1st day</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Repair</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Upgrade</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Upgrade</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Repair</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 6.5.4 Daily Maintenance Plan Form

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Types of work (Repair/upgrade)</th>
<th>Workload</th>
<th>Materials</th>
<th>Person in charge</th>
<th>Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1:00</td>
<td>...</td>
<td>24:00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Upgrade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Upgrade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 7. Track Repair

<table>
<thead>
<tr>
<th>Order</th>
<th>Description of repair</th>
<th>Arrangement of staff</th>
<th>Repair tools</th>
<th>Method of implementation</th>
</tr>
</thead>
</table>
| 1     | Correction of alignment| Number of staff: 6   | Special measure, Dolly for construction inspection, Wrench, Hammer, Pen for marking the rail, Steel clearance gauge, String, Measurement Results Recording File, Flashlight | 1. Preparatory work:  
1.1 The measurement range is plus 15 m of the work zone in the front-back direction.  
- Explanation of the measurement range Example: Sleepers A, B, C, D, E, and F are the target of the alignment adjustment. Interval is 5 m. Work zone is A to C (10 m).  
  + Reason 1: When alignment of C is adjusted, alignment of D is adjusted in connection with the adjustment of C. When alignment of D is adjusted, alignment of E is adjusted in connection with the adjustment of D. When alignment of E is adjusted, alignment of F is adjusted in connection with the adjustment of E. Therefore, alignment of D, E and F must also be adjusted in addition to work zones A, B and C.  
  + Reason 2: When measuring alignment of C, the string is stretched from B to D. Namely, work zones A, B and C are affected. Therefore, after measurement of D, the string is stretched from C to E to take a measurement. Since C is involved in this measurement, the work zones are affected. So after measuring E, you must stretch the string from D to E to take a measurement. In this way, impact on the work zones is removed. Therefore, you must also measure D, E and F. The distance from work zones A, B and C to F is 15 m.  
(See Figure 2-Measurement Range in the attached table.)  
1.2 Measure the distance from the survey point on the stock rail side to the reference point.  
- Set the survey point on the stock side rail.  
  - In a linear location and in the direction in which kilometrage increases, the stock rail shall be the left side rail. In the case of a curve, the stock rail shall be the outer rail.  
- Measure the distance from the survey point to the reference point set on the structure (in this case, the structure is the bean of an elevated bridge). The reference point is set at the time of construction.  
1.3 Gauge Measurement  
- Gauge measurement range: Up to 15 m in the front-back direction including the work zone. The measurement is usually conducted at 5 m intervals in the alignment adjustment.  
1.4 Inspection of Structure gauge Position  
- Reason: In the curve, the alignment adjustment also changes the curve of the stock side rail, thereby changing the direction the train travels. Thus, the position of structure gauge is changed. Therefore, we must check the structure gauge position to secure the structure gauge. If we cannot observe the structure gauge, we must adjust the track.  
1.5 Inspection of Fastening System  
- Check that all parts of the fastening system are tight.  
- Check that the bolts are not rusting. If any rust is seen, loosen the bolt once, lubricate it, and then tighten it again.  
- Make sure the track pad position is not displaced. If displaced, return it to the original position.  
1.6 Inspection of Clearance between Joints  
- Inspection range: Up to 50 m in the front-back direction including the work zone.  
1.7 Inspection of Bolts on Joint Bar  
Inspect the bolts on the joint bar. If they have loosened, tighten them.  
1.8 Marking Travel Distance on Sleepers and Rails  
- In the alignment adjustment, the rail may be compressed both from outside and inside. Therefore, you must mark the compressed distance and direction on the stock side rail.  
2. Actual Work  
2.1 Loosen the fastening system of the stock side rail.  
2.2 Install the gauge retention device.  
Purpose of this work: To stably maintain the distance between the right and left rails.  
2.3 Adjustment of Alignment  
- Start your work from the location that requires the largest adjustment. |
- Once adjustment at a location is completed, measure its alignment immediately. If the measurement result is acceptable, finish your work here and move to the next location to carry out alignment adjustment.
- The alignment adjustment must be continuously implemented until the work is completed.

### 2.4 Permanent Tightening of Fastening System
- After all alignment work is completed, tighten the fastening system of the stock side rail. lubricate the bolts and prevent dust from being pinched by the bolts.

### 2.5 Measurement of four items
- Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.

#### 2 Gauge Adjustment

<table>
<thead>
<tr>
<th>Number of staff: 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among them</td>
</tr>
<tr>
<td>+ Unit chief: 1 person</td>
</tr>
<tr>
<td>+ Number of workers: 5</td>
</tr>
</tbody>
</table>

- Special measure  
- Wrench  
- Hammer  
- Steel clearance gauge  
- String  
- Measurement Results  
- Recording File  
- Flashlight

1. **Preparatory work**

1.1 **Gauge Measurement**
- Excessively narrow or wide gauge can cause a train to derail. Normal survey point intervals in the gauge adjustment is 2.5 m. When there is a large variance in the measurement results at 2.5 m intervals, measure the gauge at each cross tie.

1.2 **Inspection of Fastening System**
- Check that the fastening device is not loosened.  
- Check that the bolts are not rusting. If any rust is seen, loosen the bolt once, lubricate it, and then tighten it again.
- Make sure the truck pad position is not displaced. If displaced, return it to the original position.

1.3 **Measurement of Alignment**
- When adjusting the alignment and gauge at the same time, adjust the alignment first.

1.4 **Deciding Work Position**
- Decide the work position.  
- Write the adjustment value on the rail head.  
- Start the adjustment from the stock rail. In a linear location and in the direction in which kilometrage increases, the stock rail shall be the left side rail. In the case of a curve, the stock rail shall be the outer rail.

2. **Actual Work**

2.1 **Loosen the fastening system of the stock rail once, and then tighten it again.**

2.2 **Loosen the fastening system on the opposite side of the stock rail rather than that of the stock rail.**

2.3 **Adjustment of Position of Opposite Side Rail**
- Based on the adjustment value written on the stock rail, adjust the position of the opposite side rail.

2.4 **Permanent Tightening of Fastening System**
- After all alignment work is completed, tighten the fastening system of the opposite side rail. Lubricate the bolts and prevent dust from being pinched.

2.5 **Measurement of four items**
Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.

#### 3 Rail Renewal

<table>
<thead>
<tr>
<th>Number of staff: 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among them</td>
</tr>
<tr>
<td>+ Unit chief: 1 person</td>
</tr>
<tr>
<td>+ Number of workers: 5</td>
</tr>
</tbody>
</table>

- Over-raise rail shifter  
- Wrench  
- Hammer  
- Winch  
- Measure  
- Rail cutter  
- Rail bending machine  
- Rail supporting wedge  
- Oil  
- Steel clearance gauge  
- String  
- Measurement Results  
- Recording File  
- Flashlight

1. **Preparatory Work**

1.1 **Measurement of Length of Replaced Rail**
- When measuring the length of a replaced rail, measure it in the head of the rail using a measure. Two workers who engage in the measurement shall pull both ends of the measure.  
- Measure the rail length a minimum of two times. The error in the above measurement must be 2 mm maximum. If the error is 2 mm or greater, you must repeat the measurement.  
- This work is carried out at night.

1.2 **Measure the offset. Offset must be measured at each of 1/4, 1/2 and 3/4 point. (See the offset measurement in Figure 4 of Attached Table.)**

1.3 **Measurement of Cross-section**
- Measure the joint clearance of the joint at the start and end points of the rail.  
- Measure the discrepancy and unevenness between the start and end points. Discrepancy denotes the difference in the cross direction between two rails at the end points. Unevenness means the difference between two rails in the vertical direction.

1.4 **Measurement of New Rail**
- Measure the length of a new rail in its head. - Measure the length a minimum of two times. The error shall be 2 mm maximum.

1.5 **Cutting and Chamfering of Rail**
1.6 Drilling of Rail Joint
- Drill a hole on the joint of new rail using the rail driller. Chamfer 2 mm wide area of the joint hole at an angle of 45 degrees.

1.7 Setting of Bending of New Rail
- Bend the new rail at each of 1/4, 1/2 and 3/4 point according to the offset specified in Clause 1.2 of this article.
- Caution:
  + When the radius of the rail is less than 600 m, use the bending machine for bending.
  + Bend the rail to about 2/3 of the offset specified in Clause 1.2 of this article. Exercise care not to bend it excessively.
  + When the curve radius is more than 600 m and less than 800 m, bend the rail within 5 m from the end.

1.8 Installation of Rail Supporting Wedge
- Install a rail supporting wedge in order to temporarily place the new rail. After bending the rail at Depot, move it to the rail replacement position during the preparation period.
- Place the rail outside the track so as not to affect the ballast track bed. Place the rail on the supporting wedge while exercising care not to affect the current bending of the rail. The supporting wedge is made of used, old sleepers. Arrange the pins on the supporting wedge that are used for fixing the rail.

1.9 When replacing two or more rails, you must set the joint clearance of the joints.
- When replacing two or more rails, set an appropriate joint clearance of the joint, and fasten the joint bolts for connecting the rails. In this case, be sure to insert the inner and outer bolts alternately.

1.10 Measure the length of the connected rails.
- Measure the length in the head of the rail. Measure the length two or more times. Measurement error shall be 2 mm maximum.

1.11 Decide Installation Position of Over-raise Rail Shifter
Check the position where the over-raise rail shifter is installed. Decide the position of the over-raise rail shifter in such a way that it can lift a long rail at three points and a short rail at one or two points.
Place the supporting wedge of the over-raise rail shifter temporarily in the installation position.

2. Actual Work:
2.1 Removal of Rail Joint
- On the day of replacement, remove the joints of the rail included in the replacement zone.

2.2 Removal of Fastening System
- Remove the fastening system included in the replacement zone. Exercise care not to pinch any dust.
- When removing it, also remove 10 m of adjacent rail.
  Reason: Axial force settles on the older rail. After the fastening system is removed, that axial force is removed, too.

2.3 Installation Over-raise Rail Shifter

2.4 Lifting of Rail
- Use the over-raise rail shifter when lifting the replaced rail. Do not lift the rail unnecessarily high.

2.5 Check of Track Pad
- Check that the track pad is set in an appropriate position. When replacing the track pad, replace it using this opportunity.

2.6 Setting a New Rail
- Use the over-raise rail shifter when lifting the new rail. Do not lift the rail unnecessarily high.

2.7 Adjustment of Joint Clearance of Rails
- If the joint clearance of the rail is insufficient, move the rail slightly. How to move it: Pinch the rail in a position slightly away from the position where it was pinched before, and then lift and move the rail.

2.8 Temporary Tightening of Joint Bar Bolts
- After the rail is set in the correct position, tighten the joint bar bolts temporarily. Insert the inner bolts and outer bolts alternately.
  Lubricate them, and check whether any dust is on the joint bar.

2.9 Move of Replaced Rail to Supporting Wedge
Do not lift the rail unnecessarily high.

2.10 Remove the over-raise rail shifter.

2.11 Tighten the joint and fastening system.

2.12 Measurement of Four Items
| 4 | Sleeper renewal | Number of staff: 6  
+ Unit chief: 1 person  
+ Number of workers: 5 | - Tamping  
- Wrench  
- Hammer  
- Oil  
- Tool for solidifying the concrete  
- Measure  
- Shovel  
- Concrete breaker  
- Steel clearance gauge  
- String  
- Measurement Results Recording File  
- Flashlight | 1. Preparatory Work  
1.1 Apply a mark to the sleepers to be replaced. Exercise care not to replace multiple cross tie at the same time.  
1.2 Move new sleepers to the temporary storage space.  
1.3 Check the fastening system, then lubricate and tighten it.  
1.4 If the space between the sleepers is not appropriate or if sleepers are not at right angles to the centerline of the track, adjust the sleepers beforehand.  
2. Actual Work  
2.1 Scrape out the ballast or break up the concrete beforehand.  
2.2 Remove the fastening system of the replaced sleepers.  
2.3 Remove the sleepers to be replaced.  
- Remove the sleepers to be replaced.  
- When ballast is used, rake the ballast.  
2.4 Insert new sleepers.  
- As a general rule, the center of a cross tie must be aligned with the centerline of the track.  
- Caution: In the case of a curve, the track centerline is located at a position 717.5 (≈1435/2) mm away from the stock rail (outer rail).  
2.5 Tighten the fastening system of the new cross tie temporarily.  
- Tighten it temporarily after checking that the space between the adjacent cross tie and the cross tie is at a right angle to the track centerline. Then lubricate the bolts.  
2.6 Lay out ballast temporarily.  
- When using ballast, lay out the ballast.  
2.7 Permanent Tightening of Fastening System  
2.8 Tamping down the ballast  
2.9 Level the ballast surface uniformly.  
2.10 Measurement of four items  
- Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security. |
| 5 | Tamping down of track bed | Number of staff: 6  
+ Unit chief: 1 person  
+ Number of workers: 5 | - Tamping  
- Wrench  
- Hammer  
- Oil  
- Measure  
- Steel clearance gauge  
- String  
- Measurement Results Recording File  
- Flashlight | 1. Preparatory Work  
1.1 Measurement of four items (gauge, cross level, alignment and longitudinal level)  
1.2 Inspection of fastening system  
- Check the fastening system for looseness and rust, and also check the track pad.  
1.3 Fill in the ballast for the necessary locations.  
1.4 Adjustment of space between sleepers  
- If the space between sleepers is not appropriate or they are not at right angles to the centerline of the track, adjust the sleepers beforehand.  
1.5 Measurement of gauge and alignment  
2. Actual Work  
2.1 Lifting of stock rail  
- Set a jack for the stock rail from outside the track. - Lift the stock rail up to the specified height.  
- The stock rail is the inner rail in the curved section. In a linear location and in the direction in which kilometrage increases, the stock rail shall be the left side rail.  
2.2 Lifting of opposite side rail  
- Set a jack for the opposite side rail from outside the track. - Lift the rail up to the specified height.  
2.3 Tamping down the ballast  
- As shown in Attached Figure 6, tamp down the ballast in six locations from the position 70 cm away from the cross tie. Tamping shall be continued for 40 seconds per location. Do not press the tamping bar excessively when tamping to avoid damaging the track bed.  
2.4 Replenish of ballast.  
- After the tip of the tamping bar moves past the bottom face of a cross tie, tamp down the ballast more from a diagonal direction. If the ballast is used up, replenish it. |
<table>
<thead>
<tr>
<th>2.5 Tamping of ballast at A, B, C and D</th>
</tr>
</thead>
<tbody>
<tr>
<td>- After tamping the ballast down at A and D, remove the jack to continue tamping at B and C.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.6 Clean the surface and then level it using the tamping bar.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>2.7 Measurement of four items</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.</td>
</tr>
</tbody>
</table>
8. Organization Chart of Gauge Maintenance Department

+ At HQ

- **Section Manager of Department**
  - 1 person

- **Deputy Section Manager of Department**
  - 1 person

- **Person in charge of inspection work**
  - 1 person

- **Person in charge of planning and budgetary work**
  - 1 person

- **Person in charge of maintenance technology**
  - 2 people

+ At OU

- **Manager of department that belongs to company**
  - 1 person

- **Deputy Manager of department that belongs to company**
  - 1 person

- **Person in charge of inspection work**
  - 16 people

- **Person in charge of planning**
  - 2 people

- **Person in charge of repairs**
  - 24 people

**Remark**

**HQ**

- **Section Manager of Department**: He is responsible for administering the operations at HQ and OU. If the Manager is not available, the duty may be delegated to Deputy Section Manager of the Department.
- **Deputy Section Manager of Department**: He is responsible for administering and summing operations of each unit of HQ and OU, and reporting these matters to the Section Manager. If not available, the duty may be delegated to each person in charge.
- The people in charge of respective assignments (inspection, planning and budget preparation, and maintenance technology) are responsible for the corresponding assignments at OU, too, and give their reports to the Section Manager and Deputy Section Manager.

**OU**

- **Department Manager**: He is responsible for administering the department at OU. If he is not available, the duty may be delegated to the Deputy Manager of the Department.
- **Deputy Department Manager at OU**: He is responsible for administering and summing up operations of each unit at OU, and reporting these matters to the Department Manager. If he is not available, the duty may be delegated to Unit Chief of each unit of OU.
9. Operating Procedure for Inspection, Planning and Repair

9.1 Inspection Work

Step 1: Preparation of the inspection implementation plan based on the maintenance regulations and the maintenance manual.
   - Person in charge of inspection at OU (Unit chief)

Step 2: Check of the inspection implementation plan.
   - Interpreter: Person in charge of inspection at OU (Unit chief)
   - Checker: Department Manager or Deputy Manager of OU

Step 3: Submission of the inspection implementation plan to HQ.
   - Submitter: Person in charge of inspection at OU (Unit chief)
   - Recipient: Person in charge of inspection at HQ

Step 4: Check of the inspection implementation plan.
   - Person in charge of inspection at HQ

Step 5: Approval of the inspection implementation plan.
   - Interpreter: Person in charge of inspection at HQ
   - Approver: Section Manager or Deputy Section Manager of Department at HQ

Step 6: Restitution of the inspection implementation plan to OU.
   - Person responsible for restitution: Person in charge of inspection at HQ
   - Recipient: Person in charge of inspection at OU (Unit chief)

Step 7: Execution of inspection based on the inspection implementation plan.
   - Primary person in charge: Person in charge of inspection at OU (Unit chief)
   - Assistant person in charge: People in charge of inspection at OU

<If there are no problems, go to Step 8>

Step 8: Recording of the results to the inspection implementation plan.
   - Person in charge of inspection at OU (Unit chief)

<If the inspection was not able to be carried out in Step 7, change the sequence as shown below.>

Step 7a: Setting of the new inspection implementation date.
   - Person in charge of inspection at OU (Unit chief)

Step 7b: Check of the new inspection implementation date and reasons why.
   - Interpreter: Person in charge of inspection at OU (Unit chief)
   - Checker: Department Manager or Deputy Department Manager of OU

Step 7c: Submission of the new inspection implementation date to HQ.
   - Submitter: Person in charge of inspection at OU (Unit chief)
   - Recipient: Person in charge of inspection at HQ

Step 7d: Check of the new inspection implementation date and reasons why.
   - Person in charge of inspection at HQ

Step 7e: Approval of the new inspection implementation date and reasons why.
   - Interpreter: Person in charge of inspection at HQ
   - Approver: Section Manager or Deputy Section Manager of Department at HQ

Step 7f: Reporting to OU on approval of the new inspection implementation date.
   - Reporter: Person in charge of inspection at HQ
   - Recipient: Person in charge of inspection at OU (Unit chief)

<Proceed with the inspection returning to Step 7>

Step 9: Entry of the results of evaluation to the form.
9.2 Planning Work

(This work is continued from the inspection results of 9.1)

Step 1: Confirmation of the evaluation results and the sites that require repairs, and adjustment of the time necessary for the repairs.
- OU: Person in charge of planning

Step 2: Consultation on the repair method, and requesting a quotation.
- OU: Person in charge of planning

Step 3: Preparation of the business plan based on the organized information.
- OU: Person in charge of planning

Step 4: Check of the business plan.
- Interpreter: OU: Person in charge of inspection
- Checker: OU: Department Manager or Deputy Department Manager

Step 5: Submission of the business plan to HQ.
- Submitter: OU: Person in charge of planning
- Recipient: HQ: Person in charge of planning

Step 6: Check of the business plan.
- HQ: Person in charge of planning

Step 7: Adjustment of the business plan in the company.
- HQ: Person in charge of planning

Step 8: Approval of the business plan.
- Interpreter: HQ: Person in charge of planning
- Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 9: Restitution of the business plan to OU.
- Person responsible for restitution: HQ: Person in charge of planning
- Recipient: OU: Person in charge of planning

Step 10: Development of the annual plan based on the business plan.
- OU: Person in charge of planning
Step 12: Check of the annual plan.
   - Interpreter: OU: Person in charge of inspection
   - Checker: OU: Department Manager or Deputy Department Manager

Step 13: Submission of the annual plan to HQ.
   - Submitter: OU: Person in charge of planning
   - Recipient: HQ: Person in charge of planning

Step 14: Check of the annual plan.
   - HQ: Person in charge of planning

Step 15: Approval of the annual plan.
   - Interpreter: HQ: Person in charge of planning
   - Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 16: Restitution of the annual plan to OU.
   - Person responsible for restitution: HQ: Person in charge of planning
   - Recipient: OU: Person in charge of planning

Step 17: Development of the procurement plan based on the annual plan.
   - OU: Person in charge of planning

Step 18: Development of the monthly plan based on the annual plan.
   - OU: Person in charge of planning

Step 19: Approval of the monthly plan.
   - Interpreter: OU: Person in charge of planning
   - Approver: OU: Department Manager or Deputy Department Manager

Step 20: Submission of the monthly plan to the person in charge of repairs.
   - Interpreter: OU: Person in charge of planning
   - Recipient: OU: Person in charge of repairs (Unit chief)

9.3 Repair and Maintenance Work

(Continued from the plan in 9.2)

Step 1: Development of the daily maintenance plan based on the monthly plan.
   - OU: Person in charge of repairs (Unit chief)

Step 2: Implementation of repair based on the daily maintenance plan.
   - Primary person in charge: OU: Person in charge of repairs (Unit chief)
   - Assistant person in charge: OU: Person in charge of repairs

Step 3: Entry of results of repairs to the monthly maintenance plan.
   - OU: Person in charge of repairs (Unit chief)

Step 4: Entry of repair results on the form.
   - OU: Person in charge of repairs (Unit chief)

Step 5: Confirmation of results of repairs.
   - Interpreter: OU: Person in charge of repairs (Unit chief)
   - Checker: OU: Department Manager or Deputy Department Manager

Step 6: Submission of results of repairs to HQ.
   - Submitter: OU: Person in charge of repairs (Unit chief)
   - Recipient: HQ: Person in charge of repairs

Step 7: Confirmation of results of repairs.
   - HQ: Person in charge of repairs

Step 8: Approval of results of repairs.
   - Interpreter: HQ: Person in charge of repairs
   - Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 9: Restitution of results of repairs to OU.
- Person responsible for restitution: HQ: Person in charge of repairs
- Recipient: OU: Person in charge of repairs (Unit chief)

**Step 10: Preservation of results of repairs.**
- OU: Person in charge of repairs (Unit chief)

**Step 11: Submission of a copy of results of repairs to the person in charge of planning**
- Submitter: OU: Person in charge of repairs (Unit chief)
- Recipient: OU: Person in charge of planning

**Step 12: Analysis of results of repairs.**
- OU: Person in charge of planning

**Step 13: Modification of the annual plan in consideration of results of repairs.**
- OU: Person in charge of planning

**Step 14: Repetition of Steps 12 and after (the plan portion).**
Attachment:

1. Figure 1: How to Tamp Down Ballast

2. Figure 2: Measurement Range

3. Figure 3: Measurement of Clearance between Reference Point and Survey Point
4. Figure 4: Offset is measured at the positions of 1/4, 1/2 and 3/4 (a1, a2 and a3).
JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance rule
〈communication equipment, signal equipment, electric power equipment and station equipment〉

Implementer: Nguyen Viet Quan
JICA TA Team: Mr Takeshi Ikeda

November 30, 2015, in Hanoi
Appendix 8-6-7-1(E)

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Part 1: Purpose

Article 1 Purpose
The Maintenance rule in the Fields of Communication, Signal, Electric power and Station Equipment set down the requirements for Equipment maintenance work in order to ensure stable operation of the facilities and maintain the technological functions for the safe railway transportation.

Part 2: Applicable Scope and Target

Article 2 Adjustment Range
The Equipment maintenance rule herein specify the requirements for maintenance work in the fields of communication, signal, power and station equipment. Hereinafter, the above is referred to as the Equipment maintenance rule.
(See Appendix 1 for the outline of coverage of equipment management in the fields of communication, signal, electric power and station equipment.)

Article 3 Applicable Scope and Target
1. Applicable scope: The rule herein shall be observed in the equipment maintenance processes except where priority is placed on the relevant laws. Where a conflict occurred between the laws and the rule herein due to an amendment of the laws, priority shall be given to the laws rather than the rule.
2. Target: The rule herein apply to internal and external work places, organizations and individuals that are related to maintenance activities of the urban railway administered by HMC.

Part 3: Definition of Terms and Abbreviations

Article 4 Interpretation of Terms and Abbreviations
1. Interpretation of terms
   Equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.
   Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.
   Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.
   Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.
   The electric room of a station is the room containing equipment that supplies power to station equipment.
   The electric room of a depot is the room containing equipment that supplies power to depot equipment.
   Station equipment refers to the electrical equipment under the supervision of a station except AFC equipment, communication equipment and signal equipment.
Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repairs refer to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Dates Management Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in table form.

Annual Workload Planning shows the maintenance work of a year in table form.

Long-term Workload Planning shows the multi-year maintenance work in table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.
The operating Report is used to report the result of the completed equipment maintenance. Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out equipment maintenance.

2 Abbreviations

HQ: Headquarters
OU (Operation Unit): Local companies
BGTVT: Ministry of Traffic and Transportation
BCA: Ministry of Public Safety
BCT: Ministry of Industry and Commerce
BLĐTBXH: Ministry of Industrial Injury and Society
ĐSTĐT: Urban railway
QCVN: National Technical Criteria
TCVN: National Technical Standard
TCCS: Base Criteria
QTKĐ: Verification process
ATC: Automatic Train Control
ATO: Automatic Train Operation
ATS: Automatic Train Supervision
ATP: Automatic Train Protection
PAS: Public Address Systems
AWS: Automatic Warning System

Part4: Legal Foundation and Relevant Materials

Article 5 Legal Foundation and Relevant Materials
1. Legal Foundation
   - Vietnam Railway Act of 2005
   
   The provisions of the rule herein shall be in compliance with the laws of Vietnam. MOT is currently preparing the rule and standards concerning operation and maintenance of urban railways. After the rule and standards are revised and established, our rule shall be adjusted in accordance with the above.

2. Relevant Materials
   - Circular No.05/2015/TT-BGTVT date March 30, 2015 on rule on Office Organization of Those Who are Directly Engaged in Operation of Urban Railway.
   - Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
Appendix 8-6-7-1 (E)

- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Time and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.
- Standard QCVN No. QĐT-T5: 2009 on Verification of Electric System Facility.
- Escalator Safety Technology Verification Standard QTKD No. 002:2008/BLĐTBXH.
- Ordinary Railway Structures Maintenance Standard TCCS 02:2014/VNRA.
- Seamless Railway Structures Maintenance Standard TCCS 03:2014/VNRA.
- Railway Communication Facilities Maintenance Standard TCCS 08:2014/VNRA.
- Railway Signal Facilities Maintenance Standard TCCS 09:2014/VNRA.
- Technical specifications and materials provided by the equipment suppliers.
- Technology design of Line 2A (Cat - Linh-Ha Dong) equipment- A Chinese consultant
- Technology design Line 3 (Nhon-Hanoi Station) equipment - A French consultant.
- Technology Design of Line 2 (Nam Thang Long-Tran Hung Dao) equipment - A Japanese consultant.
- Others are reference materials from TA project.

Part 5: Responsibility for Implementation

Article 6 Responsibilities of Each Section
1. HQ Equipment Section:
It shall audit and supervise each Equipment Inspection and Repair Center to implement the equipment maintenance according to the approved plan, regulation and procedure.
2. Equipment Section at OU (each Equipment Inspection and Repair Center):
It shall implement the equipment maintenance according to the plan, procedure and the rule.

3. Other Sections
Other sections shall, in cooperation with HQ Equipment Section, administer the inspection, confirmation and management processes are implemented according the rule so that safe operation of the trains may be ensured.

Article 7 Procedures for Revision and Abolition of rule
1. The Manager of the Center (OU) shall propose his opinion, if any, on revision of or addition to the rule to the Equipment Section Manager (HQ).
2. The Equipment Section Manager (HQ) shall study and review such a proposal from OU, and submit it with his opinion to the top management for their review.
3. The revision and abolition of the rule shall be decided by the President of the General Employees Meeting in accordance with the procedures stipulated in the law.

Part6: Body Text of rule

Chapter 1: Requirements for Facilities and Maintenance Staff

Article 8 Requirements for Maintenance Facilities
1. Maintenance tools, devices and facilities must be kept in good condition at all times.
2. Special equipment for an emergency purpose must be kept in a separate place, and attached with a clear indication and appropriate guidance.
3. Spare equipment must be kept in a separate place, and their quantity and quality must be capable of meeting sudden needs at any time.

Article 9 General Requirements for Maintenance Staff
1. The maintenance staff must have sufficient work-related knowledge and skills, and they must be physically and mentally strong enough to carry out the required maintenance work.
2. Before starting the work, the maintenance staff must get properly dressed, prepare necessary equipment and tools, and adjust the time appropriately.

Article 10 Requirements for Manager of Equipment Inspection and Repair Center
The Manager of the Equipment Inspection and Repair Center shall assume the total responsibility for supervising every operation performed at the Center, and guide the Center employees in such a manner that they may appropriately implement the assignments. The Manager is responsible for every operation including the safety, service, emergency inspections and repairs, and buildup of culture. For this reason, the Center Manager must meet the following requirements.
- Has a college education or above, and has an expert knowledge and experience in equipment management
- Is knowledgeable in the applicable laws and rule, and complies with the rule of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating. Has sufficient decision-making abilities, exercises leadership, and has a personality type suitable for a management role.

Article 11 Requirements for Deputy Manager of Equipment Inspection and Repair Center
The Deputy Manager of Equipment Inspection and Repair Center must assist the Center Manager in every work. The Deputy Manager assists the Center Manager to help ensure safety, production and service, and implementing emergency inspections and repairs as well as to help build company culture. For this reason, the Deputy Manager of the Center must meet the following requirements.

- Has a college education or above, and has an expert knowledge and experience in equipment management
- Is knowledgeable in the applicable laws and rule, and complies with the rule of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

**Article 12 Requirements for Section Engineer**
The Section Engineer must possess sufficient technical capabilities to handle every type of problem that may occur on equipment in his charge. For this reason, the Section Engineer of the Center must meet the following requirements.

- Has expert knowledge on the system principles of respective equipment.
- Has expert knowledge about the technical processes, technical standards and recovery countermeasures against urgent accidents, and has a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

**Article 13 Requirements for Workers**
The workers are responsible for implementing maintenance of each item of equipment according to the rule and procedures specified by the company, and rescuing passengers urgently and directly should an accident or failure occurred. For this reason, each worker must meet the following requirements.

- Has high school education or above
- Has expert knowledge, qualification or certificate for the related equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rule.

Other than the above, the Leader of the workers must have sufficient capabilities and experience in issuing instructions to the workers regarding work to be done.

**Article 14 Education and Training of Maintenance Staff**
The Manager of the Inspection and Repair Center shall develop the worker education and training programs to ensure better implementation of maintenance.

**Chapter 2: Patrol and Inspection**

**Article 15 Equipment Patrol**
1. Patrols must be carried out on a constant basis to prevent equipment failure.
2. When a natural disaster that will affect the equipment operation is anticipated, the maintenance staff must grasp and follow up the condition of equipment by patrol, and prepare recovery measures on a timely basis.

**Article 16 Equipment Inspection**
1. Every item of equipment must be inspected according to the specified procedure.
2. After the equipment inspection, the maintenance staff must input evaluation of the obtained information to the Inspection Table to enable follow up of the equipment operating condition in the use process.

Article 17 Periodic inspection

The periodic inspection must be conducted according to the inspection cycle that is set for each item of equipment in the Equipment Inspection Standard Table, and ensures inspected equipment remains in good condition until at least the time of the next inspection.

Article 18 Contents of Periodic Inspection

The periodic inspection comprises the overall equipment and the detailed equipment inspection. The following describes contents of the inspection.

1. The overall equipment inspection checks and evaluates the condition of equipment comprehensively based on the inspection staff's feeling about operating sounds, noises, operation and setup of the equipment.
2. The detailed equipment inspection checks and evaluates the condition of equipment in detail according to the set procedure after equipment is stopped.

Article 19 Setting of Inspection Base Date

The inspection base date is the date on which the periodic inspection is executed as specified. When the periodic inspection is not executable on the specified date, the inspection staff must select another day within the tolerable period specified in the following table.

<table>
<thead>
<tr>
<th>Inspection cycle</th>
<th>Tolerable period (Before or after)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half a month</td>
<td>3 days</td>
</tr>
<tr>
<td>1 month</td>
<td>7 days</td>
</tr>
<tr>
<td>2 months</td>
<td>14 days</td>
</tr>
<tr>
<td>3 months</td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>30 days</td>
</tr>
<tr>
<td>1 year</td>
<td>The inspection must take place during the month in which the base date is set.</td>
</tr>
<tr>
<td>1.5 years</td>
<td></td>
</tr>
<tr>
<td>2 years</td>
<td></td>
</tr>
<tr>
<td>3 years</td>
<td></td>
</tr>
<tr>
<td>4 years</td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td></td>
</tr>
<tr>
<td>6 years</td>
<td></td>
</tr>
</tbody>
</table>

Article 20 Management of Inspection Base Date

1. The Manager (OU) must appropriately set the inspection base date for every item of equipment managed by the Center. The Manager then summarizes the dates into the Inspection Base Dates Management Table.
2. When changing the inspection base date, the maintenance staff shall set another date within the inspection cycle of the equipment concerned, and correct the date in the Inspection Base Dates Management Table to record the change.
3. A change in the Inspection Base Dates Management Table must be approved by the Center Manager.
Article 21 Change of Periodic Inspection Date
1. When the periodic inspection is not executable on the inspection base date, the maintenance staff must set another date in its place.
2. Such changes must be recorded in the Monthly Workload Planning.
3. Such changes must be reported to and approved by the Center Manager.

Article 22 Extraordinary Inspection
An extraordinary inspection may be regarded as the periodic inspection when its contents are the same as that of the periodic inspection.

Article 23 Implementation of Extraordinary Inspection
1. When an item of equipment is newly installed, improved or repaired.
2. When a disaster occurred.
3. When an abnormality is detected or suspected on an item of equipment.
4. When using an item of equipment again that has been out of service for some time.

Chapter 3: Maintenance

Article 24 Precautions regarding Maintenance
Maintenance staff must inspect the equipment, follow up on inspections, and immediately take preventive measures against the detected defects to ensure safety of trains.

Article 25 Maintenance
Equipment maintenance must be executed in accordance with the procedures and rule to reduce potential failure of the equipment.

Article 26 Classification of Maintenance
Equipment maintenance includes daily maintenance and the periodic maintenance.

Chapter 4: Repair

Article 27 When Multiple Functions of the Equipment Failed
When a certain function of an item of equipment failed due to a natural disaster or transportation-related problem, the maintenance staff must recover the normal state by repairing it ahead of time in order to ensure safe operation.

Article 28 Implementation of Periodic Repair
The maintenance staff must abide by the work instructions when executing the periodic repair.

Article 29 Implementation of Extraordinary Repair
The maintenance staff must abide by the instructions of the leader at the site when executing extraordinary repairs.

Article 30 Completion of Repairs
After repairs are completed, the maintenance staff must prepare an Operating Report detailing the contents of repairs and the methods used.

Chapter 5: Acceptance Inspection and Check of Equipment Functions

Article 31 Work Required after Extraordinary Maintenance
Appendix8-6-7-1 (E)

1. The maintenance staff must run the equipment for tests and, as needed, run a trial on the train.
2. Inspect and confirm other relevant equipment.
3. Write an Operating Report detailing the work contents clearly.
4. Recheck the position of the equipment installed in the vicinity to the track so that the track clearance may not be affected.

**Article 32 Check of Equipment Functions**

Verification of the safety and equipment function must be carried out by the Section Engineer of the Center in accordance with the work instructions approved by the Center Manager.

**Part7: Rule on Document Retention Period**

**Chapter 1: Documents**

**Article 33 Operating Report**

After the work is completed, the Operating Reports that have been approved by the Center Manager are saved and submitted to HQ on a regular basis.

**Article 34 Inspection Table**

The Inspection Table must be retained at a minimum until the succeeding three inspections are completed. However, when the inspection cycle is less than a year, the Inspection Table must be retained for three years minimum.

**Article 35 Technical Documents of New Equipment**

When an item of equipment is newly installed, upgraded or improved, its data must be updated and retained for reference purposes for future maintenance work.

**Article 36 Technical Documents of Old Equipment**

The documents shall be retained for the period provided in the law.

**Article 37 Important Documents**

The Equipment Section Manager (HQ) may extend the specified retention period for the documents considered important and necessary.

**Article 38 Organization of Materials**

Documents used for maintenance must be put in order with clear indications so that they can be referenced when needed. In addition, a person in the section should be designated to manage and control documents.

**Article 39 Information Aggregation**

The maintenance staff shall aggregate the equipment-related information and experience acquired from recovering from failures, as well as solutions for future reference.

**Article 40 Reporting and Sharing of Information on Accident and Others**

When an accident occurs, the Equipment Section staff of HQ and the maintenance staff of OU shall report and supply information on it in accordance with the company's rule and procedures.

**Chapter 2: Others**

**Article 41 Cleaning**
The equipment room must be kept clean all of the time. These rooms must be cleaned periodically to ensure good operating condition and warranted durable years of the equipment and parts.

**Article 42 Temperature and Humidity**

The temperature and humidity of the equipment room must be kept at the specified level. When changing the temperature and humidity to fix a failure, the maintenance must finish their work as soon as possible so that the equipment may not be affected.

**Article 43 Environment**

Noises, vibrations or odors generated in the process of carrying out maintenance must not exceed the values allowed in the regulation to protect people living or working nearby.

**Article 44 Response to Accident and Transportation-related Problems**

The maintenance staff shall observe the accidents and transportation-related problems response rule specified by the law and company. The equipment maintenance staff shall observe the internal rule on accidents and transportation-related problems response specified by the Equipment Section.

(See Appendix 2 for the Internal rule of Equipment Section on Response to Accidents and Transportation-related Problems.)
Appendix 1: Outline of Coverage of Equipment Management in the Fields of Communication, Signal, Electric power and Station Equipment

**Electric power company**
- Electric power substation

**Electric power substation**
- Transformer, rectifier, etc.

**Negative feeder**
- Electric power cable
- Positive feeder
- Third rail system
- Rail

**Station**
- Electric room
  - Distribution board, power generator, battery, etc.

**Station service room**
- Distribution switchboard
  - Telephones, monitors, etc.
  - Lighting, etc.

**Distribution line**
- Lighting, elevators, escalators, air-conditioners, etc.
- ATC device, interlocking device, etc.
- Railway radio, information equipment for passengers, etc.
- Ticket checkers, ticket-vending machines, etc.

**Electric power company**
- Electric power substation

**Electric power equipment**
- Station equipment (electrical machine equipment)
- Signal equipment
- Communication equipment
- AFC equipment
Appendix 2: Internal rule of Equipment Section on Response to Accidents and Transportation-related Problems

Internal rule of Equipment Section on Response to Urban Railway Accidents and Transportation-related Problems

Part 1  General Provisions

Article 1: Purpose
The rule herein are stipulated in detail to enable the Equipment Section staff to proactively prevent urban railway accidents and transportation-related problems, respond appropriately to such, and achieve safe and stable train operation.

Article 2  Target People
Staff of the Electric Department shall observe the rule herein in addition to the company rule.

Article 3: Explanation of Terms
HQ refers to Headquarters.
OU (Operation Unit) denotes Local companies
Equipment Section staff refers to all the staff that belong to the Equipment Section of HQ and OU.
DSDT is the acronym of the urban railway.
Urban railway traffic accident refers to problems caused by railway transportation means that negatively impact human life and/or health, or property as a result of a collision, derailment, or over-turning. A collision in this context includes that with people, other transportation means, and obstacles.
Transportation-related problems are problems that occur during the execution of transportation activities of an urban railway. However, these are not categorized as a railway accident although they do affect railway operations.

Classification of Urban Railway Accidents and transportation-related problems:
- Classification by cause: Subjective causes and objective causes
- Classification of urban railway accidents by nature: Train operation accidents and other accidents
- Classification by damage level: Not so serious accident, serious accident, fairly serious accident and extremely serious accident

Classification of transportation-related problems in an urban railway:
- Classification of transportation-related problems by cause: Subjective causes and objective causes

The Equipment Section shall define accidents and transportation-related problems more specifically and clearly to help ensure appropriate efforts are made to rectify the given problem.

Accident refers to the event in which train operations, railway facilities, passengers, employees, etc. are negatively affected in one way or another.
Near accident case refers to an event that could have ended in an accident although it was prevented thanks to recovery and handling measures taken on a timely bases.

Chapter 2: Proactive Prevention of Accidents and Transportation-related Problems

Article 4: The Equipment Section staff must be conversant in relevant handling and reporting procedures when an accident or transportation-related problem occurs.
Article 5: The Equipment Section staff must execute the maintenance work processes in accordance with the relevant procedures and requirements in order to prevent occurrence of an accident or transportation-related problems.

Article 6: The Equipment Section staff must try, on a consistent basis, to enhance the capabilities and qualification in management and execution of maintenance in order to prevent occurrence of an accident or transportation-related problems that are to be avoided.

Chapter 3: Response to Accidents and Transportation-related Problems

Article 7: When an accident or transportation-related problem(s) occurs, the highest priority shall be given to preventing the damage from spreading, and securing the safety of passengers and employees.

Article 8: When an accident or transportation-related problem(s) occurs, recovery efforts shall put safe and prompt train operations first. Without regard to the full recovery of equipment, precedence shall be given to deployment of staff and emergency treatment by them, and temporary recovery.

Article 9: The Equipment Section staff shall take a series of actions provided in Articles 15, 16 and 17, namely reporting, communicating with others, holding conferences, exercising vigilance and keeping guard.

Article 10: HQ Manager and OU Manager must formulate beforehand the emergency security plan for accidents, transportation-related problems and disasters.

Article 11: The emergency security plan must cover the following factors.
1. Data of the locations that require our caution and attention.
2. List of contact addresses of employees and other departments in the company (during normal hours and in times of emergency)
3. Internal contact system (walkie-talkies, internal telephones, hot-lines, etc.)
4. List of external business partners for emergency response
5. List of equipment and materials for temporary recovery

Article 12: The HQ Manager and OU Manager shall develop the education and training plan on the following subjects for the staff.
1. Training on accident response
2. Training on disaster response
3. Training on execution of temporary measures and recovery
4. Training on rescue and aid
5. Making sure that the staff have sufficient qualifications and capabilities.

Article 13: If an urban railway accident or transportation-related problem occurs, the HQ Manager and OU Manager order the relevant employees to stop the maintenance work or construction work. Upon receiving the order, the relevant employees stop the maintenance work or construction work, and take necessary actions according to the instructions received from the HQ Manager and OU Manager.

Article 14: If an accident or disaster occurs or threatens to occur, the HQ Manager and OU Manager shall take the following measures.
1. When an accident or disaster occurs:
   a. Prevent damage from spreading
   b. Rescue and evacuation guidance
c. Notification to related organizations

d. Implementation of temporary measures

2. When an accident or disaster threaten to occur:
a. Vigilance and guard by patrol, etc.
b. Development of response plans

Chapter 4: Reporting on Accident and Transportation-related Problems

Article 15: If an accident or disaster occurs or threatens to occur, the OU Manager shall make the following reports to the HQ Manager and HQ Deputy Manager in charge. The OU Manager shall following the special instructions, if any, from the HQ Manager and HQ Deputy Manager in charge. The necessary report shall also be produced for OCC.

1. Prompt report
   It is to report an accident occurred immediately. The means of notification may be phone or mail at the point of occurrence. After the prompt report, the OU Manager shall describe the accident using the prompt report form (Form 1) and submit it to the relevant departments within a day in principle.

2. Interim report
   The OU Manager shall describe the accident's survey status and emergency measures taken using the interim report form (Form 2) and submit it to the relevant departments within seven days in principle.

3. Final report
   The OU Manager shall describe the survey results and permanent measures using the final report form (Form 3) and submit it to the relevant departments within 14 days in principle.

4. The OU Manager shall attach drawings, blueprint, measurement records and photos to the report to help quick and accurate understanding of the accident.

Article 16: After receiving the report from the OU Manager, the HQ Manager shall summarize and evaluate it, and submit the report (Form 4) to the government agency and related organizations.

Article 17: When occurrence or potential occurrence of an accident or transportation-related problem is detected, the staff of the Electric Department shall report it according to rule to the supervisor in order to receive his instructions.

Article 18: The report shall be retained for the period stipulated in the Conservation Act.

Chapter 5: Articles for Implementation

Article 19: The Equipment Section of HQ has the right to adjust or modify these rule in order to reflect actual situations.

Article 20: The Manager of the Center may propose modifications of these rule based on reality of the companies for work-site operations under his supervision.
### A. Reference Materials

#### Accidents and transportation-related problems classification table of Electric Department (including multiple cases)

<table>
<thead>
<tr>
<th>Urban railway accident</th>
<th>Cause</th>
<th>Nature</th>
<th>Specific examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMC is subjective</td>
<td>Caused by railway facility, etc.</td>
<td>Due to age-related deterioration, the motor of the ventilation system had overheated and caused a fire, which affected train operations.</td>
<td></td>
</tr>
<tr>
<td>Same as above</td>
<td>Same as above</td>
<td>Caused by humans</td>
<td>A worker connected the circuit of a distribution line inappropriately. As a result, electrical equipment failed and train operations were affected.</td>
</tr>
<tr>
<td>Same as above</td>
<td>Same as above</td>
<td>Caused by railway facility, etc.</td>
<td>Train operations were affected when ground equipment was hit and damaged by lightning.</td>
</tr>
<tr>
<td>Same as above</td>
<td>Same as above</td>
<td>Caused by humans</td>
<td>A passenger affected train operations by tampering with ground equipment, causing its failure.</td>
</tr>
<tr>
<td>Urban railway transportation-related problems</td>
<td>HMC is subjective</td>
<td></td>
<td>Train operations were affected when a proceed indicator disappeared due to the failure of a signal data transmitter.</td>
</tr>
<tr>
<td>Same as above</td>
<td>HMC is objective</td>
<td></td>
<td>Train operations were affected when the power supply to HMC was stopped due to a power failure at a Electric power company.</td>
</tr>
<tr>
<td>Accident</td>
<td></td>
<td></td>
<td>Passengers were locked in an elevator car for 30 minutes due to an elevator failure.</td>
</tr>
<tr>
<td>Accident</td>
<td></td>
<td></td>
<td>An automatic ticket checker failed soon after it was repaired due to looseness of attached parts.</td>
</tr>
<tr>
<td>Accident</td>
<td></td>
<td></td>
<td>While inspecting a high-voltage cable, a staff suffered a serious injury due to an electric shock.</td>
</tr>
<tr>
<td>Accident</td>
<td></td>
<td></td>
<td>Part of the station building was flooded because a pump could not completely drain flood water due to heavy rain.</td>
</tr>
<tr>
<td>Accident</td>
<td></td>
<td></td>
<td>While patrolling during a rain storm, a staff member was injured after being blown by strong winds from the platform onto the railway track.</td>
</tr>
<tr>
<td>Near accident case</td>
<td></td>
<td></td>
<td>Although a distribution line was inappropriately connected, train operations were not affected because the current was automatically cut off at the breaker and a spare circuit was formed.</td>
</tr>
<tr>
<td>Near accident case</td>
<td></td>
<td></td>
<td>Although the staff member forgot to cut off the power to the circuit being checked before inspecting a high-voltage cable, he avoided being injured because he checked the voltage at the site.</td>
</tr>
</tbody>
</table>
### Accident and Disaster Report (Prompt report)

<table>
<thead>
<tr>
<th>Date created</th>
<th>2017.8.2</th>
<th>Line 2A Signal and Communication Inspection and Repair Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date and time of occurrence</td>
<td>(Date) (2017.1.8)</td>
<td>Time: 10:15</td>
</tr>
<tr>
<td>Site of occurrence</td>
<td>Line 2A Ha Dong Station</td>
<td></td>
</tr>
<tr>
<td>Description of accident</td>
<td>Failure of signal device (inbound line No.1 Signal Indication stopped)</td>
<td></td>
</tr>
<tr>
<td>Duration of operation-related problems</td>
<td>33 minutes [Duration of operation-related problems of train operations (10:15 to 10:48)]</td>
<td></td>
</tr>
<tr>
<td>Concerned personnel</td>
<td>[When the accident resulted from a mistake during an inspection, input the worker's name, age, years of experience, etc.]</td>
<td></td>
</tr>
<tr>
<td>Cause</td>
<td>Failure on signal data transmitter</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>Replacement with a product in storage</td>
<td></td>
</tr>
<tr>
<td>Emergency measures</td>
<td>Extraordinary inspection of every signal data transmitter at Ha Dong Station</td>
<td></td>
</tr>
</tbody>
</table>
| Time series | 10:15 Alarm sounded indicating failure of signal device at Ha Dong Station. (Alarm was output to OCC and Line 2A Signal and Communication Inspection and Repair Center)  
10:16 Driver of an inbound train parking at Ha Dong Station reported to OCC that indication of No.1 signal remains stopped.  
10:16 Engineer A, Leader B and Worker C were dispatched from Line 2A Signal and Communication Inspection and Repair Center to Ha Dong Station.  
10:20 Ha Dong Station staff began inspection inside the track.  
10:35 Ha Dong Station reported to OCC that no abnormalities were detected on the track.  
10:40 OCC instructed Ha Dong Station to resume train operations by use of station staff hand signals.  
10:48 Operations were resumed with hand signals.  
10:52 A, B and C arrived at Ha Dong Station and started inspection (a report to this effect was made to Ha Dong Station, OCC and Line 2A Signal and Communication Inspection and Repair Center).  
11:00 They detected a failure of signal data transmitter of the inbound line signal No.1 in signal room of Ha Dong Station. |
<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:15</td>
<td>They replaced failed equipment with other equipment in storage and successfully restored normal operations.</td>
</tr>
<tr>
<td>11:16</td>
<td>They reported to Ha Dong Station and OCC that normal operations had been restored (a report to this effect was also made to Line 2A Signal and Communication Inspection and Repair Center).</td>
</tr>
<tr>
<td>11:25</td>
<td>Operations based on signal device was resumed.</td>
</tr>
</tbody>
</table>
Report form 2 (Italics and blue characters are description examples)

2017.8.7
Line 2A Signal and Communication Inspection and Repair Center

Accident and Disaster Report (Interim report)

1. Date of occurrence 2017.8.1 Tue 10:15
2. Site of occurrence Line 2A Ha Dong Station
3. Description of accident Failure of signal device (inbound line No.1 Signal Indication stopped)
4. Duration of operation-related problems 33 minutes
5. Concerned personnel None special
6. Outline
   10:15 Alarm sounded indicating failure of signal device of Ha Dong Station. It was confirmed that indication of the inbound line signal No.1 was stopped. Station staff began checking inside the track and dispatch of Signal and Communication Inspection and Repair Center staff was started. Since no abnormalities were detected by station staff, hand signal-based operations were resumed at 10:48. At around this time, staff of Signal and Communication Inspection and Repair Center arrived and began inspection.
   Inspection by staff of Signal and Communication Inspection and Repair Center detected failure of signal data transmitter of the inbound line No.1 signal. They replaced failed equipment with other equipment in storage and successfully restored normal operations. 11:25 Operations based on signal device were resumed.
7. Cause, Treatment and Problem Area
   The cause was a failure on signal data transmitter. They replaced failed equipment with other equipment in storage and successfully restored normal operations.
   Inspection of multiple the signal data transmitters in signal equipment room of Ha Dong Station found that their output power was declining.
8. Emergency Countermeasures and Results of their Implementation
   An extraordinary inspection (measurement of output power) was conducted on every signal data transmitter at Ha Dong Station
   An extraordinary inspection detected three transmitters with output power lower than the tolerance. The Center staff adjusted output power of these three transmitters to be closer to the tolerance.
9. Provisional Measures
   An extraordinary inspection (output power measurement) is going to be conducted within a month from today on every signal data transmitter of every Line 2A station. Any item of equipment with output power lower than the tolerance shall be adjusted to the tolerance.
10. Permanent Measures
    (Contents shall be outlined.)
11. Time series
    (Contents shall be outlined.)
12. Remarks

(Data obtained in last inspection, etc.)
1. Date of occurrence  2017.8.1  Tue  10:15
2. Site of occurrence  Line 2A   Ha Dong Station
3. Description of accident  Failure of signal device (inbound line No.1 Signal Indication stopped)
4. Duration of operation-related problems  33 minutes
5. Concerned personnel  None special
6. Outline
   (Contents shall be outlined.)
7. Cause, Treatment and Problem Area
   (Contents shall be outlined.)
8. Emergency Countermeasures and Results of their Implementation
   (Contents shall be outlined.)
9. Provisional Measures and Results of their Implementation
   An extraordinary inspection (output power measurement) is taking place on signal data transmitter of every Line 2A station. The staff are adjusting output power of equipment when it is lower than the tolerance.
   Currently measurement has been completed at __ stations out of total __ stations, and no abnormalities have been detected at any station other than Ha Dong Station.
10. Permanent Measures
    Equipment on which low output power was detected during an extraordinary inspection shall be replaced with new ones.
11. Time series
    (Contents shall be outlined.)
12. Remarks
    (Data obtained in last inspection, etc.)
Report form 4 (Italics and blue characters are description examples)

<table>
<thead>
<tr>
<th>Name of business operator</th>
<th>Hanoi Metro Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date submitted</td>
<td>2017.8.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date and time of occurrence</th>
<th>Date of occurrence 2017.8.1 Tue 10:15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of accident</td>
<td>Transportation-related problems</td>
</tr>
<tr>
<td>Place</td>
<td>○○ Line Between ○○ Station and ○○ Station Inbound line ○○○○m spot</td>
</tr>
<tr>
<td>Train</td>
<td>A○○ Local train 6 cars</td>
</tr>
<tr>
<td>Casualty figure</td>
<td>None</td>
</tr>
<tr>
<td>Problem on main line</td>
<td>Operation resumed: 2017.8.1 Tue 10:48, Duration of operation-related problems: 33 minutes</td>
</tr>
<tr>
<td>Number of trains affected</td>
<td>Number of canceled trains 3 and number of delayed trains 20</td>
</tr>
<tr>
<td>Amount of damage</td>
<td>(Respective costs ...)</td>
</tr>
<tr>
<td>Concerned personnel</td>
<td>None</td>
</tr>
<tr>
<td>Cause</td>
<td>Failure on signal data transmitter</td>
</tr>
<tr>
<td>Recurrence prevention measures</td>
<td>An extraordinary inspection of every signal data transmitter at Ha Dong Station and related treatment (details are being studied).</td>
</tr>
</tbody>
</table>

Overall Condition

10:15 An alarm sounded indicating failure of signal device of ___ Station. It was confirmed that indication of the inbound line signal No.1 was stopped. Station staff began checking inside the track and dispatch of Signal and Communication Inspection and Repair Center staff was started. Since no abnormalities were detected by station staff, hand signal-based operations were resumed at 10:48. At around this time, staff of Signal and Communication Inspection and Repair Center arrived and began inspection.

Inspection by staff of Signal and Communication Inspection and Repair Center detected failure of signal data transmitter of the inbound line No.1 signal. They replaced failed equipment with other equipment in storage and successfully restored normal operations. 11:25 Operations based on signal device were resumed.
JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual
〈Line 2A communication equipment〉

Implementer: Nguyen Viet Quan
JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi
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    4.2. Interpretation of Abbreviations
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    1.2. Requirements for Equipment
    1.3. Requirements for Maintenance Tools and Devices
  2. Requirements for Staff
    2.1. Requirements for Number of Maintenance Staff
    2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

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F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization
   1. Organizational Structure
   2. Responsibility for Implementation
   3. Revision and Additions

Attached Reference Materials
   1. Organizational Structure, Functions and Assignment of Maintenance Section at Headquarters (HQ) and in Field (OU)
   2. Procedure for Calculating Necessary Number of OU Staff
   3. Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)
   4. Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)
   5. Guideline for Creating Staff Training and Education Plan
   6. Criteria for Number of Units Installed
   7. Provisions on Information Sharing
   8. Guideline and Form for Creating Equipment Ledger
   9. Ledger Form of Equipment Durable Years
A: Legal Foundation

1. Laws and Regulations
- Vietnam Railway Act 2005:
- Contents of this regulation shall be compliant with the laws and regulations of Vietnam. Currently, regulations and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above regulations and standards are officially announced, we must update and recreate our regulations in order to comply with them.

2. Relevant Materials
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
- Circular No. 07/2014/TT-BLDTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 06:2011/BGTVT on Railway Signals.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.
Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.
- TCVN No. 8585:2011 on Urban Railway for Fast and Mass Transit
Basic Standard TCCS No.01:2009/VNRA on Design, Construction and Acceptance Inspection of Railway Signal Communication Construction
- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
- Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA
- Railway Communication Facility Maintenance Standard TCCS No.08:2014/VNRA
- Railway Signal Facility Maintenance Standard TCCS No.09:2014/VNRA
- Specifications provided by equipment provider/contractor
- Technology design for the Line 2A (Cat Linh-Ha Dong) Equipment (Chinese consultant)
- Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
- Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
- Other Reference Material from TA Project
- Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

3. Purpose
The Communication Equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the electric power equipment by making sure that the maintenance staff's work practices and procedures are consistent with the regulations.

4. Definition of Terms and Interpretation of Abbreviations

4.1. Definition of Terms

The term equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.

Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.

Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.

Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

The electric room of a station is the room containing equipment that supplies power to station equipment.

The electric room of a depot is the room containing equipment that supplies power to depot equipment.

Station equipment refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repair refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.
The **maintenance plan** is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

**Patrol** is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The **Equipment Inspection Standard Table** contains the inspection items indispensable in the periodic inspection.

The **Inspection Base Date** refers to the day designated for the periodic inspection.

The **Inspection Base Date Control Table** is used to control the inspection base date for every item of equipment.

The **Periodic Inspection Roadmap** is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

**Monthly Workload Planning** shows the maintenance work of a month in a table form.

**Annual Workload Planning** shows the maintenance work of a year in a table form.

**Long-term Workload Planning** shows the multi-year maintenance work in a table form.

**Inspection Table** is used to record results of the equipment inspection.

**Work Instructions** provide instructions necessary during equipment maintenance.

The **operating Report** is used to report the result of the completed equipment maintenance.

**Equipment Maintenance Manual** describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

### 4.2 Abbreviations

**HQ**: Headquarters  
**OU (Operation Unit)**: Local companies  
**BGTVT**: Ministry of Traffic and Transportation  
**BCA**: Ministry of Public Safety  
**BCT**: Ministry of Industry and Commerce  
**BLLĐTBXH**: Ministry of Industrial Injury and Society  
**ĐSĐT**: Urban railway  
**QCVN**: National Technical Criteria  
**TCVN**: National Technical Standard  
**TCCS**: Base Criteria  
**QTKĐ**: Verification process  
**ATC**: Automatic Train Control  
**ATO**: Automatic Train Operation  
**ATS**: Automatic Train Supervision  
**ATP**: Automatic Train Protection  
**PAS**: Public Address Systems  
**AWS**: Automatic Warning System
5. List of Communication Equipment

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Facilities and Equipment

1.1. Requirements for Facilities

Create a list of the maintenance facilities, devices and tools used to implement the maintenance process based on the specification, tools and devices of the communication equipment. The above list becomes the basis of future maintenance work.

**List of Facilities, Tools and Devices used for Maintenance of Communication Equipment**

<table>
<thead>
<tr>
<th>Order</th>
<th>Device name</th>
<th>Standard or specification</th>
<th>Intended purpose</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.2. Requirements for Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

**Communication Equipment Specification Table**

<table>
<thead>
<tr>
<th>Order</th>
<th>System names</th>
<th>Accessory equipment</th>
<th>Specification</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wireless device</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Telephone equipment for business use</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Electric clock system</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Security camera system</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Announcement system</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Passenger guiding system</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Communication system at depots</td>
<td>As per equipment provider</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>provider</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices
- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Staff

2.1. Requirements for Number of Maintenance Staff

*(How to calculate the number of necessary staff at HQ and OU based on the Line 2A education plan and the reference materials used in the TA project.)*

2.1.1. How to calculate the number of No.2A staff

a. Number of managerial staff

- The number depends on the workload and administrative abilities.
- Managerial staff may directly carry out maintenance work.
- In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.
- Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.
- Should be determined based on the workload.
- The number should be determined based on the maintenance plan developed.

➤ When Line 2A began operations, six managerial staff were assigned for management and implementation of maintenance work. On each of the staff was assigned as the Manager (also serves as the person in charge of signal), the Deputy Manager and Section Engineer.

b. Number of workers

- The number depends on the equipment maintenance workload.
- The number of each group represents the average number computed on the assumption that each has necessary capabilities to carry out the work.
- Holidays and sick leave taken by maintenance staff must be taken into consideration.
- A total of 18 maintenance staff engage in maintenance of the communication equipment (railway radio, telephones, switching equipment, announcement system, automatic passenger guiding system, communication system, communication line, security TV system, electric clock, station fire-prevention monitoring device, etc.) (1.5 people/station according to the standard of Beijing Railway). There are 12 stations along the Line 2A. Two groups are set up. Nine staff are assigned to each group. One of them is the Leader and eight are workers. One group covers maintenance work of 6 stations. They carry out maintenance on a 3-shift system according to the shift roster set by the Manager of OU.

2.1.2. For reference when calculating the number of other staff

- The HQ and OU staff number calculation method and shift roster developed by the specialist in the TA project and C/P (See the attached material).

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Center Manager assumes total responsibility for all operations performed at the Center, and is responsible for providing guidance to Center employees to ensure they implement the allotted assignments.
The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in signal and communication equipment management.
- Has more than three years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.
- Has sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. **The Deputy Manager in charge of communication at OU** shall assist the Manager in executing the Center's operations and assume the responsibility for managing the communication equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in communication equipment management.
- Has more than two years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. **The Deputy Manager in charge of signal at OU** shall assist the Manager in executing the Center's operations and assume the responsibility for managing the signal equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in signal equipment management.
- Has more than two years of experience in the signal equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. **The Signal Section Engineer** must manage technology related to the signal equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Signal Section Engineer must meet the following requirements.

- Has a college education or above
- Has expert knowledge about principles of the signal equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.5. The Communication Section Engineer must manage technology related to the communication equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Communication Section Engineer must meet the following requirements.
- Has a college education or above
- Has an expert knowledge about the principle of the communication equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.6. The signal equipment maintenance worker is responsible for maintaining the signal equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the signal equipment maintenance worker must meet the following requirements.
- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the signal equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

2.2.7. Communication equipment maintenance workers are responsible for maintaining the communication equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the communication equipment maintenance worker must meet the following requirements.
- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the communication equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

C: Classification of Maintenance Operations and Work Implementation Flow

1. Classification of Maintenance Operations
- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.
2. Work Implementation Flow

2.1. Operating Report Preparation Flow

- End of work
- Input to Operating Report
  - OU Worker
- Check and submission of Operating Report
  - OU Leader
- Reception and check of Operating Report
  - OU Engineer
- Check of Operating Report
  - OU Deputy Manager
- Approval of Operating Report
  - OU Manager
- Check and storage of Operating Report
  - HQ Engineer

**When the Operating Report contains descriptions about a failure, the Working Report (copy) is submitted.**

- Reporting
  - HQ Deputy Manager
- Reporting
  - HQ Manager

**When new work is required, correct Monthly Workload Planning and create Work Instructions.**

- Storage of Operating Report
  - OU Engineer

**When the contents of the extraordinary and periodic inspections are the same, input the results into the Inspection Table.**

- Proceed to input the actual achievement data into Monthly Workload Planning
  - OU Engineer
2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning

After work results in the Monthly Workload Planning have been validated, the Monthly Workload Planning (copy) is submitted.

- **HQ Manager**
  - After work results in the Monthly Workload Planning have been validated, the Monthly Workload Planning (copy) is submitted.

- **OU Deputy Manager**
  - Proceed to check of actual achievement in Monthly Workload Planning

- **OU Manager**
  - Approval of actual achievement in Monthly Workload Planning

- **HQ Engineer**
  - Reporting
  - Storage of Operating Report
    - OU Engineer
  - Proceed to input the actual achievement data into Monthly Workload Planning
    - OU Engineer
  - Proceed to check of actual achievement in Monthly Workload Planning
    - OU Deputy Manager
  - Approval of actual achievement in Monthly Workload Planning
    - OU Manager
  - Check of actual achievement in Monthly Workload Planning and its storage
    - HQ Engineer
  - Reporting
    - HQ Deputy Manager
    - HQ Manager
2.3. Monthly Workload Planning Preparation Flow

Periodic Inspection Roadmap 

- Occurrence of new work to respond to repair requests, etc.
- Necessary patrol
- Change of the working day due to a holiday or other factor

Maintenance and Repair Plan 

- Preparation and correction of Monthly Workload Planning
  OU Engineer

- Check of contents of Monthly Workload Planning
  OU Deputy Manager

- Approval of Monthly Workload Planning
  OU Manager

- Management of Monthly Workload Planning
  OU Engineer

- Proceed with preparation of work instructions

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

When changing the periodic inspection date, make sure that the changed-to-date is within the period.
2.4. Work Instructions Preparation Flow

Implementation of new work to respond to repair requests, etc.

Due to a change of scene, etc. Change of planned work

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

Monthly Workload Planning

Preparation and correction of Work Instructions
OU Engineer

Check of Work Instructions
OU Deputy Manager

Approval of Work Instructions
OU Manager

Operating instructions based on Work Instructions
OU Engineer

Preparations for and implementation of work
OU Leader and worker

End of work
OU Leader and worker

Proceed to preparation of Operating Report

OU Leader and worker
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow

- Maintenance Rules (Including Inspection Base Date Control Table)
- Extraordinary inspection, equipment improvement, equipment update, etc. (as needed)

- Preparation of Periodic Inspection Roadmap
  - OU Engineer

- Check of Periodic Inspection Roadmap
  - OU Deputy Manager

- Approval of Periodic Inspection Roadmap
  - OU Manager

- Storage of Periodic Inspection Roadmap
  - OU Engineer

- Proceed to preparation of Scheduled Monthly Workload Planning

- Submission of Periodic Inspection Roadmap (copy)

- Checking and Taking Custody of Periodic Inspection Roadmap
  - HQ Engineer

- Reporting
  - HQ Deputy Manager

- Reporting
  - HQ Manager
2.6. Business Plan and Budget Preparation Flow

- Request from other department
- Request from OU
- Preparation of Business Plan and Budget Bill
  - HQ Engineer
- Check of Business Plan and Budget Bill
  - HQ Deputy Manager
- Approval of Business Plan and Budget Bill
  - HQ Manager
- Check and adjustment by the Corporate Planning Department, Financial Department, etc.
- Decided in the board meeting or by president (depending on the company structure)

- Company policy
- Ledger of Equipment Durable Years, update plan, etc.
2.7. Flow of Response to Accidents and Transport Disorders

- **Report from Worker, etc.**
  - OU Manager
  - Accident response
    - OU

- **Report from OCC**
  - OU Manager
  - Contact from other department (OU)
    - HQ Manager

- **Contact from other department (HQ)**
  - OU Manager
  - Contact from other department (HQ)
    - HQ Manager

**Reporting**

- **Handling completed**
  - Flash report (within a day as a general rule)
    - OU Manager
  - Interim report (within seven days as a general rule)
    - OU Manager
  - Final report (within 14 days as a general rule)
    - OU Manager

**Information and instruction**

- **Reporting to the administrative agency, etc. (in accordance with the law)**
  - HQ Manager
D: Survey Measurement and Validation of Equipment Condition

1. Installation Location
- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status
2.1. Overall Inspection of Equipment
- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

<table>
<thead>
<tr>
<th>Order</th>
<th>System names</th>
<th>Contents of inspection (For reference only)</th>
<th>Inspection cycle</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Train wireless device</td>
<td>1. Device body (each communication equipment room, field and equipment of OCC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acceptability of wiring and mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. General function</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1) Acceptability of function and control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acceptability of acoustic quality, alarm activation, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Suitability of transmission and reception level</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Acceptability of interface with relevant equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4) Suitability of spurious level (level of unnecessary radio wave)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Telephone equipment for business use</td>
<td>1. Telephone switchboard body</td>
<td>2 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1) Acceptability of function</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Acceptability of wiring and mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. General function</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acceptability of interface with relevant equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Electric clock system</td>
<td>1. Electric clock system body</td>
<td>2 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1) Acceptability of function and control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Precision of time and acceptability of time correction function</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Acceptability of wiring and mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. General function</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Acceptability of interface with relevant equipment</td>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
<td>--------------------------------------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 4 | Security camera system | 1. For operation (Driver, conductor and station staff)  
Camera and monitor  
(1) Acceptability of function  
(2) Acceptability of wiring and mechanism  
2. For security <stations, OCC etc.>  
Camera, monitor and video player  
(1) Acceptability of function  
(2) Acceptability of wiring and mechanism |
| 5 | Announcement system | 1. Device body  
(1) Acceptability of function and control  
Acceptability for announcement in real voice and siren  
(2) Suitability of sound pressure  
2. General function  
Acceptability of interface with relevant equipment |
| 6 | Passenger guiding system | 1. Device body  
(1) Acceptability of function and control  
(2) Acceptability of wiring and mechanism  
2. Platform indicator  
(1) Acceptability of function  
(2) Acceptability of wiring and mechanism  
3. General function  
Acceptability of interface with relevant equipment |
| 7 | Communication equipment at depots | 1. Ground equipment for testing equipment on the vehicle side of the train radio system (simplified ground equipment)  
2. Telephone equipment for professional use, entry phones, etc.  
3. Security camera  
4. Announcement system  
Others |
| 8 | ................. |   |
**E: Development of Plan (Create the form according to the Plan Preparation Manual)**

1. Plan of the day (List the daily maintenance work items based on the monthly plan)

1.1. Work Instructions

<table>
<thead>
<tr>
<th>Work Instructions</th>
<th>Date and time (Work implementation time specified in the Work Instructions)</th>
<th>OU Manager (Approver)</th>
<th>OU Deputy Manager (Checker)</th>
<th>OU Engineer (Preparer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal and Communication Equipment Inspection and Repair Center: the Line 2A</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time when a failure detected (Describe date and time in detail)</th>
<th>Year ___ Month ___ Day ___ Hour ___</th>
<th>Requested by (Signature)</th>
<th>Including the reason why the failure was detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location and equipment name</td>
<td>Work code (When provided)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work name</td>
<td>Contents of instruction (What, how, by when, current situation, drawings, etc.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Precautions for work (A special location, requirements, precautions for work)

1
2

1.2. Operating Report
<table>
<thead>
<tr>
<th>Working hours</th>
<th>Day /Night</th>
<th>Materials used (To be clearly indicated in the instructions)</th>
<th>Available/Unavaiable</th>
<th>Arrangement Date</th>
<th>Receipt of material</th>
<th>Operating Report</th>
<th>Date repair completed</th>
<th>Date</th>
<th>Reported by (Signature of Leader)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>OU Manager</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>OU Deputy Manager</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>OU Engineer</td>
</tr>
</tbody>
</table>

**Confirmation of completion**

- Correction of records in Inspection Table
- Input to Monthly Failure Report
- Correction of maintenance drawing
- Correction of Equipment Ledger
- Input to Shipping/Receiving Card

Yes/No/Finished | Yes/No/Finished | Yes/No/Finished | Yes/No/Finished | Yes/No/Finished |

**Date** | **Name of worker** | **Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)** | Check by OU Deputy Manager (When work of the shift is not completed)
<table>
<thead>
<tr>
<th>Necessity for request of special repair</th>
<th>Necessary / Not necessary</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Cause, treatment, comments</th>
<th>Model of removed item</th>
<th>Model of installed item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial number of removed item</td>
<td>Serial number of installed item</td>
<td></td>
</tr>
<tr>
<td>Date of manufacturing of removed item</td>
<td>Date of manufacturing of installed item</td>
<td></td>
</tr>
<tr>
<td>Name of manufacturer of removed item</td>
<td>Name of manufacturer of installed item</td>
<td></td>
</tr>
</tbody>
</table>
2. Monthly Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Contents of inspection</th>
<th>Location of inspection</th>
<th>Plan (Signature)</th>
<th>Actual achievement (Signature)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>10</td>
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<td>11</td>
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<td>12</td>
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<tr>
<td>15</td>
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</tr>
</tbody>
</table>

<On Addition of and Change in Work>

1. When there was an addition or change in the scheduled work, describe it in the table using a pencil.
2. When an addition work is completed, indicate it using a red pencil. Connect the work before and after it with an arrow.
3. Select the applicable reason for the change from the following and write its number near the arrow.

"List of reasons of addition or change"

1. Because of a change in the...
<table>
<thead>
<tr>
<th>Working Schedule Due to a Holiday or Other Factors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Because of the influence of an addition or change in other work.</td>
</tr>
<tr>
<td>3. Because of an accident or disaster.</td>
</tr>
<tr>
<td>4. Because of the convenience of the business partner.</td>
</tr>
<tr>
<td>5. Because of addition of all-night feed.</td>
</tr>
<tr>
<td>6. Because of equipment failure.</td>
</tr>
<tr>
<td>7. Because of an extraordinary inspection due to equipment failure or other factor.</td>
</tr>
<tr>
<td>8. Because the work was added after the scheduled job was completed.</td>
</tr>
<tr>
<td>9. Other reason (Describe it clearly and in an easy-to-understand manner).</td>
</tr>
</tbody>
</table>

*On Actual Achievement of Work*

1. When the scheduled work was implemented, affix a “Completed” seal next to the end of the name of the work.
2. When work that was added or...
changed is completed, affix a "Completed" seal to the portion furnished with rubrics after the change.
### 3. Long-term Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Equipment name</th>
<th>Contents of inspection</th>
<th>Inspection code</th>
<th>Inspectio n period</th>
<th>Location of inspection</th>
<th>(Year)</th>
<th>(Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Maintenance</td>
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<tr>
<td>Maintenance</td>
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<tr>
<td>Repair</td>
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</tr>
</tbody>
</table>

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.
### 4. Budget Planning (Form)

**Maintenance Budget Planning - Year __**  
**Department: Communication Equipment Center**

<table>
<thead>
<tr>
<th>Maintenance time</th>
<th>Contents of work</th>
<th>Method of implementation</th>
<th>Equipment use period</th>
<th>Maintenance cycle</th>
<th>Durable years</th>
<th>Total implementation cost</th>
<th>Cost breakdown</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
F: Acceptance Inspection, Quality Evaluation and Monitoring after Work
- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the company.

G: Implementing Organization
1. Organizational Structure

![Organizational Structure Diagram]

2. Responsibility for Implementation
- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager in charge of signal equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the signal equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Deputy Manager in charge of communication equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the communication equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Section Engineer shall be responsible for developing the plan for the specialized area in his charge, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- The communication inspection and repair worker shall be responsible for maintaining the communication equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.
The signal inspection and repair worker shall be responsible for maintaining the signal equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the Signal and Communication Equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to appropriately perform signal communication equipment maintenance of the Line 2A.

Such proposals and/or propositions presented to HQ shall be made in accordance with the regulation.
JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual
〈Line 2A signal equipment〉

Implementer: Nguyen Viet Quan
JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi
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2. Relevant Materials
3. Purpose

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   1.2. Requirements for Equipment
   1.3. Requirements for Maintenance Tools and Devices

2. Requirements for Staff
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   2.2. Detailed Equipment Inspection

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2. Monthly Maintenance Plan (Form)
3. Long-term Maintenance Plan (Form)
4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization
1. Organizational Structure
2. Responsibility for Implementation
3. Revision and Additions

Attached Reference Materials

1. Organizational Structure, Functions and Assignment of Equipment Section at Headquarters (HQ) and in Field (OU)
2. Procedure for Calculating Necessary Number of OU Staff
3. Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)
4. Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)
5. Guideline for Creating Staff Training and Education Plan
6. Criteria for Number of Units Installed
7. Provisions on Information Sharing
8. Guideline and Form for Creating Equipment Ledger
9. Ledger Form of Equipment Durable Years
A: Legal Foundation

1. Laws and Regulations
- Vietnam Railway Act 2005:
  - Contents of this regulation shall be compliant with the laws and regulations of Vietnam. Currently, regulations and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above regulations and standards are officially announced, we must update and recreate our regulations in order to comply with them.

2. Relevant Materials
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
- Circular No. 07/2014/TT-BLDTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 06:2011/BGTVT on Railway Signals.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.
- Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.
- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
- Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA
- Railway Communication Facility Maintenance Standard TCCS No.08:2014/VNRA
- Railway Signal Facility Maintenance Standard TCCS No.09:2014/VNRA
- Specifications provided by equipment provider/contractor
- Technology design for the Line 2A (Cat Linh-Ha Dong) Equipment (Chinese consultant)
- Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
- Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
- Other Reference Material from TA Project
- Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

3. Purpose
The Signal Equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the signal equipment by making sure that the maintenance staff's work practices and procedures are consistent with the regulations.

4. Definition of Terms and Interpretation of Abbreviations

4.1. Definition of Terms

The term **equipment** denotes the communication equipment, signal equipment, electric power equipment and station equipment.

**Communication equipment** is the provision used to ensure safe operation and provide communication for passenger service.

**Signal equipment** consists of the interlocking device and the signal system that controls trains for the safe operation.

**Electric power equipment** is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

**The electric room of a station** is the room containing equipment that supplies power to station equipment.

**The electric room of a depot** is the room containing equipment that supplies power to depot equipment.

**Station equipment** refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

**Equipment maintenance** refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

**Inspection** means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

**Periodic inspections** involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

**Extraordinary inspection** refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

**Maintenance** denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

**Repair** is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

**Periodic repair** refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

**Extraordinary repairs** are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

**Design** quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

**Maintenance staff** denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.
The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters
OU (Operation Unit): Local companies
BGTVT: Ministry of Traffic and Transportation
BCA: Ministry of Public Safety
BCT: Ministry of Industry and Commerce
BLĐTBXH: Ministry of Industrial Injury and Society
ĐSDT: Urban railway
QCVN: National Technical Criteria
TCVN: National Technical Standard
TCCS: Base Criteria
QTKĐ: Verification process
ATC: Automatic Train Control
ATO: Automatic Train Operation
ATS: Automatic Train Supervision
ATP: Automatic Train Protection
PAS: Public Address Systems
AWS: Automatic Warning System
5. List of Signal Equipment

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Facilities and Equipment

1.1. Requirements for Facilities

Create a list of the maintenance facilities, devices and tools used to implement the maintenance process based on the specification, tools and devices of the signal equipment. The above list becomes the basis of future maintenance work.

List of Facilities, Tools and Devices used for Maintenance of Signal Equipment

<table>
<thead>
<tr>
<th>Order</th>
<th>Device name</th>
<th>Standard or specification</th>
<th>Intended purpose</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

1.2. Requirements for Signal Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

Signal Equipment Specification Table

<table>
<thead>
<tr>
<th>Order</th>
<th>System names</th>
<th>Accessory equipment</th>
<th>Specification</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Orbital unit</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Signal</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Switch</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Interlocking device</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ATC device</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ATO device</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>CTC (Centralized Traffic Control) device</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Other devices</td>
<td>As per equipment provider</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>…</td>
<td></td>
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</tr>
</tbody>
</table>
- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices
- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Staff

2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. How to calculate the number of No.2A staff
a. Number of managerial staff
- The number depends on the workload and administrative abilities.
  + Managerial staff may directly carry out maintenance work.
  + In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.
  + Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.
- Should be determined based on the workload.
- The number should be determined based on the maintenance plan developed.

➤ When Line 2A began operations, six managerial staff were assigned for management and implementation of maintenance work. On each of the staff was assigned as the Manager (also serves as the person in charge of communication), the Deputy Manager and Section Engineer.

b. Number of workers
- The number depends on the equipment maintenance workload.
- The number of each group represents the average number computed on the assumption that each has necessary capabilities to carry out the work.
- Holidays and sick leave taken by maintenance staff must be taken into consideration.

They are responsible for maintenance of the signal equipment (ATP, ATC, ATO, ATS, interlocking devices, etc.). For that purpose, 20 maintenance workers are assigned to the Line 2A (1.5 people/km according to the standard of Beijing Railway). The Line 2A is about 13 km long. Two groups are set up. Ten workers are allocated to each group. One of them is the Leader and nine are workers. One group maintains the signal equipment over a distance of 6.5 km. They carry out maintenance on a 3-shift system according to the shift roster set by the Manager of OU.

2.1.2. For reference when calculating the number of other staff
- The HQ and OU staff number calculation method and shift roster developed by the specialist in the TA project and C/P (See the attached material).

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center
2.2.1. The Center Manager assumes total responsibility for all operations performed at the Center, and is responsible for providing guidance to Center employees to ensure they implement the allotted assignments. The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.
- Has a college education or above, and expert knowledge in signal and communication equipment management.
- Has more than three years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating, and sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager in charge of communication at OU shall assist the Manager in executing the Center's operations and assume the responsibility for managing the communication equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.
- Has a college education or above, and expert knowledge in communication equipment management.
- Has more than two years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Deputy Manager in charge of signal at OU shall assist the Manager in executing the Center's operations and assume the responsibility for managing the signal equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.
- Has a college education or above, and expert knowledge in signal equipment management.
- Has more than two years of experience in the signal equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. The Signal Section Engineer must manage technology related to the signal equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Signal Section Engineer must meet the following requirements.
- Has a college education or above
- Has expert knowledge about principles of the signal equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handling software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.5. **The Communication Section Engineer** must manage technology related to the communication equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Communication Section Engineer must meet the following requirements.

- Has a college education or above
- Has an expert knowledge about the principle of the communication equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.6. **The signal equipment maintenance worker** is responsible for maintaining the signal equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the signal equipment maintenance worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the signal equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

2.2.7. **Communication equipment maintenance workers** are responsible for maintaining the communication equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the communication equipment maintenance worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the communication equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

C: **Classification of Maintenance Operations and Work Implementation Flow**

1. **Classification of Maintenance Operations**

- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.
2. Work Implementation Flow

2.1. Operating Report Preparation Flow

- End of work
- Input to Operating Report
  - OU Worker
- Check and submission of Operating Report
  - OU Leader
- Reception and check of Operating Report
  - OU Engineer
- Check of Operating Report
  - OU Deputy Manager
- Approval of Operating Report
  - OU Manager
- Check and storage of Operating Report
  - HQ Engineer
- Reporting
  - HQ Deputy Manager
- Reporting
  - HQ Manager

※ When the Operating Report contains descriptions about a failure, the Working Report (copy) is submitted.

When the contents of the extraordinary and periodic inspections are the same, input the results into the Inspection Table.

When new work is required, correct Monthly Workload Planning and create Work Instructions.

Storage of Operating Report
- OU Engineer

Proceed to input the actual achievement data into Monthly Workload Planning
- OU Engineer
2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning

After work results in the Monthly Workload Planning have been validated, the Monthly Workload Planning (copy) is submitted.

Storage of Operating Report
OU Engineer

Proceed to input the actual achievement data into Monthly Workload Planning
OU Engineer

Proceed to check of actual achievement in Monthly Workload Planning
OU Deputy Manager

Approval of actual achievement in Monthly Workload Planning
OU Manager

Check of actual achievement in Monthly Workload Planning and its storage
HQ Engineer

Storage of Monthly Workload Planning
OU Engineer

Reporting
HQ Deputy Manager

Reporting
HQ Manager
2.3. Monthly Workload Planning Preparation Flow

- Periodic Inspection Roadmap
- Maintenance and Repair Plan

Occurrence of new work to respond to repair requests, etc.
Necessary patrol

Change of the working day due to a holiday or other factor

Check of contents of Monthly Workload Planning
OU Deputy Manager

Preparation and correction of Monthly Workload Planning
OU Engineer

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

When changing the periodic inspection date, make sure that the changed-to-date is within the period.

Approval of Monthly Workload Planning
OU Manager

Management of Monthly Workload Planning
OU Engineer

Proceed with preparation of work instructions
2.4. Work Instructions Preparation Flow

- Monthly Workload Planning
- Preparation and correction of Work Instructions
  - OU Engineer
- Check of Work Instructions
  - OU Deputy Manager
- Approval of Work Instructions
  - OU Manager
- Operating instructions based on Work Instructions
  - OU Engineer
- Preparations for and implementation of work
  - OU Leader and worker
- End of work
  - OU Leader and worker
- Proceed to preparation of Operating Report

Implementation of new work to respond to repair requests, etc.
Due to a change of scene, etc.
Change of planned work

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow

- Preparation of Periodic Inspection Roadmap
  - OU Engineer

- Check of Periodic Inspection Roadmap
  - OU Deputy Manager

- Approval of Periodic Inspection Roadmap
  - OU Manager

- Submission of Periodic Inspection Roadmap (copy)

- Maintenance Rules (Including Inspection Base Date Control Table)

- Extraordinary inspection, equipment improvement, equipment update, etc. (as needed)

- Checking and Taking Custody of Periodic Inspection Roadmap
  - HQ Engineer

- Reporting
  - HQ Deputy Manager

- Reporting
  - HQ Manager

- Storage of Periodic Inspection Roadmap
  - OU Engineer

- Proceed to preparation of Scheduled Monthly Workload Planning
2.6. Business Plan and Budget Preparation Flow

- Request from other department
- Approval of Business Plan and Budget Bill
- Check of Business Plan and Budget Bill
- Preparation of Business Plan and Budget Bill
- Ledger of Equipment Durable Years, update plan, etc.
- Company policy
- Request from OU

Decided in the board meeting or by president (depending on the company structure)

Check and adjustment by the Corporate Planning Department, Financial Department, etc.

HQ Manager

HQ Deputy Manager

HQ Engineer

Preparation of Business Plan and Budget Bill

Check of Business Plan and Budget Bill

HQ Deputy Manager

Approval of Business Plan and Budget Bill

HQ Manager

Check of Business Plan and Budget Bill

HQ Deputy Manager

Approval of Business Plan and Budget Bill

HQ Manager

Company policy

Request from other department

Request from OU
2.7. Flow of Response to Accidents and Transport Disorders

- Reporting to the administrative agency, etc. (in accordance with the law)

  HQ Manager
D: Survey Measurement and Validation of Equipment Condition

1. Installation Location
- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status
2.1. Overall Inspection of Equipment
- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

<table>
<thead>
<tr>
<th>Order</th>
<th>System names</th>
<th>Contents of inspection (For reference only)</th>
<th>Inspection cycle</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Orbital unit</td>
<td>1. Acceptability of insulation state of rails 2. Acceptability of impedance bond, terminals, wiring and mechanism 3. Track circuit (1) Suitability of voltage, etc. (2) Suitability in train detection 4. Signal bonds: Acceptability of terminals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Signal including</td>
<td>1. Acceptability of wiring and mechanism 2. Appropriateness of voltage</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>supporting materials</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Switch</td>
<td>Electric switch (1) Acceptability of lock (2) Acceptability of manual changeover (3) Acceptability of function and control (4) Suitability of voltage, etc. (5) Acceptability of wiring and mechanism (6) Acceptability of lubrication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Interlocking device</td>
<td>1. Device body Acceptability of function and control 2. General function Acceptability of interface with relevant equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ATC device</td>
<td>1. Device body (1) Acceptability of function and control (2) Appropriateness of ATC signal on-the-spot</td>
<td></td>
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<tr>
<td>2. General function</td>
<td>Acceptability of interface with relevant equipment</td>
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</tbody>
</table>
| 6 | ATO device | ATO track antenna  
Acceptability of condition |   |
| 7 | CTC (Centralized Traffic Control) device | OCC device  
(1) Acceptability of function and control  
(2) Acceptability of transmission  
(3) Acceptability of interface with relevant equipment  
2. Station equipment  
(1) Acceptability of function and control  
(2) Acceptability of transmission  
(3) Acceptability of interface with relevant equipment  
3. Transmission device  
(1) Acceptability of function and control  
(2) Acceptability of transmission  
(3) Acceptability of interface with relevant equipment |   |
| 8 | Other devices (Signal) | Sign marker devices  
Acceptability of condition (Some sign markers use reflection board and LED other than paint)  
2. PRC (Programmed Route Control) device  
(Small CTC device used at depots)  
(1) Acceptability of function and control  
(2) Acceptability of transmission  
(3) Acceptability of interface with relevant equipment  
3. Supporting materials (Supporting column, supporting structure, piping, etc.)  
(1) Acceptability of condition  
(2) Acceptability of measures against damage caused by rats and disasters. |   |
| 9 | . . . |   |
E: Development of Plan (Create the form according to the Plan Preparation Manual)

1. Plan of the Day (List the maintenance items of the day according to the Monthly Maintenance Plan)

1.1. Work Instructions

<table>
<thead>
<tr>
<th>Work Instructions</th>
<th>Date and time (Work implementation time specified in the Work Instructions)</th>
<th>OU Manager (Approver)</th>
<th>OU Deputy Manager (Checker)</th>
<th>OU Engineer (Preparer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal and Communication Equipment Inspection and Repair Center: the Line 2A</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td></td>
</tr>
</tbody>
</table>

- Time when a failure detected (Describe date and time in detail)
  - Year __ Month __ Day __ Hour __ Requested by (Signature)
  - Including the reason why the failure was detected

- Location and equipment name
  - Work code (When provided)

- Work name

- Contents of instruction (What, how, by when, current situation, drawings, etc.)

- Precautions for work (A special location, requirements, precautions for work)
  1
  2
# 1.2. Operating Report

<table>
<thead>
<tr>
<th>Working hours</th>
<th>Day/Night</th>
<th>Materials used (To be clearly indicated in the instructions)</th>
<th>Available/Unavailable</th>
<th>Arrangement Date</th>
<th>Receipt of material</th>
<th>Reported by (Signature of Leader)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>OU Manager OU Deputy Manager OU Engineer</td>
</tr>
<tr>
<td>Operating Report</td>
<td>Date repair completed</td>
<td>Date</td>
<td></td>
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</tr>
</tbody>
</table>

**Confirmation of completion**

<table>
<thead>
<tr>
<th>Correction of records in Inspection Table</th>
<th>Input to Monthly Failure Report</th>
<th>Correction of maintenance drawing</th>
<th>Correction of Equipment Ledger</th>
<th>Input to Shipping/Receiving Card</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
</tr>
</tbody>
</table>

**Date**

<table>
<thead>
<tr>
<th>Date</th>
<th>Name of worker</th>
<th>Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)</th>
<th>Check by OU Deputy Manager (When work of the shift is not completed)</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Cause, treatment, comments</td>
<td>Model of removed item</td>
<td>Model of installed item</td>
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<td>----------------------------</td>
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<td></td>
<td>Serial number of</td>
<td>Serial number of</td>
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<td>removed item</td>
<td>installed item</td>
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<td>Date of manufacturing</td>
<td>Date of manufacturing</td>
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<td></td>
<td>of removed item</td>
<td>of installed item</td>
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<td></td>
<td>Name of manufacturer</td>
<td>Name of manufacturer</td>
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<tr>
<td></td>
<td>of removed item</td>
<td>of installed item</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Necessity for request of special repair (When approval of HQ Station Equipment Section is necessary)</th>
<th>Necessary / Not necessary</th>
</tr>
</thead>
</table>

- 51 -
2. Monthly Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Contents of inspection</th>
<th>Location of inspection</th>
<th>Hanoi Metro Company</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td>The Line 2A</td>
<td></td>
</tr>
</tbody>
</table>

- **Revision history**

<table>
<thead>
<tr>
<th>Year _ Month _ Workload Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department: Signal and Communication Equipment</td>
</tr>
<tr>
<td>Inspection and Repair Center</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan (Signature)</th>
<th>Actual achievement (Signature)</th>
</tr>
</thead>
</table>

- **<On Addition of and Change in Work>**

1. When there was an addition or change in the scheduled work, describe it in the table using a pencil.

2. When an addition work is completed, indicate it using a red pencil. Connect the work before and after it with an arrow.

3. Select the applicable reason for the change from the following and write its number near the arrow.

- "List of reasons of addition or
1. Because of a change in the working schedule due to a holiday or other factors.
2. Because of the influence of an addition or change in other work.
3. Because of an accident or disaster.
4. Because of the convenience of the business partner.
5. Because of addition of all-night feed.
6. Because of equipment failure.
7. Because of an extraordinary inspection due to equipment failure or other factor.
8. Because the work was added after the scheduled job was completed.
9. Other reason (Describe it clearly and in an easy-to-understand manner).

<On actual achievement of work>
(1) When the scheduled work was
implemented, affix a “Completed” seal next to the end of the name of the work.

(2) When work that was added or changed is completed, affix a “Completed” seal to the portion furnished with rubrics after the change.
### 3. Long-term Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Sheet number/Total number of sheets</th>
<th>Periodic Maintenance Plan</th>
<th>Hanoi Metro Company</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Department: Signal and Communication Equipment Inspection and Repair Center</td>
<td>Route: 2A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Equipment name</th>
<th>Contents of inspection code</th>
<th>Inspection period</th>
<th>Location of inspection</th>
<th>(Year)</th>
<th>(Year)</th>
</tr>
</thead>
</table>

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<th>September</th>
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<th>November</th>
<th>December</th>
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<tr>
<td>Inspection</td>
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<td>Repair</td>
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</tbody>
</table>

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.
4. Budget Planning (Form)

<table>
<thead>
<tr>
<th>Maintenance time</th>
<th>Contents of work</th>
<th>Method of implementation</th>
<th>Equipment use period</th>
<th>Maintenance cycle</th>
<th>Durable years</th>
<th>Total implementation cost</th>
<th>Cost breakdown</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
F: Acceptance Inspection, Quality Evaluation and Monitoring after Work
- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the company.

G: Implementing Organization
1. Organizational Structure

2. Responsibility for Implementation
- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager in charge of signal equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the signal equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Deputy Manager in charge of communication equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the communication equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Section Engineer shall be responsible for developing the plan for the specialized area in his charge, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- The communication inspection and repair worker shall be responsible for maintaining the communication equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.
- The signal inspection and repair worker shall be responsible for maintaining the signal equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the Signal and Communication Equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to appropriately perform signal communication equipment maintenance of the Line 2A.

Such proposals and/or propositions presented to HQ shall be made in accordance with the regulation.
JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual
〈Line 2A electric power equipment〉

Implementer: Nguyen Viet Quan
JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi
Contents
A: Legal Foundation
  1. Laws and Regulations
  2. Relevant Materials
  3. Purpose
  4. Definition of Terms and Interpretation of Abbreviations
     4.1. Definition of Terms
     4.2. Interpretation of Abbreviations
  5. List of Power Facilities
     (List of outline of the equipment and systems managed by the electric power equipment Section.)

B: Requirements for Maintenance Facilities, Equipment and Staff
  1. Requirements for Facilities and Equipment
     1.1. Requirements for Facilities
     1.2. Requirements for Equipment
     1.3. Requirements for Maintenance Tools and Devices
  2. Requirements for Staff
     2.1. Requirements for Number of Maintenance Staff
     2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

C: Classification of Maintenance Operations and Work Implementation Flow
  1. Classification of Maintenance Operations
  2. Work Implementation Flow
     2.1. Operating Report Preparation Flow
     2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning
     2.3. Monthly Workload Planning Preparation Flow
     2.4. Work Instructions Preparation Flow
     2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow
     2.6. Business Plan and Budget Preparation Flow
     2.7. Flow of Response to Accidents and Transport Disorders

D: Survey Measurement and Validation of Equipment Condition
  1. Installation Location
  2. Validation of Equipment Operating Status
     2.1. Overall Inspection of Equipment
     2.2. Detailed Equipment Inspection

E: Plan Development
  1. Plan of the Day (Form)
  2. Monthly Maintenance Plan (Form)
3. Long-term Maintenance Plan (Form)
4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization
1. Organizational Structure
2. Responsibility for Implementation
3. Revision and Additions

Attached Reference Materials

1. Organizational Structure, Functions and Assignment of Maintenance Section at Headquarters (HQ) and in Field (OU)
2. Procedure for Calculating Necessary Number of OU Staff
3. Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)
4. Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)
5. Guideline for Creating Staff Training and Education Plan
6. Criteria for Number of Units Installed
7. Provisions on Information Sharing
8. Guideline and Form for Creating Equipment Ledger
9. Ledger Form of Equipment Durable Years
A: Legal Foundation

1. Laws and Regulations
- Vietnam Railway Act 2005:
  - Contents of this regulation shall be compliant with the laws and regulations of Vietnam. Currently, regulations and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above regulations and standards are officially announced, we must update and recreate our regulations in order to comply with them.

2. Relevant Materials
- Vietnam Railway Act 2005:
  - Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
  - Circular No. 07/2014/TT-BLDTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
  - Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
  - Standard QCVN No. 06:2011/BGTVT on Railway Signals.
  - Standard QCVN No. 08:2015/BGTVT on Railway Operation.
  - Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.
  - Standard QCVN No. QB-T-5: 2009 on Verification of Electrical System Facility.
  - TCVN No. 8585:2011 on Urban Railway for Fast and Mass Transit
  - Basic Standard TCCS No.01:2009/VNRA on Design, Construction and Acceptance Inspection of Railway Signal Communication Construction
  - General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
  - Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA
  - Specifications provided by equipment provider/contractor
  - Technology design for the Line 2A (Cat Linh-Ha Dong) Equipment (Chinese consultant)
  - Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
  - Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
  - Other Reference Material from TA Project
  - Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

3. Purpose
The electric power equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the electric power equipment by making sure that the maintenance staff's work practices and procedures are consistent with the regulations.
4. Definition of Terms and Interpretation of Abbreviations

4.1. Definition of Terms

The term **equipment** denotes the communication equipment, signal equipment, electric power equipment and station equipment.

**Communication equipment** is the provision used to ensure safe operation and provide communication for passenger service.

**Signal equipment** consists of the interlocking device and the signal system that controls trains for the safe operation.

**Electric power equipment** is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

**The electric room of a station** is the room containing equipment that supplies power to station equipment.

**The electric room of a depot** is the room containing equipment that supplies power to depot equipment.

**Station equipment** refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

**Equipment maintenance** refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

**Inspection** means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

**Periodic inspections** involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

**Extraordinary inspection** refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

**Maintenance** denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

**Repair** is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

**Periodic repair** refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

**Extraordinary repairs** are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

**Design** quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

**Maintenance staff** denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

**The maintenance plan** is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.
Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTĐBXH: Ministry of Industrial Injury and Society

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard

TCCS: Base Criteria

QTKĐ: Verification process

ATC: Automatic Train Control

ATO: Automatic Train Operation

ATS: Automatic Train Supervision

ATP: Automatic Train Protection

PAS: Public Address Systems

AWS: Automatic Warning System

..........................

5. List of Power Facilities
B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Facilities and Equipment

1.1. Requirements for Facilities

Create a list of facilities, devices and tools used to implement the maintenance process based on the specifications of the electric power equipment and the requirements for tools and devices. The above list becomes the basis of future maintenance work.

**List of Facilities, Tools and Devices used for Maintenance of Electric power equipment**

<table>
<thead>
<tr>
<th>Order</th>
<th>Device name</th>
<th>Standard or specification</th>
<th>Intended purpose</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.2. Requirements for Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

**Electric power equipment Specification Table**

<table>
<thead>
<tr>
<th>Order</th>
<th>System names</th>
<th>Accessory equipment</th>
<th>Specification</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cable</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Transformer (low voltage)</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Main potential transformer for rectifier</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Distribution board</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Enclosed AC switchboard</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Enclosed DC switchboard</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>DC breaker</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Section over protective equipment</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Emergency block system</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Earthing device</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Third rail</td>
<td>As per equipment</td>
<td>As per equipment</td>
<td></td>
</tr>
</tbody>
</table>

- 65 -
12. Landmarks and Sign Markers

As per equipment provider

13. ........................................

- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices

- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Staff

2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. How to calculate the number of No.2A staff

a. Number of managerial staff

- The number depends on the workload and administrative abilities.
  + Managerial staff may directly carry out maintenance work.
  + In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.
  + Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.

- Should be determined based on the workload.
- The number should be determined based on the maintenance plan developed.

➤ When Line 2A began operations, four managerial staff were assigned to the line. Namely, they were a Manager, a Deputy Manager and two Section Engineers.

b. Number of workers

- The number depends on the equipment maintenance workload.
- Holidays and sick leave taken by maintenance staff must be taken into consideration.
- Three workers shall be allocated to each of the main transformer stations according to the standard set down for the Line 2A. Six main transformer stations are installed for each station of the Line 2A.

➤ Number of electric power inspection and repair workers

  3 workers x 6 transformer stations = 18 workers

One Leader and 17 workers engage in maintenance of equipment in the transformer station. Workers of two shifts in a 3-shift system are on duty of maintenance. The shift roster approved by the Manager must be observed (The number of workers of a team varies depending on the workload and the number of equipment items subject to maintenance).

2.1.2. For reference when calculating the number of other staff
2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Center Manager assumes the total responsibility for all operations performed at the Center, and provides guidance to the Center employees to ensure they implement the allotted assignments. The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager meet the following requirements.

- Has a college education or above, and expert knowledge on management of the electric power equipment.
- Has more than three years of experience in the electric power equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating, and has sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager shall assist the Manager in executing the Center's operations, and share and manage the field of safety, production and general affairs of the Center. Therefore, the Deputy Manager must meet the following requirements.

- Has a college education or above, and expert knowledge on management of the electric power equipment.
- Has more than two years of experience in the electric power equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Electricity Section Engineer assumes the responsibility of managing the electric power equipment-related technology, handling failures and implementing recovery measures in urgent situations. Therefore, the Electricity Section Engineer must meet the following requirements.

- Has a college education or above
- Has an expert knowledge about the principle of the electric power equipment system, understands the technical processes, technical standard and recovery measures in urgent situations, and a high degree of skill in handling software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. The electric power equipment maintenance worker is responsible for maintaining the electric power equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the worker must meet the following requirements.
- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the electric power equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

C: Classification of Maintenance Operations and Work Implementation Flow

1. Classification of Maintenance Operations

- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.
2. Work Implementation Flow

2.1. Operating Report Preparation Flow

End of work

Input to Operating Report
OU Worker

Check and submission of Operating Report
OU Leader

When the Operating Report contains descriptions about a failure, the Working Report (copy) is submitted.

Check and storage of Operating Report
HQ Engineer

Reception and check of Operating Report
OU Engineer

When new work is required, correct Monthly Workload Planning and create Work Instructions.

Check of Operating Report
OU Deputy Manager

Storage of Operating Report
OU Engineer

Approval of Operating Report
OU Manager

When the contents of the extraordinary and periodic inspections are the same, input the results into the Inspection Table.

Reporting
HQ Deputy Manager

Reporting
HQ Manager

Proceed to input the actual achievement data into Monthly Workload Planning
OU Engineer
2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning

After work results in the Monthly Workload Planning have been validated, the Monthly Workload Planning (copy) is submitted.
2.3. Monthly Workload Planning Preparation Flow

- Occurrence of new work to respond to repair requests, etc.
  - Necessary patrol

- Change of the working day due to a holiday or other factor

---

Periodic Inspection Roadmap

Maintenance and Repair Plan

---

Preparation and correction of Monthly Workload Planning
OU Engineer

- When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

---

Check of contents of Monthly Workload Planning
OU Deputy Manager

When changing the periodic inspection date, make sure that the changed-to-date is within the period.

---

Approval of Monthly Workload Planning
OU Manager

Management of Monthly Workload Planning
OU Engineer

Proceed with preparation of work instructions
2.4. Work Instructions Preparation Flow

Implementation of new work to respond to repair requests, etc.

Due to a change of scene, etc. Change of planned work

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

Monthly Workload Planning

Preparation and correction of Work Instructions
OU Engineer

Check of Work Instructions
OU Deputy Manager

Approval of Work Instructions
OU Manager

Operating instructions based on Work Instructions
OU Engineer

Preparations for and implementation of work
OU Leader and worker

End of work
OU Leader and worker

Proceed to preparation of Operating Report
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow

<table>
<thead>
<tr>
<th>Activity</th>
<th>Responsible Party</th>
<th>Activity</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Periodic Inspection Roadmap</td>
<td>OU Engineer</td>
<td>Storage of Periodic Inspection Roadmap</td>
<td>OU Engineer</td>
</tr>
<tr>
<td>Check of Periodic Inspection Roadmap</td>
<td>OU Deputy Manager</td>
<td>Proceed to preparation of Scheduled Monthly Workload Planning</td>
<td>OU Engineer</td>
</tr>
<tr>
<td>Approval of Periodic Inspection Roadmap</td>
<td>OU Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Checking and Taking Custody of Periodic Inspection Roadmap</td>
<td>HQ Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance Rules</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Including Inspection Base Date Control Table)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraordinary inspection, equipment improvement, equipment update, etc. (as needed)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.6. Business Plan and Budget Preparation Flow

Company policy

Request from other department

Request from OU

Ledger of Equipment
Durable Years, update plan, etc.

Preparation of Business Plan and
Budget Bill
HQ Engineer

Check of Business Plan and
Budget Bill
HQ Deputy Manager

Approval of Business Plan and
Budget Bill
HQ Manager

Check and adjustment by the
Corporate Planning Department,
Financial Department, etc.

Decided in the board meeting or by
president (depending on the
company structure)
2.7. Flow of Response to Accidents and Transport Disorders

- Report from Worker, etc.
- Report from OCC
- Contact from other department (OU)
- Contact from other department (HQ)

OU Manager
Accident response
OU

HQ Manager

Accident response
HQ

Handling completed

Flash report (within a day as a general rule)
OU Manager

Interim report (within seven days as a general rule)
OU Manager

Final report (within 14 days as a general rule)
OU Manager

Information and instruction

Reporting to the administrative agency, etc. (in accordance with the law)
HQ Manager
D: Survey Measurement and Validation of Equipment Condition

1. Installation Location
- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status

2.1. Overall Inspection of Equipment
- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

<table>
<thead>
<tr>
<th>Order</th>
<th>System names</th>
<th>Contents of inspection (For reference only)</th>
<th>Inspection cycle</th>
<th>Note</th>
</tr>
</thead>
</table>
| 1     | Circuit breaker    | 1. Acceptability of wiring and mechanism  
                                    2. Suitability of insulation resistance  
                                    3. Acceptability of operation and condition (including lubrication) |                  |      |
| 2     | Transformer        | 1. Acceptability of wiring and mechanism  
                                    2. Suitability of insulation resistance  
                                    3. Acceptability of operation and condition of accessory device |                  |      |
| 3     | Rectifier          | 1. Acceptability of wiring and mechanism  
                                    2. Suitability of insulation resistance  
                                    3. Acceptability of operation and condition of cooling system  
                                    4. Acceptability of operation and condition of accessory device |                  |      |
| 4     | Distribution board | 1. Suitability of voltage, etc.  
                                    2. Acceptability of display  
                                    3. Acceptability of wiring and mechanism  
                                    Acceptability of relay  
                                    4. Suitability of insulation resistance  
                                    5. Acceptability of sequence control (program-based control of conditions)  
                                    Acceptability of control after the conditions are met |                  |      |
<p>| 5     | Power management   | 1. Acceptability of function and control of OCC equipment |                  |      |</p>
<table>
<thead>
<tr>
<th>Device</th>
<th>1. Acceptability of grounding wire</th>
<th>2. Suitability of earth resistance value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting materials</td>
<td>1. Acceptability of various power poles, supporting brackets, accessory fixtures, insulation materials, etc.</td>
<td>2. Acceptability of trough, fire-proof compartment, etc.</td>
</tr>
<tr>
<td>(including supporting insulator)</td>
<td>3. Acceptability of measures against water leakage, water immersion, damage caused by rats and disasters.</td>
<td>4. Measurement of track clearance</td>
</tr>
<tr>
<td>Positive feeder</td>
<td>1. Suitability of insulation resistance (= Leak current)</td>
<td>2. Acceptability cables, connections, etc.</td>
</tr>
<tr>
<td>DC breaker</td>
<td>1. Acceptability of wiring and mechanism</td>
<td>2. Suitability of insulation resistance</td>
</tr>
<tr>
<td>Return circuit and grounding wire</td>
<td>3. Acceptability of operation and condition</td>
<td>4. Acceptability of accessory device</td>
</tr>
<tr>
<td>Third rail</td>
<td>1. Suitability of insulation resistance (= Leak current)</td>
<td>2. Acceptability of installed condition of third rail</td>
</tr>
<tr>
<td>Land marks and sign markers</td>
<td>1. Acceptability of installed condition</td>
<td>2. Acceptability attached cables, connections, etc.</td>
</tr>
<tr>
<td>12</td>
<td>Acceptability of installed condition</td>
<td>4. Acceptability of accessory device</td>
</tr>
<tr>
<td>13</td>
<td>..........................</td>
<td>..........................</td>
</tr>
</tbody>
</table>
E: Development of Plan (Create the form according to the Plan Preparation Manual) 1. Plan of the day (List the maintenance items of the day according to the Monthly Maintenance Plan)

1.1. Work Instructions

<table>
<thead>
<tr>
<th>Work Instructions</th>
<th>Date and time (Work implementation time specified in the Work Instructions)</th>
<th>OU Manager (Approver)</th>
<th>OU Deputy Manager (Checker)</th>
<th>OU Engineer (Preparer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric power equipment Inspection and Repair Center: the Line 2A</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time when a failure detected (Describe date and time in detail)</th>
<th>Year __ Month __ Day __ Hour __</th>
<th>Requested by (Signature)</th>
<th>Including the reason why the failure was detected Station, alarm, periodic inspection, patrol and other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location and equipment name</td>
<td>Work code (When provided)</td>
<td>Work code (When provided)</td>
<td></td>
</tr>
<tr>
<td>Work name</td>
<td>Contents of instruction (What, how, by when, current situation, drawings, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>-----------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Precautions for work (A special location, requirements, precautions for work)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 1.2. Operating Report

<table>
<thead>
<tr>
<th>Working hours</th>
<th>Day/Night</th>
<th>Materials used (To be clearly indicated in the instructions)</th>
<th>Available/Unavailable</th>
<th>Arrangement Date</th>
<th>Receipt of material</th>
<th>Operating Report</th>
<th>Date repair completed</th>
<th>Date</th>
<th>Reported by (Signature of Leader)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OU Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Confirmation of completion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Correction of records in Inspection Table</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes/No/Finished</td>
</tr>
<tr>
<td>Date</td>
<td>Name of worker</td>
<td>Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)</td>
<td>Check by OU Deputy Manager (When work of the shift is not completed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Necessity for request of special repair
(When approval of HQ Station Equipment Section is necessary)

<table>
<thead>
<tr>
<th>Cause, treatment, comments</th>
<th>Model of removed item</th>
<th>Serial number of removed item</th>
<th>Date of manufacturing of removed item</th>
<th>Name of manufacturer of removed item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Necessity / Not necessary</td>
<td>Model of installed item</td>
<td>Serial number of installed item</td>
<td>Date of manufacturing of installed item</td>
<td>Name of manufacturer of installed item</td>
</tr>
</tbody>
</table>

### 2. Monthly Maintenance Plan (Form)
### Revision history

#### Year _ Month _ Workload Planning

**Department:** Electric power equipment Inspection and Repair Center

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Contents of inspection</th>
<th>Location of inspection</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shift 1</td>
<td>Shift 2</td>
<td>Shift 3</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
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</table>

(1) When there was an addition or change in the scheduled work, describe it in the table using a pencil.

(2) When an addition work is completed, indicate it using a red pencil. Connect the work before and after it with an arrow.

(3) Select the applicable reason for the change from the following and write its number near the arrow.

"List of reasons of addition or change"

1. Because of a change in the working schedule due to a holiday
2. Because of the influence of an addition or change in other work.
3. Because of an accident or disaster.
4. Because of the convenience of the business partner.
5. Because of addition of all-night feed
6. Because of equipment failure.
7. Because of an extraordinary inspection due to equipment failure or other factor.
8. Because the work was added after the scheduled job was completed.
9. Other reason (Describe it clearly and in an easy-to-understand manner)

<On actual achievement of work>
(1) When the scheduled work was implemented, affix a “Completed” seal next to the end of the name of the work.
(2) When work that was added or changed is completed, affix a
“Completed” seal to the portion furnished with rubrics after the change.
### Long-term Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Equipment name</th>
<th>Contents of inspection</th>
<th>Inspection code</th>
<th>Inspection period</th>
<th>Location of inspection</th>
<th>(Year)</th>
<th>(Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection</td>
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<td>Repair</td>
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</tbody>
</table>

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.
4. Budget Planning (Form)

<table>
<thead>
<tr>
<th>Maintenance time</th>
<th>Contents of work</th>
<th>Method of implementation</th>
<th>Equipment use period</th>
<th>Maintenance cycle</th>
<th>Durable years</th>
<th>Total implementation cost</th>
<th>Cost breakdown</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>Day</td>
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</tbody>
</table>
F: Acceptance Inspection, Quality Evaluation and Monitoring after Work
- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the company.

G: Implementing Organization

1. Organizational Structure

2. Responsibility for Implementation

- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager shall be responsible for developing the safety-related plan, instructing staff on how to manage the electric power equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Power Section Engineer shall be responsible for developing the plan for his specialized area, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- The power inspection and repair worker shall be responsible maintaining the electric power equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the electric power equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to ensure electric power equipment of the Line 2A is appropriately maintained.

Such proposals and/or propositions presented to HQ shall be made in accordance with the regulation.
JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual
   (Line 2A station equipment)

Implementer: Nguyen Viet Quan
JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi
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4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization
1. Organizational Structure
2. Responsibility for Implementation
3. Revision and Additions

Attached Reference Materials

1. Organizational Structure, Functions and Assignment of Maintenance Section at Headquarters (HQ) and in Field (OU)
2. Procedure for Calculating Necessary Number of OU Staff
3. Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)
4. Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)
5. Guideline for Creating Staff Training and Education Plan
6. Criteria for Number of Units Installed
7. Provisions on Information Sharing
8. Guideline and Form for Creating Equipment Ledger
9. Ledger Form of Equipment Durable Years
A: Legal Foundation

1. Laws and Rules

- Vietnam Railway Act 2005:
  - Contents of this rule shall be compliant with the laws and rules of Vietnam. Currently, rules and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above rules and standards are officially announced, we must update and recreate our rules in order to comply with them.

2. Relevant Materials

- Vietnam Railway Act 2005
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No. 21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.
- Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.
- Standard QCVN No. QDT-5: 2009 on Verification of Facility of Electrical System.
- National Technical Standard QCVN No. 02:2011/BLĐTBXH on Electric Elevators.
- Escalator Safety Technology Verification Standard QTKD No. 002:2008/BLĐTBXH.
- Electric Elevator and Hydraulic Elevator Safety Technology Verification Standard QTKD No. 003:2008/BLĐTBXH.
- Vietnam Standard No. TCVN 5760 on Requirements for General Technology used for Design, Installation and Use of Fire Extinguishing System.
- Vietnam Standard No. TCVN 5738 on Requirements for Technology used for Automatic Fire Alarm System.
- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
3. Purpose
The Station Equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the station equipment by making sure that the maintenance staff's work practices and procedures are consistent with the rule.

4. Definition of Terms and Interpretation of Abbreviations
4.1 Definition of Terms
The term equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.
Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.
Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.
Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.
The electric room of a station is the room containing equipment that supplies power to station equipment.
The electric room of a depot is the room containing equipment that supplies power to depot equipment.
Station equipment refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.
Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.
Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.
Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.
Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.
Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.
Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.
Periodic repair refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTBXH: Ministry of Industrial Injury and Society

ĐĐTBDXH: Ministry of Industrial Injury and Society

ĐSMART: Ministry of Public Safety

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard
5. List of Station Facilities

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Maintenance Facilities and Equipment

1.1. Requirements for Facilities

Create a list of facilities, devices and tools used to implement the maintenance process based on the specifications of the station equipment and the requirements for tools and devices. The above list becomes the basis of future maintenance work.

<table>
<thead>
<tr>
<th>Order</th>
<th>Device name</th>
<th>Standard or specification</th>
<th>Intended purpose</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

1.2. Requirements for Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

<table>
<thead>
<tr>
<th>Order</th>
<th>Equipment and system names</th>
<th>Specification</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Elevator</td>
<td>As per equipment provider</td>
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<tr>
<td>2</td>
<td>Escalator</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Equipment of air conditioning and ventilation systems</td>
<td>As per equipment provider</td>
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</tr>
<tr>
<td>4</td>
<td>Lighting equipment</td>
<td>As per equipment provider</td>
<td></td>
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<tr>
<td>5</td>
<td>Lightning protection system</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Fire alarm and detection equipment</td>
<td>As per equipment provider</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Feed-water and drainage equipment (pump, water pipe, etc.)</td>
<td>As per equipment provider</td>
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</tbody>
</table>
Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices
- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Maintenance Staff
2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU: Based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. The number of managerial staff computed based on the method used in calculating the number of necessary staff for the Line 2A
- The number depends on the workload and administrative abilities.
+ Managerial staff may directly carry out maintenance work.
+ In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.
+ Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.
- Should be determined based on the workload of 12 stations (the Line 2A comprises 12 stations)
- The number should be determined based on the maintenance plan developed.

➔ When the business was started, six managerial staff were working at the Station Equipment Inspection and Repair Center of the Line 2A to ensure management and execution of the maintenance work. Its composition was a Manager, two Deputy Managers (one in charge of safety and the other in charge of operations), and three Section Engineers.

b. Number of workers
- The number depends on the equipment maintenance workload.
- The maintenance criteria of the Beijing Railway specifies 3.5 general inspection and repair workers per station and 0.1 elevator inspection and repair worker per station for each of 12 stations of the Line 2A.

➔ Therefore, 42 general inspection and repair workers (3.5 x 12) are necessary.

12 elevator inspection and repair workers (0.1 x 12) are required.

General inspection and repair workers are grouped into two teams and a Leader is assigned to each team. One team is in charge of maintenance of six stations and carries out the work over three shifts according to the shift table approved by the Manager. (The number of workers in a team varies depending on the workload and the number of equipment items subject to maintenance.)

- Elevator inspection and repair workers are grouped into two teams. A team, consisting of a Leader and five workers, carries out elevator maintenance at six stations. According to the system, 2/3 out of the three shifts carries out the work.

2.1.2. For reference when calculating the number of other staff
- The HQ and OU staff number calculation method and shift table created by the specialist in the TA project and C/P (Attached material)

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Manager of OU assumes total responsibility for all operations performed at the Center, and is responsible for providing guidance to Center employees to ensure they implement the allotted assignments. The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager of OU must meet the following requirements.
- Has a college education or above, and expert knowledge on station equipment management.
- Has more than three years of experience in the station equipment management.
- Is knowledgeable in the applicable laws and rules, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating, and has sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager in charge of safety shall assist the Manager of OU in executing the Center's operations and assume the responsibility in managing the safety-related assignment. Therefore, the Deputy Manager in charge of safety at the Station Equipment Inspection and Repair Center must meet the following requirements.
- Has a college education or above, and expert knowledge on station equipment management.
- Has more than two years of experience in the station equipment management.
- Is knowledgeable in the applicable laws and rules, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Deputy Manager in charge of operation shall assist the Manager of OU in executing the Center's operations and assume the responsibility mainly in the production sector. Therefore, the Deputy Manager in charge of operation at the Station Equipment Inspection and Repair Center must meet the following requirements.
- Has a college education or above, and expert knowledge on station equipment management.
- Has more than two years of experience in the station equipment management.
- Is knowledgeable in the applicable laws and rules, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.
2.2.4. The Section Engineer assumes responsibility for managing the technology used for the station elevators and other equipment, handling failures, and implementing recovery measures in the case of urgent accidents. Therefore, the Section Engineer must meet the following requirements.
- Has a college education or above
- Has expert knowledge about the principles of the station equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.5. The general inspection and repair worker is responsible for implementing respective phases of maintenance for each item of equipment except elevators according to the rules and procedures specified by the company, and is also responsible for rescuing passengers rapidly and directly should an accident or failure occur. Therefore, the worker must meet the following requirements.
- Has a high school education or above
- Has generic knowledge about station equipment or specialist knowledge in the relevant area.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

2.2.6. Elevator inspection and repair workers have the responsibility of implementing elevator maintenance work according to the rules and procedures specified by the law or company, and directly implementing emergency measures should an accident occur. Therefore, elevator inspection and repair worker must meet the following requirements.
- Has a high school education or above
- Is legally qualified to carry out elevator maintenance and possesses the relevant certificate.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

C: Classification of Maintenance Operations and Work Implementation Flow
1. Classification of Maintenance Operations
- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.
2. Work Implementation Flow

2.1. Operating Report Preparation Flow

- End of work

- Input to Operating Report
  OU Worker

- Check and submission of Operating Report
  OU Leader

End of work

- Reception and check of Operating Report
  OU Engineer

- Check of Operating Report
  OU Deputy Manager

- Approval of Operating Report
  OU Engineer

When the contents of the extraordinary and periodic inspections are the same, input the results into the Inspection Table.

When new work is required, correct Monthly Workload Planning and create Work Instructions.

When the Operating Report contains descriptions about a failure, the Working Report (copy) is submitted.

Proceed to input the actual achievement data into Monthly Workload Planning.

OU Engineer

HQ Manager

HQ Deputy Manager

HQ Engineer

Reporting

Reporting

* When the Operating Report contains descriptions about a failure, the Working Report (copy) is submitted.
2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning

After work results in the Monthly Workload Planning have been validated, the Monthly Workload Planning (copy) is submitted.

**Storage of Operating Report**
OU Engineer

**Proceed to input the actual achievement data into Monthly Workload Planning**
OU Engineer

**Proceed to check of actual achievement in Monthly Workload Planning**
OU Deputy Manager

**Approval of actual achievement in Monthly Workload Planning**
OU Manager

**Check of actual achievement in Monthly Workload Planning and its storage**
HQ Engineer

**Reporting**
HQ Deputy Manager

**Reporting**
HQ Manager

**Storage of Monthly Workload Planning**
OU Engineer
2.3. Monthly Workload Planning Preparation Flow

Periodic Inspection Roadmap

Repair Plan

Occurrence of new work to respond to repair requests, etc.
Necessary patrol

Change of the working day due to a holiday or other factor

Preparation and correction of Monthly Workload Planning
OU Engineer

Check of contents of Monthly Workload Planning
OU Deputy Manager

Approval of Monthly Workload Planning
OU Manager

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

Management of Monthly Workload Planning
OU Engineer

Proceed with preparation of work instructions

When changing the periodic inspection date, make sure that the changed-to-date is within the period.

Occurrence of new work to respond to repair requests, etc.
Necessary patrol
2.4. Work Instructions Preparation Flow

Due to a change of scene, etc.
Change of planned work

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

Implementation of new work to respond to repair requests, etc.

Preparation and correction of Work Instructions
OU Engineer

Check of Work Instructions
OU Deputy Manager

Approval of Work Instructions
OU Manager

Operating instructions based on Work Instructions
OU Engineer

Preparations for and implementation of work
OU Leader and worker

End of work
OU Leader and worker

Proceed to preparation of Operating Report

Monthly Workload Planning
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow

- Maintenance Rules (Including Inspection Base Date Control Table)
- Extraordinary inspection, equipment improvement, equipment update, etc. (as needed)

- Preparation of Periodic Inspection Roadmap
  - OU Engineer

- Check of Periodic Inspection Roadmap
  - OU Deputy Manager

- Approval of Periodic Inspection Roadmap
  - OU Manager

- Storage of Periodic Inspection Roadmap
  - OU Engineer

- Submission of Periodic Inspection Roadmap (copy)

- Checking and Taking Custody of Periodic Inspection Roadmap
  - HQ Engineer

- Proceed to preparation of Scheduled Monthly Workload Planning

- HQ Deputy Manager

- Reporting

- HQ Manager
2.6. Business Plan and Budget Preparation Flow

- Company policy
- Request from other department
- Request from OU

Ledger of Equipment
Durable Years, update plan, etc.

Preparation of Business Plan and Budget Bill
HQ Engineer

Check of Business Plan and Budget Bill
HQ Deputy Manager

Approval of Business Plan and Budget Bill
HQ Manager

Check and adjustment by the Corporate Planning Department, Financial Department, etc.

Decided in the board meeting or by president (depending on the company structure)
2.7. Flow of Response to Accidents and Transport Disorders

- **Report from Worker, etc.**
  - OU Manager

- **Report from OCC**
  - OU Manager

- **Contact from other department (OU)**
  - OU Manager

- **Contact from other department (HQ)**
  - HQ Manager

- **Accident response (OU)**

- **Handling completed**

- **Flash report (within a day as a general rule)**
  - OU Manager

- **Interim report (within seven days as a general rule)**
  - OU Manager

- **Final report (within 14 days as a general rule)**
  - OU Manager

- **Reporting to the administrative agency, etc. (in accordance with the law)**
  - HQ Manager
D: Survey Measurement and Validation of Equipment Condition

1. Installation Location
- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status

2.1. Overall Inspection of Equipment
- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

<table>
<thead>
<tr>
<th>Order</th>
<th>Equipment name</th>
<th>Contents of inspection (For reference only)</th>
<th>Inspection cycle</th>
<th>Note</th>
</tr>
</thead>
</table>
| 1     | Equipment of air conditioning and ventilation systems | 1. Operating rate of equipment  
2. Operating status of heating device and motor  
3. Operating status of fan of cooling device  
4. Operating status of fan for change of direction  
5. Appropriateness of voltage | Check them once a year or as many as suggested by the provider. |                   |
| 2     | Elevator                             | 1. Distribution board and hoisting machine  
2. Balance between elevator car and weight  
3. Elevator door  
4. Pit  
5. Elevator car door  
6. Test run | Twice a year or as many as suggested by the provider. |                   |
| 3     | Escalator                            | 1. Distribution board and hoisting machine  
2. Control board  
3. Intermediate place  
4. Exterior  
5. Test run | Twice a year or as many as suggested by the provider. |                   |
| 4     | Feed-water and drainage equipment (pump, water pipe, etc.) | - According to the rule of, or suggestion from, the provider. | According to suggestion by provider. |                   |
| 5     | Lighting equipment                   | - According to the rule of, or suggestion from, the provider. | According to suggestion by provider. |                   |
| 6     | Lightning protection system          | 1. Acceptability of wiring of distribution lines.  
2. Suitability of earth resistance value.  
3. Presence or absence of evidence of wear. | Once a year at minimum (According to |                   |
4. Presence or absence of influence of structural change of a station to the lightning protection system.

5. Fire alarm and detection equipment

- According to the rule or suggestion from the provider.
- Twice a year (According to TT52/2014/TT-BCA)
### E: Preparation of Plan (Request for plan and format preparation)

1. Plan of the Day (List the maintenance items of the day according to the Monthly Maintenance Plan)

#### 1.1. Work Instructions

<table>
<thead>
<tr>
<th>Work Instructions</th>
<th>Date and time (Work implementation time specified in the Work Instructions)</th>
<th>OU Manager (Approver)</th>
<th>OU Deputy Manager (Checker)</th>
<th>OU Engineer (Preparer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Station Equipment Inspection and Repair Center: the Line 2A</td>
<td>(Signature)</td>
<td>(Signature)</td>
<td>(Signature)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time when a failure detected (Describe date and time in detail)</th>
<th>Year __ Month __ Day __ Hour __</th>
<th>Requested by (Signature)</th>
<th>Including the reason why the failure was detected Station, alarm, periodic inspection, patrol and other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location and equipment name</td>
<td>Work code (When provided)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work name</td>
<td></td>
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</tr>
</tbody>
</table>

Contents of instruction (What, how, by when, current situation, drawings, etc.)

<table>
<thead>
<tr>
<th>Precautions for work (A special location, requirements, precautions for work)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

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# 1.2. Operating Report

<table>
<thead>
<tr>
<th>Working hours</th>
<th>Day/ Night</th>
<th>Materials used (To be clearly indicated in the instructions)</th>
<th>Available/ Unavailable</th>
<th>Arrangement Date</th>
<th>Receipt of material</th>
<th>Operating Report</th>
<th>Date repair completed</th>
<th>Date</th>
<th>Reported by (Signature of Leader)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**OU Manager**

**OU Deputy Manager**

**OU Engineer**

**Confirmation of completion**

<table>
<thead>
<tr>
<th>Correction of records in Inspection Table</th>
<th>Input to Monthly Failure Report</th>
<th>Correction of maintenance drawing</th>
<th>Correction of Equipment Ledger</th>
<th>Input to Shipping/Receiving Card</th>
<th>Yes/No/Finished</th>
<th>Yes/No/Finished</th>
<th>Yes/No/Finished</th>
<th>Yes/No/Finished</th>
<th>Check by OU Deputy Manager (When work of the shift is not completed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Report</td>
<td>Date repair completed</td>
<td>Date</td>
<td></td>
<td></td>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
<td>Yes/No/Finished</td>
<td>Check by OU Deputy Manager (When work of the shift is not completed)</td>
</tr>
</tbody>
</table>

**Date**

<table>
<thead>
<tr>
<th>Date</th>
<th>Name of worker</th>
<th>Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>Cause, treatment, comments</td>
<td>Model of removed item</td>
<td>Model of installed item</td>
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<tr>
<td>---------------------------</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Necessity for request of special repair (When approval of HQ Station Equipment Section is necessary)</th>
<th>Necessary / Not necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model of removed item</td>
<td>Serial number of removed item</td>
</tr>
<tr>
<td>Model of installed item</td>
<td>Serial number of installed item</td>
</tr>
<tr>
<td>Date of manufacturing of removed item</td>
<td>Date of manufacturing of installed item</td>
</tr>
<tr>
<td>Name of manufacturer of removed item</td>
<td>Name of manufacturer of installed item</td>
</tr>
</tbody>
</table>
### 2. Monthly Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Contents of inspection</th>
<th>Location of inspection</th>
<th>Plan (Signature)</th>
<th>Actual achievement (Signature)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;On Addition of and Change in Work&gt;</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) When there was an addition or change in the scheduled work, describe it in the table using a pencil.</td>
</tr>
<tr>
<td>2</td>
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<td></td>
<td>(2) When an addition work is completed, indicate it using a red pencil. Connect the work before and after it with an arrow.</td>
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<tr>
<td>3</td>
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<td>(3) Select the applicable reason for the change from the following and write its number near the arrow.</td>
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<tr>
<td>4</td>
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<td></td>
<td></td>
<td></td>
<td>&quot;List of reasons of addition or change&quot;</td>
</tr>
<tr>
<td>5</td>
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<td></td>
<td>1. Because of a change in the</td>
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</tbody>
</table>
working schedule due to a holiday or other factors.
2. Because of the influence of an addition or change in other work.
3. Because of an accident or disaster.
4. Because of the convenience of the business partner.
5. Because of addition of all-night feed
6. Because of equipment failure.
7. Because of an extraordinary inspection due to equipment failure or other factor.
8. Because the work was added after the scheduled job was completed.
9. Other reason (Describe it clearly and in an easy-to-understand manner)

<On actual achievement of work>
(1) When the scheduled work was implemented, affix a “Completed” seal next to the end of the name of the work.
(2) When work that was added or
changed is completed, affix a "Completed" seal to the portion furnished with rubrics after the change.
### 3. Long-term Maintenance Plan (Form)

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Equipment name</th>
<th>Contents of inspection</th>
<th>Inspection code</th>
<th>Inspection period</th>
<th>Location of inspection</th>
<th>(Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection</td>
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<tr>
<td>Maintenance</td>
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<td>Repair</td>
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<td>......</td>
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</tbody>
</table>

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.
### 4. Budget Planning (Form)

**Maintenance Budget Planning - Year __**  
**Department: Station Equipment Section**

<table>
<thead>
<tr>
<th>Maintenance time</th>
<th>Contents of work</th>
<th>Method of implementation</th>
<th>Equipment use period</th>
<th>Maintenance cycle</th>
<th>Durable years</th>
<th>Total implementation cost</th>
<th>Cost breakdown</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>Day</td>
<td></td>
<td></td>
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</tbody>
</table>
F: Acceptance Inspection, Quality Evaluation and Monitoring after Work
- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the law or company.

G: Implementing Organization
1. Organizational Structure

2. Responsibility for Implementation
- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager in charge of safety shall be responsible for developing the safety-related plan, instructing staff on how to implement safety inspections of equipment, goods and tools in order to maintain and manage them, and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Deputy Manager in charge of operations shall be responsible for developing the equipment operation plan, inspecting and confirming the equipment functions, instructing staff on how to create the center's maintenance budget, and teaching staff how to take emergency initiatives in response to accidents that occur at the site in cooperation with others.
- The Section Engineer shall be responsible for developing the plan for the specialized area in his charge, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- General inspection and repair workers shall be responsible for maintaining the equipment (except elevators) according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

- The elevator inspection and repair worker shall be responsible for implementing the elevator maintenance work according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the Station Equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to ensure appropriate maintenance of station equipment is carried out on the Line 2A.

Such proposals and/or propositions presented to HQ shall be made in accordance with the rule.
Organizational structure and operation/functions of the equipment sections in the Headquarters (HQ) and the Operation Unit (OU)

1. Organizational structure
   1.1. Organizational structure of the company

   ![Organizational structure of the company]

1.2. Organizational structure of the equipment sections of the Headquarters (HQ)

   ![Organizational structure of the equipment sections of the Headquarters]

   OU under the control of the equipment sections consists of the signal/communication inspection and repair center, the power inspection and repair center, and the station equipment inspection and repair center.

1.3. Organizational structure of the Operation Unit (OU)

   ![Organizational structure of the Operation Unit]

   OU under the control of the equipment sections consists of the signal/communication inspection and repair center, the power inspection and repair center, and the station equipment inspection and repair center.
2. Operation/functions of the equipment sections

2.1. Operation/functions of the HQ equipment sections

(a) Functions: The sections possess management functions for maintenance, replacement, and updating of equipment; they also give out advice to corporate executives and implement these functions (including signal communication, power, and station equipment).

(b) Operation:

1) Inspect plans on maintenance, replacement, and updating of equipment, training plans, and related procedures submitted by OU, with reference to related standards specified for each line.
2) Strike a deal with supervisory authorities concerning business under their control and make application for approval (including submission to the presidential meeting for approval).
3) Manage consignment contracts on maintenance, replacement, and updating of equipment and put them out to tender.
4) Sort out and formulate equipment maintenance rules.
5) Compile and adjust plans for maintenance, replacement, and updating of equipment.
6) Formulate steps and procedures of maintenance, replacement, and updating of equipment.
7) Supervise, inspect, assess, and manage work for maintenance, replacement, and updating of equipment OU is to undertake.
8) Cooperate with OU and other divisions in HQ so as to prevent and investigate accidents and make reports on them.
9) Collect data on accidents to analyze them, inspect related technologies, and formulate accident handling procedures in cooperation with OU.
10) Formulate plans concerning power demand.
11) Inspect budgets on costs and values related to repair, maintenance, and updating of equipment.
12) Adjust and manage work in response to requests for material supply and also in terms of use of parts in each line.
13) Manage and transfer maintenance personnel for each line in response to request based on human resource development plans.
14) Carry out work in its charge through cooperation with related departments.
15) Carry out other work that higher-ranking persons have taken their share of.

2.2. Operation/functions of the OU equipment sections

(a) Functions: OU is responsible for directly carrying out work for maintenance, replacement, and repair of equipment subject to rules and procedures specified by the company.
(b) Operation:
   1) Draw up detailed maintenance plans of equipment under control of OU.
   2) Draw up lists of equipment to be maintained, replaced or updated, and make up related budgets.
   3) Formulate manuals for maintenance, updating, and repair of equipment in a line at issue.
   4) Formulate work deployment plans for operation under its control.
   5) Formulate plans related to power demand arising in line operation processes.
   6) Formulate detailed plans concerning demand for replacement, updating, repair, and improvement of equipment.
   7) Formulate plans and schedules for personnel in charge of maintenance, repair, and updating of equipment.
   8) Prevent, investigate, and handle accidents related to operation under its control, and make reports on them.
   9) Collect data on accidents to analyze them and improve equipment functions.
  10) Formulate plans of maintenance and periodical updating of equipment.
  11) Set tender prices and work out consignment contracts concerning equipment maintenance, improvement, and updating.
  12) Formulate and complete equipment maintenance rules.
  13) Carry out work in its charge through cooperation with related departments.
  14) Formulate plans of education and training of equipment maintenance personnel.
  15) Carry out other work that higher-ranking persons have taken partial charge of.

3. Relationship between the HQ and OU equipment sections.
4. Roles, responsibilities, and competence of each position in the HQ equipment sections
(Material attached)
5. Roles, responsibilities, and competence of each position in the OU equipment sections
(Material attached)
## Roles, responsibilities, and competence of each job duty for the equipment sections of HQ

<table>
<thead>
<tr>
<th>Manager</th>
<th>Deputy Manager</th>
<th>Section Engineer (in charge of a field of signal, communication, power or station equipment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) <strong>Take a responsibility to manage work assigned to the section in a comprehensive manner, have employees in the section share job duty, and carry out all the work assigned to the section.</strong>&lt;br&gt;(2) <strong>Take the responsibility for issuing instructions on, and managing formulation of, each plan of the section and implementing it.</strong>&lt;br&gt;(3) <strong>Take the responsibility for formulating, inspecting, and completing equipment technical standards, operation procedures, and maintenance rules, and further for supervising, inspecting, and giving guidance on implementation conditions of them.</strong>&lt;br&gt;(4) <strong>Take the responsibility for periodically performing analytical and statistical work on conditions of equipment management and operation maintenance, and also for supervising, giving guidance on, and inspecting adjustment work toward solution of problems that arise in operation processes.</strong>&lt;br&gt;(5) <strong>Take the responsibility for following up domestic and overseas equipment development conditions; pursuing and studying new technologies, objectivity codes, and equipment management methods; and improving ceaselessly his/her own ability and operation quality of equipment.</strong>&lt;br&gt;(6) <strong>Take the responsibility for organizing formulation work of outsourcing contracts related to equipment maintenance; getting engaged in negotiations on consignment contracts with subcontractors; auditing contract fulfillment; and adjusting relationships with consigned businesses.</strong>&lt;br&gt;(7) <strong>Take the responsibility for adjustment and cooperation in order to respond to emergency situations on site, recovery from accidents during operation time, and sudden accidents/incidents. Also take the responsibility for investigating quality problems and implementing security measures.</strong></td>
<td>(1) <strong>Support the manager in deployment of business assigned to the section.</strong>&lt;br&gt;(2) <strong>Take the responsibility for studying technical standards concerning equipment management to be implemented based on corporate decision; collecting and grasping information related to railway equipment management; and studying and exploring new models concerning equipment operation and maintenance.</strong>&lt;br&gt;(3) <strong>Take the responsibility for issuing instructions on and managing preparation and completion of related maintenance quality standards as well as other standards, rules, and institutions concerning equipment management, and further for observing, promoting, guiding, and inspecting preparation and completion of standards, rules and institutions related to the organization he or she belongs to.</strong>&lt;br&gt;(4) <strong>Take the responsibility for issuing instructions and guidance on statistical/analytical work on conditions of equipment operation and maintenance, and giving out advice for solutions of problems that arise in operation processes.</strong>&lt;br&gt;(5) <strong>Take the responsibility for reviewing projects for technological improvement, scientific and technological research, remodeling or updating of equipment, and major repairs. Simultaneously, also observe, manage, and inspect project implementation processes; issue instructions and guidance on acceptance validation (or a completion test) of remodeling work; and give guidance on appraisement (inspection with professional methods) and acceptance validation of each project.</strong>&lt;br&gt;(6) <strong>Supervise, promote, give guidance on, and manage plans of outsourced equipment maintenance and implementation status of these plans, and also instruct and manage personnel in charge of implementation of outsourced maintenance contracts.</strong></td>
<td>(1) <strong>Sort out and complete standards, rules and institutions concerning equipment each engineer is in charge of, and submit applications for approval to the manager.</strong>&lt;br&gt;(2) <strong>Take the responsibility for guiding and inspecting the status of OU in implementation of contracts and compliance to related rules and procedures.</strong>&lt;br&gt;(3) <strong>Analyze periodically technological conditions of equipment, and then instruct and guide OU to analyze and address accidents that occur frequently in equipment each engineer is in charge of and difficult problems related to technology.</strong>&lt;br&gt;(4) <strong>Make database of equipment failures and accidents, and prepare statistics and analysis for equipment technical standards.</strong>&lt;br&gt;(5) <strong>According to equipment conditions, issue a request on outsourcing of equipment maintenance, formulate outsourcing contracts, take part in contract negotiations and conclusions, and check implementation status of subcontractors.</strong>&lt;br&gt;(6) <strong>Take the responsibility for formulating maintenance rules, taking part in drawing up and completion of maintenance manuals of equipment each engineer is in charge of, and participating in negotiations of equipment maintenance contracts.</strong>&lt;br&gt;(7) <strong>Take the responsibility for guiding, and inspecting preparation and completion of each plan of the section and implementing it.</strong>&lt;br&gt;(8) <strong>Take the responsibility for formulating, inspecting, and completing equipment technical standards, operation research, remodeling or updating of equipment, and further for supervising, inspecting, and giving guidance on major repairs. Simultaneously, also observe, manage, and inspect project implementation processes; issue instructions and guidance on acceptance validation (or a completion test) of remodeling work; and give guidance on appraisement (inspection with professional methods) and acceptance validation of each project.</strong>&lt;br&gt;(9) <strong>Supervise, promote, give guidance on, and manage plans of outsourced equipment maintenance and implementation status of these plans, and also instruct and manage personnel in charge of implementation of outsourced maintenance contracts.</strong>&lt;br&gt;(10) <strong>Take part in analytical surveys on failures, accidents, etc. and confirm and sum up results of expert research and analysis of accident causes.</strong></td>
</tr>
<tr>
<td>(8) Take the responsibility for controlling budgets for maintenance, updating, and remodeling of equipment, and for reducing costs of operation management and maintenance by leveraging new management measures and technological countermeasures.</td>
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<tr>
<td>(9) Take the responsibility for building good relationships with corporate executives, other sections and departments, and the personnel belonging to his/her section, and adjusting relationships with other sections and departments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) Take the responsibility for structuring his/her section, developing ability of employees, and promoting and inspecting work performance of the employees belonging to the section.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(7) In order for the section to carry out business, support the manager, train and develop ability of employees, and promote and inspect implementation status of work done by employees.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8) Guide subordinates in their work and support them in their addressing problems in work processes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(11) Take the responsibility for sorting out consumption states of materials and technological countermeasures, making analysis and reports on them, and managing price reduction and cost saving.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(12) Take the responsibility for managing the asset register of the company, and for supervising, promoting, and inspecting asset use status of related organizations.</td>
</tr>
<tr>
<td>(13) Take the responsibility for giving guidance on development of education and training to equipment maintenance organizations.</td>
</tr>
<tr>
<td>(14) Take the responsibility for studying and comprehending new achievements of technologies, managing the direction of proceedings of expertise and efforts for development, and studying technology innovation for updating equipment.</td>
</tr>
</tbody>
</table>
**Roles, responsibilities, and competence of each job duty in the equipment sections (the inspection and repair centers) of OU**

<table>
<thead>
<tr>
<th>Manager</th>
<th>Deputy Manager (Safety)</th>
<th>Deputy Manager (Operation)</th>
<th>Section Engineer</th>
<th>Leader</th>
<th>Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Take the responsibility for managing the center under his or her control; issuing instructions and guidance on formulation and implementation of each project; and inspecting, observing, promoting, and managing the implementation. (2) Take the responsibility for issuing instructions and guidance, based on related rules of the company, on formulation and implementation of detailed implementation plans, duty standards, and work procedures of the center under his or her control. (3) Take the responsibility for building and completing the safety management system of the center and achieving</td>
<td>(1) Support the manager to manage the center in a comprehensive manner and carry out work in his or her charge. (2) Formulate and report construction execution plans and maintenance plans of the center, obtain approval for them, and then take responsibility for issuing instructions and guidance on implementation of them. (3) Hold periodically a meeting on safety of the center, and take responsibility for the safety of the center in a comprehensive manner. (4) Issue instructions and guidance on safety inspection; secure facilities, equipment on which safety should be secured, and materials for</td>
<td>(1) Manage risk falling into his/her management scope according to a risk level, and make recording, analysis, inspection/observation, and adjustment. Take responsibility for reporting to higher-ranking persons in conformity to rules, proposing effective measures, and implementing them. (2) Support the manager and carry out business in his/her charge. Based on a fiscal-year maintenance plan of the maintenance center, issue instructions and guidance on formulation of a maintenance budget, and implement it following maintenance indexes the company has specified. (3) Take the responsibility for managing status of complying with indexes each engineer is in charge of based on equipment maintenance budget indexes the company has specified, and for compiling statistics on equipment maintenance costs. (4) Take the responsibility for</td>
<td>(1) Subject to the corporate rules, take responsibility for formulating manuals and the like for maintenance of facilities and equipment each engineer is in charge of within the scope of his/her duty in the center. (2) Take the responsibility for drawing up a maintenance plan for every month and for every quarter in response to maintenance requests from the company and also for inspecting and observing implementation of each plan. (3) Take the responsibility for formulating methods of securing equipment maintenance and operation under special circumstances and on public holidays and festival days, and for</td>
<td>[Common items] - Issue work instructions to workers. - Take responsibility for all work items specified in the work instruction. - Receive and check results of the work workers have performed without his or her presence. - When a failure occurs, input necessary data into the equipment failure database after repair work. [Inspection (periodical and occasional)] - Make judgment on conditions of equipment at whose inspection he or she was present. - Receive and check results of inspection by workers at which he or she was not present.</td>
<td>[Common items] - Carry out the work ordered by a leader. [Inspection (periodical and occasional)] - Conduct the inspection ordered by a leader. - In the case without leader’s presence, make a judgment on equipment conditions. - In the case without leader’s presence, go back to the office and make a report to a leader on equipment conditions. [Repair/Revamping] - Carry out repair or revamping work subject to leader’s order. - Make a judgment on conditions of equipment at whose inspection he or she was present. - Receive and check results of repair or revamping work in the case without leader’s</td>
</tr>
<tr>
<td>Conditions specified by yearly safety management indexes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Take the responsibility for issuing instructions and guidance on rescues in sudden accidents, emergency measures, and recovery work, and also for working on site.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Take the responsibility for issuing instructions and guidance on formulating a rescue and emergency project of the center, issuing guidance on planning each project for the center, conducting periodical trainings, building an emergency rescue system and continually improving it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Take the responsibility for managing assets and materials in the center under his or her control.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emergency rescue work so that they can be used as normal, issue guidance on and promote safety inspection of the center.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4) Take the responsibility for properly making business adjustment and negotiations with internal and external organizations.</td>
</tr>
<tr>
<td>(5) Take the responsibility for issuing instructions and guidance on management and measurement of energy use in the center, control of energy saving, and reduction and control of emissions.</td>
</tr>
<tr>
<td>(6) Take the responsibility for building a scheme for securing and inspecting/observing maintenance quality.</td>
</tr>
<tr>
<td>(7) Take the responsibility for issuing instructions and guidance on formulation of budgets for costs of equipment operation safety, employee training, etc., and at the same time, rigorously managing budget execution status and making periodical reports.</td>
</tr>
<tr>
<td>(8) Take the responsibility for managing and using equipment to be operated within a management formulating a maintenance plan and a construction execution scheme, submitting an application for approval of them, and executing them.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formulating a rescue and emergency project of the center, issuing guidance on planning each project for the center, conducting periodical trainings, building an emergency rescue system and continually improving it.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4) Take the responsibility for properly making business adjustment and negotiations with internal and external organizations.</td>
</tr>
<tr>
<td>(5) Take the responsibility for issuing instructions and guidance on management and measurement of energy use in the center, control of energy saving, and reduction and control of emissions.</td>
</tr>
<tr>
<td>(6) Take the responsibility for building a scheme for securing and inspecting/observing maintenance quality.</td>
</tr>
<tr>
<td>(7) Take the responsibility for issuing instructions and guidance on formulation of budgets for costs of equipment operation safety, employee training, etc., and at the same time, rigorously managing budget execution status and making periodical reports.</td>
</tr>
<tr>
<td>(8) Take the responsibility for managing and using equipment to be operated within a management formulating a maintenance plan and a construction execution scheme, submitting an application for approval of them, and executing them.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[Repair/Revamping] - Make a study and a decision on necessary handling. - Make a judgment on results of repair or revamping at whose execution he or she was present. - Receive and check results of repair or revamping workers implemented without his or her presence.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Asset register] - When a change happens in assets, write it in the asset register.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[Repair/Revamping] - In the case without leader’s presence, go back to office and make a report to the leader on equipment conditions after repair or revamping.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Asset register] - When a change happens in assets, write it in the asset register.</td>
</tr>
</tbody>
</table>
for drawing up and submitting statistical and analysis reports.

| for drawing up and submitting statistical and analysis reports. | scope in a unified manner. (9) Formulate personnel training plans based on the human resources development plan of the company, and issue instructions and guidance on implementation of the plans. |  |  |  |
Method for calculating the number of personnel for the OUs
(operation units)

1. Purpose

This document is intended to help understand the way of deploying personnel for operation units and the way of developing a plan related to maintenance works, and encourage the company to promptly approve a personnel plan and personnel allocation.

2. Guidelines for preparing materials

2.1. Prerequisites for preparing materials

- Laws and regulation stipulate that an employer must not allow its employees to work for over 8 hours per day and 40 hours per week.
- The numbers of pieces of equipment related to signaling, power supply and electric machinery (M&E) are assumed (when the materials are prepared). This is because there is not much information on the equipment for the Line 2A when the materials are prepared.
- Organizational structures of the electric divisions at the headquarters and the operation units
- Periodical/monthly maintenance plan
- Abilities of workers (including the leader) shall be secured (after being educated, workers can engage in maintenance works)

2.2. Methodology for preparing a shift table

- One week consists of seven days, which are equivalent to 168 hours.
To ensure continuous execution of maintenance works (i.e., workers are always deployed for 24 hours), it is necessary to divide a team of maintenance personnel into three shifts (8 hours on duty and 1 hour of rest for each shift).

It is necessary to ensure that each worker rests for 24 hours after completing his/her shift.

The maximum on-duty hours of each worker are 40 hours per week.

To satisfy the above conditions, the following number of maintenance teams will be required.

$$168 \div 40 = 4.2 \text{ (rounded up to 5)}$$

Therefore, five worker teams need to be deployed in order to execute the maintenance works.

Since the equipment maintenance works vary, the headcounts of teams may also vary.

*Based on the above assumption, a shift table can be prepared as follows.*

<table>
<thead>
<tr>
<th></th>
<th>On-duty hours: 9 hours Including 1-hour rest</th>
<th>Team A</th>
<th>Team B</th>
<th>Team C</th>
<th>Team D</th>
<th>Team E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>7:00 - 16:00</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15:00 - 24:00</td>
<td></td>
<td>○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23:00 - 8:00</td>
<td></td>
<td></td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>7:00 - 16:00</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15:00 - 24:00</td>
<td></td>
<td></td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23:00 - 8:00</td>
<td></td>
<td>○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>7:00 - 16:00</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15:00 - 24:00</td>
<td></td>
<td></td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23:00 - 8:00</td>
<td></td>
<td></td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>7:00 - 16:00</td>
<td></td>
<td>○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15:00 - 24:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>23:00 - 8:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Day 5</td>
<td>7:00 - 16:00</td>
<td></td>
<td></td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15:00 - 24:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Time</td>
<td>23:00 - 8:00</td>
<td>7:00 - 16:00</td>
<td>15:00 - 24:00</td>
<td>23:00 - 8:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
<td>--------------</td>
<td>---------------</td>
<td>--------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 6</td>
<td></td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 7</td>
<td></td>
<td></td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Working hours in 7 days</td>
<td>40 hours</td>
<td>32 hours</td>
<td>32 hours</td>
<td>32 hours</td>
<td>32 hours</td>
</tr>
</tbody>
</table>

In the second week, team B will be the first to execute the operation. The shift sequence is as shown in the above shift table.

2.3. Methodology for calculating the number(s) of administrative personnel (Manager, Deputy Manager and Engineer)

- Positions other than Manager, such as Deputy Manager and Engineer, can perform the shift works.
- To deploy an administrator for each shift team under the 3-shift structure, a sufficient number of administrators will be required.
- To ensure simplicity and convenience of administration without substantially increasing the number of administrators, the Deputy Manager will perform the Engineer’s duties. Therefore, to ensure the administration of the 3-shift work structure, at least the number of Deputy Managers will be increased.
- Deputy Manager and Engineer can administer or instruct personnel engaging in the maintenance works by directly going to the work site.
- An administrator for instructing maintenance personnel at time of roll call will be required.
- One Engineer will be required for each equipment unit (communication, signals, AFC, power, M&E). If the Engineer is absent, the Deputy Manager can act for the Engineer.
At each maintenance center, 5 to 6 Deputy Managers (administrators) (for 5 teams + one reserve) will be required.

2.4. Methodology for calculating the number of maintenance personnel (workers)

- Clarify a specific quantity of equipment.
- The headcount of each team is an average headcount. Since each line has different equipment, it is necessary to clarify the equipment specifications, equipment inspection criterion table, equipment maintenance manual, worker ability (standard and actual ability), etc. in order to classify the equipment and appropriately determine the number of maintenance personnel.
- There is some equipment for which an inspection cycle and inspection items have not been defined under the laws and regulation of Vietnam. There is also equipment for which specifications have not been specified. Therefore, under these circumstances it is necessary to calculate the headcount based on shift work of the work team. As a means of the calculation, prepare a roadmap for the maintenance works. Based on this roadmap, the number of personnel for the electric divisions at the OUs can be calculated.
- Take into account elements such as days-off, sickness, etc. of maintenance personnel.

Calculation of the number of personnel for each maintenance item at the electric division

(1) Items of communication equipment maintenance

The communication equipment shall be maintained (train radio, telephones, exchange system, broadcasting system, automatic passenger guiding system, communication network,
communication line, television system for monitoring, electric clock, station disaster control
monitoring system, etc.)

5 teams × (3 to 4 workers/team) = 15 to 20 workers

⇒ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the
headcount for each team will substantially vary depending on these pieces of equipment, difference in
equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4
workers/team here).

(2) Items of signal equipment maintenance

The signaling systems and traffic control system shall be maintained.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

⇒ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the
headcount for each team will substantially vary depending on these pieces of equipment, difference in
equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4
workers/team here).

(3) Items of AFC equipment maintenance

Equipment such as ticket gates and ticket machines shall be maintained.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

⇒ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the
headcount for each team will substantially vary depending on these pieces of equipment, difference in
equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4
workers/team here).
(4) Items of M&E equipment maintenance

The M&E equipment shall be equipment such as escalators (48 escalators), lightings, ventilation, air conditioning, and pumps.

Five teams will maintain the escalators.

\[5 \text{ teams} \times (3 \text{ to } 4 \text{ workers/team}) = 15 \text{ to } 20 \text{ workers}\]

Therefore, if three teams were operative, there would be 13 opportunities for maintenance per week, or 52 opportunities for four weeks. If it is assumed that there are 48 escalators, one or two teams will be staffed with only one or two workers. These teams will perform only emergency response in case of failure.

In such situations, five other teams will maintain the equipment.

\[5 \text{ teams} \times (3 \text{ to } 4 \text{ workers/team}) = 15 \text{ to } 20 \text{ workers}\]

\[\Rightarrow\] In total, 30 to 40 workers will be required for maintaining the M&E equipment. If the assumed equipment were actually used, 30 to 40 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(5) Items of power supply equipment maintenance

The power management system, substation (receiving station) (\(\times 7\)), electric room (\(\times 12\)) + depot, third rail (35 km), and transmission/distribution lines shall be maintained.

\[5 \text{ teams} \times (3 \text{ to } 4 \text{ workers/team}) = 15 \text{ to } 20 \text{ workers}\]

\[\Rightarrow\] If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in
equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(6) Items of elevator maintenance

The number of elevators shall be 50.

5 teams × (2 to 3 workers/team) = 10 to 15 workers

As with the escalators, if three teams were operative, there would be 13 opportunities for maintenance per week, or 52 opportunities for four weeks. The five teams will include one or two teams each staffed with one or two workers, and these teams will perform only emergency response in case of failure.

➔ If the assumed equipment were actually used, 10 to 15 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (2 to 3 workers/team here). However, since elevator maintenance personnel will not be educated for the Line 2A project, the elevator maintenance shall be subcontracted or maintenance personnel shall be employed (employed personnel must satisfy the legal/regulatory requirements).

(A detailed personnel headcount calculation table will be attached to this document)
Table of calculation of worker (including Leader) personnel at OU [basic No. of personnel]

<table>
<thead>
<tr>
<th>Basic number</th>
<th>Personnel per</th>
<th>Working teams per</th>
<th>No. of days</th>
<th>Total No. of personnel in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>personnel</td>
<td>team</td>
<td>No. of teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of on-duty days per team</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personnel per team</th>
<th>No. of teams</th>
<th>No. of on-duty days per team</th>
<th>Total No. of personnel in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV</td>
<td>3.5</td>
<td>6</td>
<td>175 [workers]</td>
</tr>
<tr>
<td>other than ES</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
<tr>
<td>M&amp;E (ES)</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
<tr>
<td>AFC</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
<tr>
<td>Signals</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
<tr>
<td>Communication</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
<tr>
<td>Monthly plan</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
<tr>
<td>Basic number</td>
<td>3.5</td>
<td>6</td>
<td>200 [workers]</td>
</tr>
</tbody>
</table>

Appendix 8-6-7-3 (E)
### Table of calculation of worker (including Leader) personnel at EV (example 1)

<table>
<thead>
<tr>
<th>Personnel per team</th>
<th>Basic number</th>
<th>Monthly plan</th>
<th>Total No. of personnel in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV</td>
<td>2.4</td>
<td>10</td>
<td>2.4</td>
</tr>
<tr>
<td>AFC</td>
<td>3.4</td>
<td>11</td>
<td>3.4</td>
</tr>
<tr>
<td>Communication</td>
<td>3.4</td>
<td>12</td>
<td>3.4</td>
</tr>
<tr>
<td>M&amp;E (other than ES)</td>
<td>3.4</td>
<td>13</td>
<td>3.4</td>
</tr>
<tr>
<td>M&amp;E (ES)</td>
<td>3.3</td>
<td>14</td>
<td>3.3</td>
</tr>
<tr>
<td>EV</td>
<td>2.5</td>
<td>15</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### Table of calculation of worker (including Leader) personnel at EV (example 2)

<table>
<thead>
<tr>
<th>Personnel per team</th>
<th>Basic number</th>
<th>Monthly plan</th>
<th>Total No. of personnel in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV</td>
<td>2.5</td>
<td>16</td>
<td>2.5</td>
</tr>
<tr>
<td>AFC</td>
<td>3.4</td>
<td>17</td>
<td>3.4</td>
</tr>
<tr>
<td>Communication</td>
<td>3.4</td>
<td>18</td>
<td>3.4</td>
</tr>
<tr>
<td>M&amp;E (other than ES)</td>
<td>3.4</td>
<td>19</td>
<td>3.4</td>
</tr>
<tr>
<td>M&amp;E (ES)</td>
<td>3.3</td>
<td>20</td>
<td>3.3</td>
</tr>
<tr>
<td>EV</td>
<td>2.5</td>
<td>21</td>
<td>2.5</td>
</tr>
</tbody>
</table>
### Table of Calculation of Worker (Including Leader) Personnel at OU (Example 2)

<table>
<thead>
<tr>
<th>Personnel per</th>
<th>Working hours per day</th>
<th>Monthly plan</th>
<th>No. of teams</th>
<th>Total No. of personnel in 30 days</th>
<th>Total No. of actual teams in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC 3.2</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
<tr>
<td>Signals 3.2</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
<tr>
<td>Communication 3.2</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
<tr>
<td>EV 2.4</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
</tbody>
</table>

#### Monthly Plan

<table>
<thead>
<tr>
<th>Personnel per</th>
<th>Days On-duty</th>
<th>No. of on-duty days per team</th>
<th>Personnel per team</th>
<th>No. of teams</th>
<th>Total Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV (other than ES) 3.2</td>
<td>(other than ES) 3.2</td>
<td>(other than ES) 3.2</td>
<td>EV (other than ES) 3.2</td>
<td>(other than ES) 3.2</td>
<td>EV (other than ES) 3.2</td>
</tr>
<tr>
<td>AFC 3.2</td>
<td>20</td>
<td>20</td>
<td>AFC 3.2</td>
<td>20</td>
<td>AFC 3.2</td>
</tr>
<tr>
<td>Signals 3.2</td>
<td>20</td>
<td>20</td>
<td>Signals 3.2</td>
<td>20</td>
<td>Signals 3.2</td>
</tr>
<tr>
<td>Communication 3.2</td>
<td>20</td>
<td>20</td>
<td>Communication 3.2</td>
<td>20</td>
<td>Communication 3.2</td>
</tr>
<tr>
<td>EV 2.4</td>
<td>20</td>
<td>20</td>
<td>EV 2.4</td>
<td>20</td>
<td>EV 2.4</td>
</tr>
</tbody>
</table>

#### Reserve Personnel

<table>
<thead>
<tr>
<th>Personnel per</th>
<th>Working hours per day</th>
<th>Monthly plan</th>
<th>No. of teams</th>
<th>Total No. of personnel in 30 days</th>
<th>Total No. of actual teams in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC 3.2</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
<tr>
<td>Signals 3.2</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
<tr>
<td>Communication 3.2</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
<tr>
<td>EV 2.4</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>315 (workers)</td>
<td>225 (workers)</td>
</tr>
</tbody>
</table>

#### Total No. of Personnel in 30 Days

<table>
<thead>
<tr>
<th>Basic number per team</th>
<th>AFC</th>
<th>Signals</th>
<th>EV</th>
<th>(other than ES)</th>
<th>M&amp;E (ES)</th>
<th>EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No. of basic teams in 30 days</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Total No. of actual teams in 30 days</td>
<td>278</td>
<td>278</td>
<td>278</td>
<td>278</td>
<td>288</td>
<td>288</td>
</tr>
</tbody>
</table>

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### Table of calculation of worker (including Leader) personnel at OJ [example 3]

<table>
<thead>
<tr>
<th>Personnel per team</th>
<th>No. of teams</th>
<th>Total No. of personnel in 30 days</th>
<th>Total No. of basic teams in 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>3.3 x</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>AFC</td>
<td>3.3 x</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>Power</td>
<td>3.3 x</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>No. of personnel</td>
<td>3.3 x</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>Total (other Excel)</td>
<td>3.3 x</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>EV</td>
<td>2.4 x</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total No. of personnel in 30 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>216</td>
</tr>
</tbody>
</table>

### Appendix 6-7-3 (E)

- **3.3**
  - AFC
  - M&E (ES)
- **3.3**
  - AF
  - M&E (ES)
- **3.3**
  - AFC
  - M&E (ES)
- **3.3**
  - AFC
  - M&E (ES)
- **3.3**
  - AFC
  - M&E (ES)
- **3.3**
  - AFC
  - M&E (ES)
- **3.3**
  - AFC
  - M&E (ES)
- **2.4**
  - AFC
  - M&E (ES)

### Detailed Calculation

1. **Basic number**
   - Total No. of teams
   - Total No. of personnel

2. **AFC**
   - Number of personnel
   - Total personnel

3. **M&E (ES)**
   - Number of personnel
   - Total personnel

4. **Communication**
   - Number of personnel
   - Total personnel

5. **Signals**
   - Number of personnel
   - Total personnel

6. **Personnel**
   - Number of personnel
   - Total personnel

7. **Reserve**
   - Number of personnel
   - Total personnel

8. **Total**
   - Number of personnel
   - Total personnel

### Summary

- **Total No. of basic teams in 30 days**
  - Total No. of basic teams in 30 days
  - Total No. of personnel in 30 days
  - Total No. of personnel in 30 days

- **Total No. of personnel**
  - Total No. of personnel
  - Total No. of personnel
  - Total No. of personnel

- **Total No. of personnel**
  - Total No. of personnel
  - Total No. of personnel
  - Total No. of personnel

- **Total No. of personnel**
  - Total No. of personnel
  - Total No. of personnel
  - Total No. of personnel

- **Total No. of personnel**
  - Total No. of personnel
  - Total No. of personnel
  - Total No. of personnel
Method for calculating the cost for the required maintenance items
(for directly conducted maintenance and outsourced maintenance each)

1. Purpose
The method for calculating the cost for the required maintenance item shall be formulated for the purpose of calculating the maintenance cost accurately, leveling the cost for maintenance items, enabling the company to map out an appropriate direction for development, and increasing the company’s profit.

In case of the electric division, it is very important to calculate the cost for the required maintenance items. If the maintenance cost at each stage is accurately calculated with this method, the electric division will be able to level the maintenance process operations, and increase the effect of the maintenance operations, and most importantly, a perfect maintenance work implementation plan can be formulated, and the electric division can implement it.

2. Concept of formulating a method for calculating the cost for the required maintenance items
2.1 Generalization
- Knowing the "cost for the required maintenance items" means calculating the initial cost for implementing the maintenance of the items that require maintenance.
- Initial cost calculation
  In addition to complying with laws and regulation, company rules, and bylaws of the electric division, it is necessary to calculate the accurate initial cost based on the actual circumstances.

2.2 Meaning of calculating the initial cost
The initial cost is the cost that is required when the company provides its product, and the selling price of the product can be expressed as a value calculated by adding a profit to the initial cost.

\[ \text{Price} = \text{initial cost} + \text{profit} \quad (1) \]

However, recently the price is determined by the needs of the market in many cases. Therefore, it can be said that the profit is determined by the initial cost.

\[ \text{Profit} = \text{price} - \text{initial cost} \quad (2) \]

In case of HMC, the passenger transport service corresponds to the product and the fare represents the price. The fare is determined while considering factors such as the ease of use of an urban railway, in a way close to (2) above.
To increase the profit, the initial cost must be reduced. The initial cost contains various costs related to corporate activities, and is deeply connected to the quality of company management. To reduce the initial cost, the quality of company management must be improved through operational improvement, etc.

The initial cost of the passenger transport service that Hanoi Metro Company provides consists of costs of services that the company’s respective divisions provide. To increase the profit by reducing the initial cost of the passenger transport service, it is necessary for the respective divisions to pursue operational improvement in order to reduce the initial cost.

To achieve this, each division needs to know the initial cost of their operation. If they know the initial cost of their operation, they will be able to implement efforts for operational improvement based on the initial cost as an index, and evaluate the effect.

As described above, calculation of the cost for the required maintenance items at the electric division has an important meaning for the improvement of management quality of Hanoi Metro Company through management quality improvement at the electric division.

2.3 Composition of the initial cost

The initial cost consists of material cost, labor cost and expense. Therefore, to specify the initial cost, it is necessary to start with determining the labor cost, expense and material cost at the electric division.

\[
\text{Initial cost} = \text{material cost} + \text{labor cost} + \text{expense}
\]

2.3.1 Material cost

This cost is generated by material used when the electric division conducts maintenance works. The following is an example of material cost classification, and the cost shall be tallied according to such classification. Details of the calculation will be described later.

1) Cost of parts purchased: cost for parts or units of equipment purchased for maintenance
2) Cost of consumable supplies: cost of consumable supplies used for maintenance
3) Cost of consumable tools and equipment: cost of tools or appliances with short useful life (complying with laws/regulations [if any] or company rules) and small value (complying with laws/regulations [if any] or company rules)
4) Fuel cost: cost of fuel such as gas for welding used for maintenance works
2.3.2 Labor cost
This is an expense concerning staff of the electric division, and its major items are as follows.
1) Salary: salary and bonus paid to staff of the electric division
2) Temporary salary: salary paid to temporarily hired people
3) Reserve for retirement allowance: fund accumulated in preparation for the payment of retirement allowance
4) Welfare cost: health insurance and pension premium, etc.

2.3.3 Expense
All costs excluding labor cost and material cost are included here. The following are examples of expenses.
1) Measuring expense: cost with which consumptions such as electricity and water can be measured
2) Expense payable: travel expense and carfare, telephone and communication, repair cost (cost in case of outsourcing)
3) Monthly expense: cost to be paid in monthly installments such as insurance premiums and lease fees
4) Accrued expense: expense not accompanied by monetary payment even if an event occurs
   For example, if a maintenance part becomes rusted while in storage, it will be disposed of and the amount equivalent to the value of the part will be recorded as a depletion cost.

2.4 Method for calculating the initial cost
2.4.1 Material cost
Material cost shall be calculated by metering each material used for maintenance and multiplying the value with the unit price in principle. However, it is difficult to apply this calculation method to all the materials. For example, it is difficult and unrealistic to meter lubricant oil that is dropped on the slider in a few drips.

Therefore, for example, a method of tallying the cost of materials used for a certain period (e.g., three months, one year) by types, and calculating the average cost per maintenance work based on the count of maintenance in which the material is used, is one of the possible approaches.

1) How to calculate the cost of material used in a certain period
   Based on the inventory value of material possessed at the beginning of the
term and the inventory value at the end of the term, as well as the purchase amount of material purchased during the term, the cost can be calculated as follows.

Cost of material used in a certain period = inventory value at the end of the term – inventory value at the beginning of the term + amount of purchase made during the term

2) Method for calculating the material cost for each maintenance item (example)
- Calculate the cost of material used in a certain period for each type of material using the above method
- Specify the material used for each maintenance item.
- Tally the count of maintenance conducted during the above certain period based on the maintenance record. Table 1 shows the result of tallying items (1) to (3).
- Based on the above data, for example the material cost (M₁) of maintenance item 1 (Maintenance 1) can be calculated as follows.

\[
M₁ = \frac{X}{(a + c)} + \frac{Y}{(a + b)} + \frac{W}{(a + b + c)}
\]

Table 1 Tabulation table for calculating the material cost

<table>
<thead>
<tr>
<th>Material used, number of maintenance</th>
<th>Number of maintenance count</th>
<th>Material 1</th>
<th>Material 2</th>
<th>Material 3</th>
<th>Material 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost material used in a certain period</td>
<td>X</td>
<td>Y</td>
<td>Z</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Maintenance 1</td>
<td>a</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Maintenance 2</td>
<td>b</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Maintenance 3</td>
<td>c</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

3) In the initial period after the Line 2A is opened, there will be no recorded data on the material used, price, maintenance, etc. Therefore, during Line 2A handover, obtain data on the material used for maintenance, unit price of material, major maintenance items, estimated maintenance frequency, etc. and budget an approximate cost in advance. Additionally, after the Line 2A is opened, accumulate data necessary for the calculation so that initial cost calculation
based on the recorded data can be started in the second year.

2.4.2 Labor cost and expense

1) Cost and items of account

The calculation of the labor cost and the expense begins with clarifying the items of costs incurred in operations of the electric division and tallying each cost in accordance with certain rules. The operations of the electric division extend across the life cycle of equipment from its introduction to operation/maintenance and disposal, and the costs related to operations can be classified as indicated in Table 2. However, since the table is provided only as a reference example, it is necessary to check the actual contents of the operations when preparing it.

<table>
<thead>
<tr>
<th>Table 2 Costs incurred at the electric division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of equipment introduction</td>
</tr>
<tr>
<td>Planning/design cost</td>
</tr>
<tr>
<td>Planning cost</td>
</tr>
<tr>
<td>Basic design cost</td>
</tr>
<tr>
<td>Execution design cost</td>
</tr>
<tr>
<td>Work cost</td>
</tr>
<tr>
<td>Carry-in, installation, adjustment/test cost</td>
</tr>
<tr>
<td>Field management cost</td>
</tr>
<tr>
<td>Acquisition extra charge</td>
</tr>
<tr>
<td>Application procedure cost</td>
</tr>
<tr>
<td>Disaster control/safety/environmental cost</td>
</tr>
<tr>
<td>Equipment maintenance cost</td>
</tr>
<tr>
<td>Operation cost</td>
</tr>
<tr>
<td>Operation personnel cost</td>
</tr>
<tr>
<td>Daily inspection and maintenance cost</td>
</tr>
<tr>
<td>Energy cost</td>
</tr>
<tr>
<td>Electric rate</td>
</tr>
<tr>
<td>Gas rate</td>
</tr>
<tr>
<td>Fuel oil rate</td>
</tr>
<tr>
<td>Operation extra charge</td>
</tr>
<tr>
<td>Education and training cost</td>
</tr>
<tr>
<td>Maintenance work cost</td>
</tr>
<tr>
<td>Overall, general, minute, temporary maintenance cost</td>
</tr>
<tr>
<td>Maintenance extra charge</td>
</tr>
<tr>
<td>Equipment maintenance technique management, asset management cost</td>
</tr>
<tr>
<td>Equipment disposal cost</td>
</tr>
<tr>
<td>Removal cost</td>
</tr>
<tr>
<td>Removal and dismantling work cost</td>
</tr>
<tr>
<td>Disposal cost</td>
</tr>
<tr>
<td>Equipment selling cost</td>
</tr>
<tr>
<td>Disposal cost</td>
</tr>
</tbody>
</table>
On the other hand, in Japan accounting is conducted in accordance with the Railway Business Accounting Rules, which are stipulated under a ministerial order of the Ministry of Land, Infrastructure, Transport and Tourism. Account titles for classifying costs are also specified in the rules.

(*) Railway Business Accounting Rules:

Table 3 shows a list of account titles required for the electric division. The auxiliary division cost represents the initial cost at a division supporting the electric division’s operations such as personnel affairs and accounting allocated to the electric division. The idea is that since the auxiliary division’s operation services are used for maintenance, such cost must be reflected in the initial cost.

There are several methods for allocating the cost incurred at the auxiliary division. The traditional method is prorating the cost according to the number of personnel at the division to which the cost is allocated. Recently, in an increasing number of cases, the cost is allocated with the ABC (Activity Based Costing) approach (*).

Unless there is any legal rule, the allocation may be implemented in accordance with Hanoi Metro’s accounting policy.

(*) Examples include methods of allocating the cost according to the activity level, such as prorating the expense incurred at the purchase division with the number of procurement transactions for the respective divisions.

(1) Precautions for tallying the cost by account titles

Table 3 does not have any account title under which to enter the equipment purchase amount. Structures, equipment, software, etc. that are continuously used for a long period are treated as fixed assets, and purchase amounts cannot be recorded in a lump. It must be noted that during the useful life defined by laws/regulations, a constant-rate or constant-value depreciation amount should be recorded as a cost. In Vietnam, rules related to the useful life and depreciation approach according to the type of equipment are also established under the accounting act and the tax system, and corporate bodies in the
country must implement the recording of expenses in accordance with the laws/rule.

The judgment of whether such recording should be performed in the form of cost processing for a fixed asset, or ordinary cost processing can be performed, must be based on the applicable laws/rule, and should be made by the account division, which has expertise.

Table 3 Account titles at the electric division

<table>
<thead>
<tr>
<th>Classification</th>
<th>Account title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor cost</td>
<td>Salary</td>
</tr>
<tr>
<td></td>
<td>Allowance</td>
</tr>
<tr>
<td></td>
<td>Bonus</td>
</tr>
<tr>
<td></td>
<td>Retirement allowance</td>
</tr>
<tr>
<td></td>
<td>Legal welfare cost</td>
</tr>
<tr>
<td></td>
<td>Welfare cost</td>
</tr>
<tr>
<td></td>
<td>Temporary employment wage cost</td>
</tr>
<tr>
<td>Expense</td>
<td>Fixed asset retirement cost</td>
</tr>
<tr>
<td></td>
<td>Supplies cost</td>
</tr>
<tr>
<td></td>
<td>Clothing cost</td>
</tr>
<tr>
<td></td>
<td>Power cost</td>
</tr>
<tr>
<td></td>
<td>Utilities cost</td>
</tr>
<tr>
<td></td>
<td>Traveling expense and carfare</td>
</tr>
<tr>
<td></td>
<td>Communication and transportation cost</td>
</tr>
<tr>
<td></td>
<td>Meeting cost</td>
</tr>
<tr>
<td></td>
<td>Expense-account</td>
</tr>
<tr>
<td></td>
<td>Rental</td>
</tr>
<tr>
<td></td>
<td>Nonlife insurance premium</td>
</tr>
</tbody>
</table>
(2) How to incorporate the labor cost and expense in the initial cost

There are several methods for incorporating the labor cost and expense in the initial cost of maintenance items. The easiest method is calculating the average value by dividing the sum of the labor cost and the expense by the total time of maintenance works that electric division conducted in one year, and then calculating the necessary cost from the necessary maintenance time for each maintenance item. The following shows the calculation method.

\[
S_{1} = T_{1} \times \frac{S_{total}}{T_{total}}
\]

Incorporation into the initial cost should be implemented in accordance with the accounting rules established for the whole Hanoi Metro. The system in which accounting is conducted in accordance with such accounting rules is called internal control. Internal control is intended to prevent fraudulent accounting, achieve accounting that can be used for managing the effectiveness and efficiency of operations, and increase reliability, etc. of accounting and financial reporting.

(3) Cost of the required maintenance items

Since the cost of the required maintenance items is the sum of the material cost, labor cost and expense required for the maintenance works, it can be calculated as follows based on the material cost \(M_{1}\) calculated earlier and the above.

Cost of the required maintenance items
\[ M_1 + S_1 = \frac{X}{(a + c)} + \frac{Y}{(a + b)} + \frac{W}{(a + b + c)} + T_1 \times \frac{S_{\text{total}}}{T_{\text{total}}} \]

(4) Comparison between the cost for direct conduct and the outsourcing cost

The cost in case of direct conduct is as indicated above. In case of outsourcing, an outsourcing cost shall be added to the items. Even in case of outsourcing, operations such as order placement and completion inspection must be directly conducted, and there will still be items for labor cost and expense. Therefore, the cost of the required maintenance items is calculated as follows.

Cost of the required maintenance items

\[ = M_{\text{outsourcing}} + S_{\text{outsourcing}} = \text{outsourcing cost} + T_{\text{outsourcing}} \times \frac{S_{\text{total}}}{T_{\text{total}}} \]

(5) Another viewpoint of cost calculation

The above are the methods for calculating the initial cost as performed by the electric division. Implementing operational improvement of each division as an index is an effective method for improving the company’s management quality. However, there is another way of thinking that only the initial cost of the whole Hanoi Metro should be grasped. Decision of which approach to take should be based on the business policy. In case of the latter, the electric division will only implement the cash flow management. In case of direct conduct, the material cost shall be managed. In case of outsourcing, the outsourcing cost shall be managed.
3. Reference material

The following exemplifies the formulation of account titles based on the railway business accounting standard in Japan, as a reference material.

Since only costs will be incurred at the electric division, attention should be focused on the classification on costs. Under the Railway Business Accounting Rules, cost classification is defined as shown in Table 4.

| Cost classification | Transportation cost | Line preservation cost | Electric circuit preservation cost | Car preservation cost | Operation cost | Transport cost | Maintenance management cost | Transport management | Other costs | Guiding and advertisement cost | Welfare facility cost | General and administrative expense | Taxes | Depreciation cost | Tangible fixed asset depreciation cost | Intangible fixed asset depreciation cost | Non-operating expense | Cost incurred from non-operating activities (e.g., interest paid) | Extraordinary loss | Loss temporarily generated due to a special cause other than normal business activity (e.g., loss on sale of fixed asset) | Corporate tax, resident tax and business tax | National tax (corporate tax), local tax, etc. |
|---------------------|---------------------|------------------------|----------------------------------|-----------------------|---------------|---------------|-----------------------------|---------------------|------------|-------------------------------|---------------------|--------------------------------------|-------|----------------|----------------------------------|------------------------|----------------|--------------------------------|-----------------------------|-----------------------------------------------|------------------|--------------------------------------------|--------------------|---------------------------------------------|

In Table 4, classification of costs related to electricity, communication, signals, and station equipment that the electric division will administer is as follows.

(1) Line preservation cost

Operation expense required for the maintenance of electric circuits of tangible fixed asset transport facilities (including substation machinery and communication machinery), cars (excluding special cars for railway track preservation), and all fixed assets excluding machinery for business use such as automatic fare collection equipment.

(2) Electric circuit preservation cost

Operation expense required for the maintenance of electric circuits of tangible fixed asset transport facilities (substation machinery, communication machinery and
special cars for preserving electric circuits)

(3) Operation cost
   Operation expense required for the operation of trains. Electricity purchase is included in this account title.

(4) Transport cost
   Operation expense required for the handling of passengers, as well as the composition of trains and shunting operation. This includes cost of repair of machinery for business use such as automatic fare collection equipment.

(5) Maintenance management cost
   Expense required for the management of maintenance work for tangible fixed asset transport facilities.

(6) Depreciation cost
   Depreciation cost concerning railway business fixed assets, and a portion of the depreciation cost concerning fixed assets related to various businesses that the railway business bears.

In Table 4, classification of costs related to electricity, communication, signals, and station equipment that the electric division will administer is as follows.

The above cost classification shall be further subdivided into account titles, and cost shall be tallied for each account title. To help select the account titles required to calculate the initial cost at the electric division, Table 5 shows the account titles that constitute the above categories and the cost categories.

The repair costs shaded in Table 5 are recorded as material costs, and not recorded as expenses. However, this only represents sorting in terms of account titles in accounting. If costs (budget) of the division are to be formulated, the actually paid costs including repair cost shall be added up together.

The other shaded items are accounts regarded as not falling under the electric division’s operations. (The account titles included in the respective cost categories are checked.)
<table>
<thead>
<tr>
<th>Account title</th>
<th>Content</th>
<th>Line preservation cost</th>
<th>Electric circuit preservation cost</th>
<th>Operation cost</th>
<th>Transport cost</th>
<th>Maintenance management cost</th>
<th>Depreciation cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salary</td>
<td>Basic wage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Allowance</td>
<td>Extra wage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Bonus</td>
<td>Bonus, temporary salary, and reserve amount</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Retirement allowance</td>
<td>Retirement allowance, amount of reserve for retirement allowance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Legal welfare cost</td>
<td>Amount borne by the business operator under the Health Insurance Act, Employment Insurance Act, and Workmen’s Accident Compensation Insurance Law, etc.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Welfare cost</td>
<td>Cost concerning welfare of employees such as medical affairs, sanitation, health, recreation, and cultivation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Temporary employment wage</td>
<td>Salary for temporary employees</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Account title</td>
<td>Content</td>
<td>Line preservation cost</td>
<td>Electric circuit preservation cost</td>
<td>Operation cost</td>
<td>Transport cost</td>
<td>Maintenance management cost</td>
<td>Depreciation cost</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------------------------------------</td>
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<td>-----------------------------------</td>
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<td>-----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Expense</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement material cost</td>
<td>Cost of repair items related to replacement asset</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsourced replacement cost</td>
<td>Cost of outsourced repair related to replacement asset</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ordinary material cost</td>
<td>Cost of repair items related to asset other than replacement asset</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ordinary outsourcing cost</td>
<td>Cost of outsourced repair related to asset other than replacement asset</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed asset retirement cost</td>
<td>Temporary cost of operation line related activity such as discontinuance, excluding huge amounts</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tickets, ledger reports</td>
<td>Cost required for tickets and ledger reports for station service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Supplies cost</td>
<td>Cost of supplies and cost of equipment for works and office (including newspaper cost and library cost)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Account title</td>
<td>Content</td>
<td>Line preservation cost</td>
<td>Electric circuit preservation cost</td>
<td>Operation cost</td>
<td>Transport cost</td>
<td>Maintenance management cost</td>
<td>Depreciation cost</td>
</tr>
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<td>---------------</td>
<td>-----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Clothing cost</td>
<td>Cost required for clothing provided or lent</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power cost</td>
<td>Cost of power for operation (to be classified into electricity, fuel oil, etc.)</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities cost</td>
<td>Cost of water, lighting, gas, petrol for heating, etc.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Expense</td>
<td>Ticket selling commission</td>
<td>Charge for commissioned sale of tickets</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Station cleaning cost</td>
<td>Cost for contracting station cleaning work</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traveling expense and carfare</td>
<td>Transportation cost such as travel expense, train fare and bus fare</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Communication and transportation cost</td>
<td>Cost for communication such as postage and telephone charge, and for transportation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Meeting cost</td>
<td>Cost required for meetings</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expense-account</td>
<td>Cost required for entertainment, gifts, etc.</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rental</td>
<td>Land rent, house rent,</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Account title</td>
<td>Content</td>
<td>Line preservation cost</td>
<td>Electric circuit preservation cost</td>
<td>Operation cost</td>
<td>Transport cost</td>
<td>Maintenance management cost</td>
<td>Depreciation cost</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
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<td>------------------------------------</td>
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<td>----------------</td>
<td>----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>movable property rent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonlife insurance premium</td>
<td>Nonlife insurance premium for tangible fixed asset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Cost not falling under other titles</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tangible fixed asset depreciation cost (transportation facility depreciation cost)</td>
<td>Depreciation cost for fixed assets related to the railway business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Intangible fixed asset depreciation cost (business-related fixed asset)</td>
<td>Depreciation cost for fixed assets related to businesses other than the railway business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Intangible fixed asset depreciation cost (transportation facility depreciation cost)</td>
<td>Depreciation cost for fixed assets related to the railway business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Tangible fixed asset depreciation cost (business-related fixed asset)</td>
<td>Depreciation cost for fixed assets related to businesses other than the railway business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Guidelines for preparing a list of items of maintenance operations to be conducted directly or outsourced

1. Purpose
Preparation of a list of items of maintenance operations to be conducted directly or outsourced would help administrators and maintenance personnel understand the outline of the maintenance works. Based on the list, the execution method and a work plan in the maintenance process will be formulated.

However, railway equipment must be maintained so that users can use the railway safely and stably with an easy mind. For its maintenance, the railway operator shall directly conduct inspections, repairs, etc. in principle. The direct maintenance by the operator enables it to diagnose and manage the operation state of the pieces of equipment that are most important in business operation. Such accumulation of experience would lead to maintaining and improving the technical strength.

2. Guidelines for preparation

2.1. Methodology
It is significantly important to classify equipment maintenance operations to be conducted directly or outsourced. The classification will not only facilitate the compliance with laws and regulations for equipment related to urban railways, but also enable the administrator of the OU electric division to prepare a list of maintenance operations to be conducted directly or outsourced based on the budget situation, the level of the maintenance personnel, etc.

When the list of maintenance operations to be conducted directly or outsourced is issued, the administrator will easily develop a work plan and implement it.

To prepare this list, it is necessary for the administrator to pay attention to major elements and issue a list at each development stage at the company.

2.2. Prerequisites for preparing the list
Criteria for preparing a list of items of maintenance operations to be conducted directly or outsourced are as follows.

1) Equipment subject to legal control
Equipment for which laws/regulations concerning maintenance are established for a reason such as the possibility that conditions of the equipment may affect the safety of users or impair other equipment

The maintenance of equipment subject to legal control shall be directly conducted by the railway operator in principle. If the maintenance is to be outsourced, it is necessary to carefully review the compliance with the legal conditions and then make a judgment.

(Examples) Elevators, escalators, radio station equipment, etc.

2) COTS equipment (Commercial Off The Shelf)

- COTS is equipment that requires advanced expertise and devices for its maintenance. Maintenance operations such as equipment inspection, adjustment and repair shall be outsourced to the manufacturer or supplier of the equipment or a maintenance company that has advanced expertise, in principle. This is because conducting maintenance operations that require advanced technical requirements needs special measuring instruments and expertise.

- When the administrator prepares this list, he/she shall classify items of maintenance operations into those to be conducted directly or those to be outsourced based on the technical level of the maintenance personnel and the state of the accessory equipment company.

- For any maintenance operations that are conducted directly or outsourced, those operations such as equipment maintenance planning and management must be conducted by the railway operator.

(Examples) Servers, management software, interface equipment, etc.

3) Equipment containing LRU (Line Replaceable Unit)

- Equipment generally consists of various LRUs. LRUs are devices that the manufacturer or supplier can replace ahead of time as necessary, as with modules. However, since LRUs are manufactured with blocks each containing multiple parts, it is difficult to maintain
them. Conducting maintenance works that require advanced technical requirements needs special measuring instruments and expertise. Therefore, the maintenance operation shall be outsourced to the unit manufacturer or a maintenance company that has advanced technology or equipment in principle.

- For any maintenance operations that are conducted directly or outsourced, those operations such as equipment maintenance planning and management must be conducted by the railway operator.

(Examples) IC units and reader/writer units

4) Non-important equipment (equipment not affecting train operation)
- Equipment whose condition or maintenance work may not substantially affect the safety of users and workers or convenience
- Equipment that requires simple maintenance work and will not affect train operation
- Equipment that falls under either of the above two items, and whose maintenance cost is higher than outsourcing

(Examples) Equipment, etc. in office, employee lounge

5) Maintenance level
- General inspections (including temporary inspections with equivalent content): Inspections using sensor organ(s) that are conducted on an installed basis. They shall be conducted periodically, such as daily, weekly and monthly, according to the characteristics, usage, etc. of the equipment.

- Minute inspections (including temporary inspections with equivalent content)/repair: These inspections include minute inspections using tools or measuring instruments that are conducted on an installed basis, as well as adjustment, part replacement, and major repairs in which the equipment is overhauled after being transferred to the directly-operated maintenance factory, equipment manufacturer, or supplier. This
inspection shall be conducted for months or years according to the characteristics, usage, etc. of the equipment.

- Repairs: Repairs conducted on an installed basis, or conducted after the equipment is transferred to the directly-operated maintenance factory, equipment manufacturer, or supplier.
Based on the five items determined above, a table of maintenance operations to be conducted directly or outsourced can be issued as follows.

<table>
<thead>
<tr>
<th>Name of equipment</th>
<th>Equipment subject to legal control</th>
<th>COTS equipment</th>
<th>Equipment containing LRU</th>
<th>Non-important equipment</th>
<th>General</th>
<th>Minute insp./major repair</th>
<th>Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outsourced</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outsourced</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outsourced</td>
<td></td>
</tr>
</tbody>
</table>
### Entry example:

<table>
<thead>
<tr>
<th>Name of equipment</th>
<th>Equipment subject to legal control</th>
<th>COTS equipment</th>
<th>Equipment containing LRU</th>
<th>Non-important equipment</th>
<th>General</th>
<th>Minute insp./major repair</th>
<th>Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td>Outsourced</td>
<td>Directly operated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td>Outsourced</td>
<td>Directly operated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td>Outsourced</td>
<td>Directly operated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td>Outsourced</td>
<td>Directly operated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Directly operated</td>
<td>Outsourced</td>
<td>Directly operated</td>
</tr>
</tbody>
</table>

- **Station server**
  - Server: ✔️
  - Workstation: ✔️
  - Peripherals (e.g., printer): ✔️

- **Uninterruptible power source**
  - UPS: ✔️
  - Battery unit: ✔️

- **Lift**
  - Escalator: ✔️
  - Elevator: ✔️

- **Automatic Ticket Gate**
  - ✔️

- **Automatic Ticket Machine**
  - ✔️

- **Monitoring camera system**
  - Camera unit: ✔️
  - Control system: ✔️

- **Lighting equipment**
  - Inspection: ✔️
  - [Lamp replacement only]: ✔️

*1: If the camera unit fails, it will not be repaired, but replaced with a new camera unit.

*2: For lighting lamps, preventive maintenance where they are replaced in a regular cycle shall be conducted in principle. Lamp replacement due to other reasons shall be conducted directly.
Guidelines for formulating a business plan

4. Basic policy for formulating a business plan of the electric division

(1) Outline of a business plan

The purpose of formulating a business plan is to define a specific content of a company's business execution according to a management philosophy, a management policy, a medium-term management plan, etc. Depending on the company, a medium-term management plan is formulated on the basis of approximately three years, while a business plan, which is based on the medium-term management plan, is formulated on the basis of approximately one year. By making the framework of the formulated plan open to the public, the company holds up its promise.

A company's business plan is an integration of business plans that its divisions have formulated. A business plan at the electric division is formulated with the aim of securing safe, stable and secure operation of electric equipment. Examples include an overhead contact line replacement plan, a switch overhauling plan and an automatic ticket gate updating plan.

Corporate activity can be rephrased as repetition of formulating a medium-term management plan and a business plan in accordance with the company's management philosophy and management policy, and implementing the plans.

(2) Relationship with business plans of other divisions and the system for formulating a business plan at the electric division

The relationship with business plans of other divisions and the system for formulating a business plan at the electric division are as shown in Fig. 1. A business plan of the whole Hanoi Metro is a collection of business plans of the respective divisions, while a business plan of each division represents a collection of business plans of the respective staff in charge.

The process for formulating a business plan at the electric division (OU and HQ) is described below.

The OU electric division shall submit opinions and requests to the respective staff in charge at the HQ electric division based on daily maintenance. Specific examples include a request for advancing switch overhauling at a certain station and a request for simultaneously updating units of ticket gates.

The HQ electric division shall formulate a repair plan, updating plan, etc. based on the opinions/requests from the respective OU electric divisions, and on the useful life management ledger, equipment management ledger, etc.

Staff in charge of planning at the HQ electric division shall formulate an electric division business plan while coordinating with the medium-term management plan and business plans of other divisions as the overall supervisor/point of contact.
The characteristics of the electric division’s business plan

The electric division’s business plan shall be formulated in order to contribute to the management of Hanoi Metro under the following policies:

- Quality improvement through securing and improvement of safety, reliability and convenience in railway transport
- Operational efficiency improvement and cost reduction through operational improvement
- Social contribution through adoption of energy-saving equipment, etc.

5. Formulation of the electric division’s business plan

2.1 Operation and maintenance of equipment

2.1.1 Equipment maintenance

a. Electric division of OU

- Checking the description of equipment registered in the equipment management ledger with the actual state.
- Conducting inventory inspection of equipment parts, work materials, etc., and formulating a purchase plan. Paying particular attention to parts, etc. for which manufacturer warranty periods are set.
- Formulating a purchase plan also for equipment such as tools and measuring instruments.
- For equipment with much failure, comparing a repair cost and an updating cost, and planning an effective action.
- Summarizing the above, and submitting opinions/requests to the respective staff in charge at the HQ electric division.

b. Electric division of HQ

- Checking the opinions/requests from OU, and conduct on-site verification as necessary.
- Respective staff in charge shall formulate a business plan for repairs, updating, etc. based on OU’s opinions/requests, useful life management ledger, equipment management ledger, etc. (coordinating with related sections of other divisions as necessary).
- Respective staff in charge shall formulate a business plan for new equipment
installation, improvement, etc. based on the medium-term management plan, the company’s measures, requests from other divisions, etc. (coordinating with related sections of other divisions as necessary).
- Staff in charge of planning shall finally formulate the electric division's business plan while coordinating with the medium-term management plan and business plans of other divisions as the overall point of contact/supervisor.

2.1.2 Budget
A plan for budgets required to implement a business plan shall be formulated. In budgeting, acquire as much information as possible to calculate the appropriate price.
- Budget for maintenance (personnel cost, material and equipment purchase cost, etc.)
- Budget for outsourcing maintenance cost
- Budget for electricity purchase cost *(for the time being, the electric division shall formulate the budget, and purchase electricity in cooperation with the electric company)*
- Budget for communication cost incurred if an external line is used
- An equipment investment budget for new equipment installation, updating, etc.
- Repair budget for equipment inspection, repairs, etc.
- Budget for general expenses at the electric division (budget for education/training cost, business trip cost, office supplies cost, document management cost, etc.)

2.2 Investment plan
1) When the Line 2A is handed over and Hanoi Metro starts train service, depreciation of the equipment over which the electric division has control will begin, and after the completion of depreciation, generally equipment updating will begin. According to the provisions of laws/regulations and the manufacturer’s specifications, a useful life management ledger for the railway equipment shall be prepared.

2) When the updating timing has come, it will become necessary to make a large equipment investment. When the scale of management of Hanoi Metro increases after the Line 2A starts train service, followed by the start of train service of the No. 3 and Line 2s, the amount of equipment investment will be further increased to substantially affect the company’s management. Therefore, it is necessary to instruct OU to make follow-ups with the formulation of related documents and update them so that the company’s investment plan will be ensured and sufficient equipment and materials will be supplied to the respective lines as necessary.

3) The electric division must fully grasp the useful life, operation state, etc. of equipment, and then define an investment plan from a medium-term perspective, and make up a detailed one-year investment plan in the business plan so that the investment timings will not be overlapped.

4) An investment plan relates not only to the useful life of equipment, but also to the state of equipment such as its failure rate. If equipment is maintained with a low failure rate even after the legal useful life is exceeded, it is not necessary to rush to updating.

5) In formulating an equipment investment plan associated with the start of train service of the Line 2A, examine whether or not a useful life of railway equipment is defined under laws/regulations of Vietnam, and if it is, apply that useful life. If a useful life is not defined under laws/regulations concerning railway equipment, determine a basic useful life based on the specifications, etc. that the manufacturer provides.

There will be no data on an equipment failure rate, etc. in the beginning. Therefore, an updating time for each piece of equipment shall be set based on the useful life. The investment amount for the updating timing shall be estimated based on information on the equipment assets of the Line 2A, and the estimated amount shall be posted in the business plan.

6) Since the Line 2A will be basically transferred under a turnkey agreement, it is considered that there will not be a large equipment investment immediately after the transfer. However, since it may become necessary to extend or improve equipment according to the state of usage by customers, etc., it will be necessary to secure a certain amount of cost.

7) Fig. 2 shows an image graph of necessary cost, while Fig. 3 shows an image graph
of transitions in asset value and stability of equipment.

Fig. 2 provides an image of maintenance operation cost, updating cost, construction cost, etc. as the necessary costs on the assumption that the useful life is set at 10 years, 15 years, 30 years, etc. The construction cost represents the cost of new equipment installation, extension, etc., the updating cost represents the cost of equipment updating, and the maintenance operation cost represents the cost of inspection, repair, etc. Since this graph is prepared using dummy numbers, the ratios are also dummy.

Fig. 3 provides an image of assumed single piece of equipment for which the set useful life is 30 years and overhauling is conducted at the 15th year, in transition of the equipment’s asset value and stability. The asset value decreases as the useful life elapses. Although stability also decreases as the time elapses, it will be recovered once through overhauling, and then decrease as the time elapses. Since this graph is prepared using dummy numbers, the ratios are also dummy.

2.3 Equalization of a business plan and a budget

The electric division’s business plan and budget include updating, improvement, new installation, inspection, repair, and removal, etc. of equipment, and can be formulated on the basis of 10 years, 30 years or 40 years if the policy is clarified. Useful lives of pieces of electric equipment are basically within 30 years, and it is important to equalize the plan and budget in the long term in order to eliminate year-on-year disproportion (or to prevent concentration in a certain year).
Since the ability to implement income and investment plans in the railway business is almost constant, it is important to equalize the budget. In addition, to implement the optimal investment plan, the difference between the budget and the result should be small. Therefore, it is necessary to collect as much information as possible, and prepare an appropriately sized (not too large, not too small) budget. It is necessary to continually update information on technical innovation, and update information on equipment such as new installation, updating and improvement.

Fig. 4 and 5 show images of an un-equalized budget and an equalized budget.
## Budget planning for maintenance operations for the Line ○○○ - year ○○○

(electric division)

<table>
<thead>
<tr>
<th>Maintenance time</th>
<th>Content of operation</th>
<th>Implementation method</th>
<th>Period of use</th>
<th>Maintenance cycle</th>
<th>Useful life</th>
<th>Implementing division</th>
<th>Implementation cost</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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## Interim budget planning for maintenance operations
( electric division )

<table>
<thead>
<tr>
<th>Month</th>
<th>Line ○○○</th>
<th>Line ○○○</th>
<th>Line ○○○</th>
<th>Line ○○○</th>
<th>Line ○○○</th>
<th>Remarks</th>
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Total: ..  Total: ..  Total: ..  Total: ..  Total: ..  Total: ..  Total: ..  Total: ..  Total: ..  Total: ..  Total: ..

**Cost for implementing maintenance operations for all lines**

- 164 -
### Table of detailed cost for maintenance operations for the Line ○○○ - year ○○○
(electric division)

<table>
<thead>
<tr>
<th>Maintenance time</th>
<th>Content of operation</th>
<th>Implementation method</th>
<th>Implementing division</th>
<th>Implementation cost</th>
<th>Others</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Month</td>
<td>Date</td>
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<td>Maintenance cost</td>
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<td>Outsourcing cost</td>
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<td>General cost at</td>
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<td>Cost</td>
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<td>additionally</td>
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<td>generated</td>
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<td></td>
<td></td>
<td>during maintenance</td>
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</tr>
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</table>

- Jan. 1
- Feb. 1
- Mar. 1
- Apr. 1
- May. 1
- Jun. 1
- Jul. 1
- Aug. 1
- Sep. 1
- Oct. 1
- Nov. 1
- Dec. 1

<table>
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<tr>
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<tbody>
<tr>
<td>Jan.</td>
<td>31</td>
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<tr>
<td>Feb.</td>
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<tr>
<td>Mar.</td>
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<td>Jun.</td>
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<td>Nov.</td>
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<td>Dec.</td>
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</tbody>
</table>

Total: ….. Total: ….. Total: ….. Total: ….. Total: ….. Total: …..
Guidelines for preparing a renewal plan

1. Purpose
- The purpose of equipment renewal is to maintain/improve the stable operation of equipment, or implement necessary function improvements.
- The purpose of the renewal plan is to ensure that the company’s overall plan (business plan and budget plan) will be followed, in addition to preparing a long-term maintenance work plan and maintaining stable operation of the equipment system.
- Equipment renewal shall be implemented in the following cases.
  + The useful life of the equipment has expired, and it is predicted or considered that the equipment may become unusable.
  + The equipment has failed, and it is predicted or considered that the equipment cannot be repaired.
  + There is demand for improving the operating capacity or function of the system.

2. Guidelines for preparing a renewal plan
2.1. Grounds for preparing/checking a renewal plan
- Laws and regulations concerning the equipment system
- The company’s rules and overall plan
- Equipment management ledger and equipment useful life management ledger for each line
- State of budget for each line/year (to ensure budget leveling between years)
- State of equipment for each line
- Business plan of OU (long-term business plan, periodical inspection plan, repair plan, etc.)

2.2. The company’s renewal plan format (attached document)
2.3. Annual renewal plan (examined and prepared by OU)
- OU of each line shall appropriately prepare an annual renewal plan based on the company’s renewal plan and budget plan.
- Since equipment may temporarily fail, and be updated on an unscheduled basis, it is necessary to allow leeway when preparing a budget plan for each line or each year.
### Updating plan

(Assume that the longest useful life among all equipment of the electric division is 30 years. Therefore, an updating plan for 30 years shall be prepared.)

Lines ...

#### Hanoi Metro Company

<table>
<thead>
<tr>
<th>Classification</th>
<th>Name of equipment</th>
<th>Equipment code</th>
<th>Useful life</th>
<th>Installation site</th>
<th>Remarks</th>
<th>2016</th>
<th>2017</th>
<th>2046</th>
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<td>Stallion equipment</td>
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</table>
Guideline for Training/Education Plan Development for the Maintenance Personnel of the Line 2A Communication, Signal, Power and Station Equipment Sections

1. Policies

Purpose: This training plan shall be drawn up for the purpose of cultivation and enhancement of maintenance personnel ability along with clear directionality.
- The maintenance personnel of OU mean all of the managers, the deputy managers, the section engineers, the leaders, and the workers who belong to the communication, signal, power, and station equipment inspection and repair centers of OU.

Education: The role of education is to enhance knowledge, technology, and other capacities of human resources, aiming at raising the level of a whole organization by repeatedly providing education. The role of education is important in the railway business, since this industry is supported by a multitude of human resources. Without properly conducting education, there is no securing adequate human resources in terms of the number and quality.
- This education can be divided as follows:
  + Position based trainings (the manager training, the deputy manager training, the section engineer training, the leader training, and the worker training of the inspection and repair centers in OU)
  + Purpose based trainings (the transfer-staff training, the new-staff training, the theoretical/practical training, the handling training of tools for holding and equipment, the training to comprehend laws and corporate rules, etc.)
  + Trainings based on different methods (the on-the-job-training [OJT], the in-house training, the external training, training by external instructors, etc.)

Matters to be attended to in the maintenance personnel education process
- Analyze needs for education and types of individual ability, viewed from personnel management, which can be enhanced through the educational program at issue.
- Analyze an ability model for each position.
- Formulate details of education for each ability type.
- Compose educational modules by assembling educational contents.
- Develop plans so that they will become educational programs or models of the company.

2. Guideline for the formulation

2.1. Prerequisites for the formulation
Subject to:
- Development plans of the company
- Actual demand of the inspection and repair centers of OU
- Work ability of all the members of the inspection and repair centers of OU
- Business plans of the company (to implement education on technologies and equipment the company has decided to introduce)
- Yearly budget planning of the inspection and repair centers
- Applicable laws
- Personnel policies corresponding to laws and corporate development strategies

2.2. Division of educational plans
(1) External training plans
- Education plans based on individual demand: This is the education to be conducted with reference to subjective opinions of each member of the maintenance personnel. When a member realizes a weak point or ability he or she lacks, training to make up for it is planned. As a simple example, questionnaires should be distributed to all the maintenance personnel, a meeting should be held where a manager (OU) discusses related topics and the maintenance personnel express their views on necessary matters.
- Education plans based on real demand of the inspection and repair centers: When a manager (OU) finds a lack of knowledge or ability that the maintenance personnel have during the work process, he needs to do something to make up for it. The manager (OU) should propose an idea about an education plan of the personnel of a related inspection and repair center to a manager of a related equipment section of HQ.
  - Education plans based on corporate demand: Each inspection and repair center of OU should submit an education plan to a corresponding equipment section of HQ. The HQ side should submit the plan to the corporate management after discussions with the OU side.
The corporate management should draw up a company-wide common education plan along with its development directionality and development plan based on the submitted education plan. The inspection and repair center should formulate a concrete implementation plan and implement it based on the company-wide common education plan drawn up by the corporate management.

- Education plans based on opinions of the personnel department: The personnel department should propose a training and education plan of maintenance personnel with reference to a business plan of each department and ability of personnel, and then the department should submit it to the head of the company. However, to secure conformity, the personnel department needs to make arrangements beforehand with the head of each department and issue a proper and exact education plan.

(2) Internal education plans
- Managers (OU) need to deliver measures to improve work effectiveness of the inspection and repair centers with reference to actual work conditions and work ability levels of the personnel.
- Managers (OU) and deputy managers (OU), together with section engineers (OU), may assign homework to leaders and workers according to their knowledge, technology, and experiences in order to improve their ability. They should check results of the homework and provide necessary guidance.
- The managers of OU should guide leaders and workers by teaching knowledge and technology they have, in order to increase work ability and achieve high performance.
- Meetings for study, exchange of experiences, and the like should be held, while working out themes of the meetings and inviting all the personnel of the inspection and repair centers.

(3) Other education plans
- Education plans may be formulated in cooperation with business partners, equipment suppliers, etc. for the purpose of educating the maintenance personnel.
- Experiences can be exchanged and enhanced by sending maintenance personnel to external seminars.

2.3. Guideline for training/education plan development for the personnel of the inspection and repair centers
- Draw up training and education plans for personnel in line with the development directionality and development plan of the company.
- Draw up education plans based on demand and actual conditions of the inspection and repair centers.
- Ensure that all the personnel of the inspection and repair centers receive training on management and maintenance work so that their ability and levels of skills will be enhanced.
- Set specific conditions for personnel members who have higher ability and concentration for work as well as excellent quality, so that they can further enhance them.
- Proactively hold study meetings and seminars for all the personnel of the inspection and repair centers to exchange, share and learn their experiences.
- Issue policies to the human resources management of the inspection and repair centers on incentives and encouragement for enhancement of solidarity and full exercise of work ability of individuals and teams so as to achieve higher effectiveness during work time.
- Develop and maintain educational formats that can bring about a good effect.
Composition of criteria for installed quantity
(for communication equipment, signal equipment, electric electric power equipment, elevators and escalators)

Purpose
If equipment is to be newly installed, extended, improved, updated, etc., installation criteria will be required and are essential.
However, equipment will have been installed when the Line 2A starts train service. Therefore, these installation criteria will not be applied. Nevertheless, equipment may be extended, improved or updated depending on the situation after the train service is started, and in such cases, these installation criteria would be adopted.
As with the Line 2A, these criteria will be applied when the other urban railway lines under construction and investment start train service. These installation criteria can be applied to those lines for which construction investment has not been made from the beginning. This way, criteria for the installed quantity of all lines in Hanoi City will be unified in the future. Since a technical standard law will be established in the future, it shall be promptly reflected after it is established.

Content
Part 1: Equipment standard rules
Chapter 1. General rule
Chapter 2. Railway tracks
Chapter 3. Electric power equipment
Chapter 4. Electric machinery and equipment
Chapter 5. Signal equipment
Chapter 6. Communication equipment
Chapter 7. Related regulations and materials

Part 2: Equipment design manual
Chapter 1. Outline
Chapter 2. Power transformation
Chapter 3. Electric line
Chapter 4. Electric facilities
Chapter 5. Legends of symbols indicated in construction drawings

Part 3: Equipment order specification
Chapter 1. General rule
Chapter 2. Equipment configuration
Chapter 3. Functions
Chapter 4. Specifications
Chapter 5. Testing method and inspection method
Chapter 6. Spares, accessories, etc.
Chapter 7. Documents to be submitted

Part 4: Equipment installation criteria manual
Chapter 1. General rule
Chapter 2. Site management
Chapter 3. Inspections
Chapter 4. Standard construction (common among all equipment)
Chapter 5. Standard construction (by types of equipment)
Chapter 6. A collection of drawings
Chapter 7. A collection of photos
Part 1: Equipment standard rules

Criteria for performance and technical property of equipment intended to achieve safe, stable and secure passenger transport shall be established.

At this point, standard rules shall be formulated as rules common among all staff in charge and all lines. Subsequently, in the course of operation and at the time of construction investment in other urban rail lines, standard rules shall be formulated in the form of by staff in charge and by lines. The purpose of this is to respond to the actual situations of different lines because they have different equipment.

The equipment to be described in these rules shall be equipment involved in safe, stable and secure passenger transport.

Chapter 1. General rule

1.1. Purpose

Article 1. These rules are established with the aim of clarifying technical standard and performances of urban railway equipment in order to ensure safe, stable and secure passenger transport.

1.2. Scope of application

Article 2. The personnel of the electric division shall comply with these rules in addition to the applicable laws and regulations of the country.

Article 3. If a revision, addition, etc. on related content is made in any of the applicable laws and regulations of the country, updating, revision or addition must be made also in these rules for compliance and unification.

1.3. Definitions of terms (in accordance with a standard for urban railways No. TCVN 8585:2011)

"Railway signals" is a generic term of signals, signs and indicators.

Signals are a method for indicating conditions or instructions for operation and car shunting for trains and railway transport means, in the form of shape, color or sound.

Signs are a method for communicating information, commands and conditions on operation or car shunting that staff engaged in train operation conducted between railway staff, in the form of shape, color or sound.

Indicators are a method for providing necessary information on the display of the position, direction, condition, etc. related to railways, in the form of shape, color, etc.

Car gauge is a cross section range at which to permit the size of the train, etc. for securing a passage space for a train, etc. on a railway track.

Construction gauge is a cross section range at which to permit installation of a building, etc. for a passage space for a train, etc. on a railway track.

Interlocking device is a device that links between signals, switches, and between a signal and a switch, etc. at places, etc. where collision or derailment could occur.

Electric train line is an electric line that supplies power to the train from a power collector. It contains a third rail, overhead contact line and rigid contact line.

Chapter 2. Railway tracks

Article 4. Equipment must be maintained in a state where the train can be safely operated at the prescribed speed. In other conditions, safety must be secured through speed limiting, monitoring, etc.

Article 5. A construction gauge shall be specified based on the car gauge. When installing equipment, be sure not to install those pieces of equipment that may be within the construction gauge due to deformation, deterioration, etc. even if it is outside the construction gauge.

Chapter 3. Electric power equipment

Article 6. An appropriate type of contact line shall be adopted based on the infrastructure of the respective line. If a third-rail system is adopted, a security measure must be taken for any place people can access.

Article 7. For a third rail, install protection equipment to protect people from touching it. In a station, a third rail shall be installed on the opposite side of the platform in principle.

Article 8. If scaffolds intended to be used for inspection of an electric train line and a feeder liner on the platform are to be installed, the height above the platform shall be ○○m or more. However, this does not apply in cases such as those where the scaffolds can be stored inside, and a fence for preventing people from accessing the proximity of the place is erected (while referring to Tokyo Metro, the height was set at 1.8 m so that people with their hands raised will not touch the scaffolds on the assumption of an average [Japanese] height of 1.6 m).

Article 9. The rails for the return line shall be electrically connected at each joint by means of bonding or the like. The electric resistance at the joint shall not exceed the electric resistance of a 5 m portion of the rail.

Article 10. The strength and durability of the transmission line and distribution line shall be as indicated in the table below in accordance with the laws and regulations (values will be added when information
on the Line 2A’s equipment is acquired, and updated when a standard for urban railway operation and maintenance is published).

<table>
<thead>
<tr>
<th>Strength and durability of transmission line and distribution line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission line</td>
</tr>
<tr>
<td>Distribution line</td>
</tr>
</tbody>
</table>

Article 11. An arrester shall be installed in the following places and their proximities.
- Places where lightning may affect related equipment
- Substation, receiving end and transmitting end of overhead transmission/distribution lines, and feeding end of overhead feeder

Article 12. Each substation shall have a fence, wall, etc. in order to prevent any person other than the personnel handling the substation from accessing it. A locking device shall be installed at the doorway, and a NO ENTRY indication shall be posted.

Article 13. Each substation shall have the following security equipment.
- Automatic breaker for protecting extra-high-voltage or high-voltage equipment
- Protection system against an overload and an abnormal electric current
- Equipment against fires

Chapter 4. Electric machinery and equipment
Article 14. Equipment, cables, switchboards, etc. must be installed in a manner to prevent short circuiting, ground fault, ground leakage, electrification and fires from occurring.
Article 15. For any place where short circuiting, ground fault, ground leakage, etc. may occur, a protector, monitoring device, alarm, etc. must be installed.

Chapter 5. Signal equipment
Article 16. For any railway, a device that secures an interval between trains shall be installed in order to secure safety between trains.
Article 17. For any cross section or branch of a railway track, an interlocking device shall be installed.

Chapter 6. Communication equipment
Article 18. A dedicated telephone with a private circuit shall be installed in any station, substation, OCC and any other places requiring it.
Article 19. To prevent communication between OCC and the train from being interrupted, a train radio device shall be installed.

Chapter 7. Related regulations and materials
Chapter 1. Outline

1.1. Purpose
This design manual specifies a procedure for electric power equipment design, precautions, etc. This manual shall be prepared from the viewpoints of safety, reliability, operability, functions, cost, maintainability, etc. based on the equipment standard rules.

The design manual shall be prepared in the form of by staff in charge and by lines. At this point, the design manual is prepared in the form of by staff in charge of communication, signals, power and station equipment, and common among lines.

The equipment to be described in this manual shall be electric power equipment that the power inspection and repair center manages.

1.2. Outline of transforming equipment
Transforming equipment is intended to supply electric power to electric power equipment, station equipment, signal equipment, communication equipment, employee office, etc., and is installed in various places.

Electric power is received at a high voltage from the electric power company to a substation, which then steps down the voltage and transmits the stepped down voltage to contact lines and electric rooms at stations, etc.

In addition to stepping down a voltage, a substation rectifies an alternate current to a direct current, and supplies a direct current to contact lines.

Equipment, cables, etc. involved in transformation in a substation are transforming equipment.

1.3. Outline of electric line equipment
Equipment that supplies electricity from transforming equipment to contact lines and electric rooms of stations, etc. is electric line equipment.

1.4. Outline of electric facilities
Electric room equipment of a station to which electric power from the transforming equipment is supplied via electric line equipment is electric facility equipment. An electric room further steps down the received electricity, and supplies the stepped down electricity to various equipment installed in various places.

1.5. Equipment configuration drawing

Chapter 2. Power transformation

2.1. Philosophy

2.2. Design criteria

Chapter 3. Electric line

3.1. Philosophy
Electric lines in urban railways shall be highly reliable systems. Material, structure, characteristics of an electric line shall be fully considered also for the place/region where it is used and for the equipment alone. In addition, it is also necessary to pay much attention to the cost calculation at time of adoption.

3.2. Design criteria

3.2.1. Method for receiving electricity from the electric power company
The electric power company supplies electricity from a substation that it controls.

Electricity is transmitted via a cable from the substation that the electric power company controls, to a substation that HMC controls for supplying electricity to various equipment and trains. This cable shall be managed by HMC.

This shall be a three-phase AC three-wire system.

3.2.2. Distribution system
Basic distribution drawing

3.2.3. Cables
(1) Transmission/distribution lines (the provided figures are tentative figures, and values will be added after specifications for the Line 2A's transmission/distribution lines are obtained)

<table>
<thead>
<tr>
<th>Type</th>
<th>Conductor section area [mm²]</th>
<th>Permissible current [A]</th>
<th>Transmission capacity [kVA]</th>
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<td>CV</td>
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<td>(cross-linked polyethylene insulated vinyl sheath cable)</td>
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<td>200</td>
<td>7,000</td>
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(2) Overhead transmission line
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<th>Type</th>
<th>Conductor section area [mm²]</th>
<th>Permissible current [A]</th>
<th>Transmission capacity [kVA]</th>
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<tbody>
<tr>
<td>Hard drawn copper stranded wire</td>
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<td>400</td>
<td>2,000</td>
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</tbody>
</table>

3.2.4. Contact lines

(1) Third-rail system
- Configuration diagram, material, related equipment, etc.
- Design guidelines (installation method, calculation method, installation site, installation layout, etc.)
- Precautions
- Procedures/method for application for approval with the government, and method for communicating them to the related divisions in the company

(2) Overhead wiring system
- Configuration diagram, material, related equipment, etc.
- Design guidelines (installation method, calculation method, installation site, installation layout, etc.)
- Precautions
- Procedures/method for application for approval with the government, and method for communicating them to the related divisions in the company

Chapter 4. Electric facilities

4.1. Philosophy
4.2. Design criteria

Chapter 5. Legends of symbols indicated in construction drawings
Part 3: Equipment order specification

An equipment order specification is intended to be attached to contract documents when a special order for a device or material is placed with the manufacturer after equipment is designed based on the equipment standard rules and the equipment design manual.

For railway electric power equipment, a product with special specifications or a special order product based on an ordinary product with enhanced specifications is used in many cases, and its production requires a specification describing the requirements of the equipment. Such a specification shall be prepared every time an order for equipment is placed.

This specification will be prepared in the form of by equipment and by lines. Those specifications requiring the company’s higher technology than specifications issued under laws/regulations and by the supplier will be mentioned in this document.

When this document is prepared, a specification of a security camera (The security surveillance camera at the Vietnamese) used in the communication equipment shall be prepared in order to help grasp an image of the configuration of this document.

Chapter 1. General rule

1.1. Purpose

This specification specifies the equipment specifications of a security system designed to check the images from security cameras installed in stations. The owner shall request the contractor to produce the equipment based on this specification, while the contractor shall produce the equipment based on this specification.

1.2. Scope of application

This equipment specification shall be applied when the contract on the production of the equipment as indicated in this equipment specification is signed by the owner and the contractor. If any deliberation or discussion on the content of the contract arises, the matter shall be examined between the parties. For important matters, a document that is mutually agreed on shall be prepared, and its copy shall be maintained by each party.

1.3. Applicable laws and regulations

If an order for the production of equipment is placed, the contractor shall follow the signed contract in accordance with the applicable laws and regulations and applicable standards.

1.4. Compensation matters

The contractor shall respond faithfully to any equipment failure attributable to the contractor, including a monetary burden.

The owner may not seek compensation from the contractor for equipment failure other than those attributable to the contractor.

Chapter 2. Equipment configuration

2.1. Drawing of the operating principle of the system

- Equipment configuration drawing
- Symbols, parameters, materials, etc.

2.2. OCC Center

(1) Image display device
- Controller
- Display
- System diagnosis device
- Power supply

(2) Image controller
- Controller
- Transmitter
- Power supply

2.3. Stations

(1) Image display device
- Controller
- Display
- Power supply

(2) Image controller
- Controller
Chapter 3. Functions
3.1. Function requirements
This system shall have a self-diagnosis function. The system’s operating status shall be diagnosed at a constant cycle, and if an anomaly or a sign of anomaly arises, an alarm shall be output.

The startup and shutdown of this system shall be automatically performed in conjunction with the power supply. Even in case of power outage, system failure shall not occur, and manual operation of startup or shutdown shall not be required.

This system shall be composed of multiple systems. If the main system fails, it shall be automatically switched to the subsidiary system.

This system shall have a memory function at each station. At each station, the stored images can be checked at a later date/time. Even if images cannot be checked at OCC in case of transmission trouble, the images shall be stored at each station. The stored images can be duplicated and output to a disk.

3.2. Environmental requirements
This equipment shall have ordinary mechanical durability, electric durability, etc., and withstand long-term use in an office and an equipment room.

The metal material used for this equipment shall be provided with corrosion protection processing.

This equipment shall be provided with a rack so that it can flexibly respond to the installation space.

Heat dissipation shall be considered for this equipment.

3.3. RAMS requirements (reliability, usability, operability and safety)

Chapter 4. Specifications
The standard specifications to be described are as follows.

- Power supply voltage
- OS
- CPU
- Transmission capacity
- Camera image quality
- Strength
- Coating
- State of components constituting the system
- Redundant configuration
- Number of spares, etc.

4.1. OCC Center
Image display device
- Power supply voltage: 220 V AC + 10%
- OS: Windows 8 or higher (information on the Line 2A can be added when it is acquired; can be updated/improved to a better OS when technical development is achieved)

4.2. Stations

Chapter 5. Testing method and inspection method
5.1. Testing method
At the plant, a ☐ day operation test shall be conducted (according to the rules and specifications provided by the firm). Some products may have been standardized. Here, assuming a special order product, a number of days that can be secured from production to delivery shall be set (approximately 30 to 90 days) (reference of Tokyo Metro).

During the operation test, the voltage, current, insulation resistance, etc. shall be measured.
During the operation test, outage-restoration operation shall be performed \( o \) times (according to the rules and specifications provided by the firm), to check the operation.

Example: Assuming that the equipment is used for 10 years in an environment where power outage occurs twice a month, power outage would occur 240 times. Therefore, outage-restoration test should be conducted approximately 300 times (rounded up from 240 times).

The test result shall be recorded in a document, and approval at an authorized level shall be obtained for the document recording the test result.

5.2. Inspection method

Inspecting the appearance (dimensions, components of equipment, etc.)
Inspecting the document recording the test result
Reproducing the test result as necessary, and checking for consistency with the description in the record document
Recording the inspection result in a document, and obtaining approval at an authorized level of the contractor and the owner

Chapter 6. Spares, accessories, etc.

Operability and cost shall be weighed and the result shall be recorded.

Chapter 7. Documents to be submitted

Detailed specification of the delivered product, test result record, inspection result record, etc.
Part 4: Equipment installation criteria manual

This equipment installation criteria manual specifies the construction method, construction procedure, etc. to be followed in performing the installation as designed.

This manual shall be prepared in the form of by staff in charge and by lines. At this point, the manual shall be prepared in the form of being common among staff in charge and common among lines.

The equipment to be described in this manual shall be all equipment of the electric division.

At the time of preparing this document, a signal equipment installation criteria manual of the electric division shall be prepared as a reference material.

Chapter 1. General rule
1.1. Purpose
This manual specifies the construction method, construction procedure, etc. to be followed in the equipment installation for the electric division.

1.2. Scope of application
In performing the equipment installation for the electric division, the matters specified in this manual shall be observed.

1.3. Applicable laws and regulations
In performing the equipment installation for the electric division, the applicable laws and regulations shall be observed first, and then the company’s equipment installation criteria manual and other applicable rules shall be observed.

Chapter 2. Site management
2.1. Administrator/responsible person
Responsibility and authority of the construction manager in the site

An construction procedure aimed at security during the work shall follow the laws and regulations, and can be additionally specified by the field manager with the aim of improving safety.

2.2. Materials
For the materials to be used, approval of the field manager or a superior shall be obtained.

For the supplied materials, their sources, etc. shall be clearly guaranteed.

2.3. Precautions for construction
2.3.1. Construction gauge
The cross section of the construction gauge shall be indicated.

2.3.2. Fire control actions
Regulations for fire control shall be observed.

It shall be ensured that the material meets the standards and requirements concerning fires.

2.3.3. Measures to prevent intrusion of rats and insects
Methods and measures to prevent rats and insects from affecting the equipment.

Chapter 3. Inspections
This manual shall contain a general inspection procedure.

Chapter 4. Standard construction (common among all equipment)
4.1. Equipment
Self-supported equipment
Wall-mounted equipment
Ceiling-mounted equipment

4.2. Cables
Storage trough
Storage rack
Metal cable
  - Laying
  - Cable connection
  - Cable end connection
Optic cable
  - Laying
  - Cable connection
  - Cable end connection

4.3. Coating
Coating standards
Coating method

Chapter 5. Standard construction (by types of equipment)
5.1. Signals
5.2. Switches
5.3. Indicators

Chapter 6. A collection of drawings
6.1. Legends of symbols indicated in the working drawings
6.2. A collection of drawings for the standard construction (sketch drawing, plan view drawing, cross-section drawing, etc.)

Chapter 7. A collection of photos
A collection of photos of the standard construction
Structure of Information Sharing Rules

Overview

This document presents proposed structure of a mechanism for improvement where the information sharing policy and the policy to make an equipment failure information database are actively applied and equipment failure information is actively used.

As these elements are strongly related to one another, they were compiled as single material when making the mechanism. Hereafter, when information is securely obtained and collection of necessary material is completed, the material will be divided into three different categories, and they will be compiled as rules for information sharing.

This material shall include the following content:

- Guideline for management and use of information
  This guideline shall be rules that specify how to manage and use information related to accidents, etc. In the rules, methods of collecting, storing, making widely known, and accessing information are specifically described as content.

- Guideline for recording data concerning failures, accidents, etc.
  This guideline shall be rules that specify methods of building and managing a database of information concerning accidents, etc. In the rules, formats and methods of inputting, storing, and accessing information are specifically described as content.

- Guideline for the PDCA cycle and operation quality
  This guideline shall be rules of operation enhancement processes where the PDCA concept is adopted.
Chapter 1 General rule

1.1 Purpose

These rules are formulated here for the purpose of specifying methods of managing and using information on accidents and the likes that have occurred in order to ensure safe, reliable, and secure passenger transport in the electric division of HMC.

These rules shall be based on correspondence to “The rules of response to urban railway accident and transport trouble” of HMC and “The electric division’s internal regulations concerning response to urban railway accident and transport trouble” of the electric division of HMC.

1.2 Scope of application

These rules apply to the electric division of HMC.

1.3 Interpretation of terms

- HQ stands for the Head Quarters.
- OU stands for the Operation Unit.
- Personnel of the electric division refer to all staff members belonging to the electric division of HQ and OU.
- Accident refers to an event in which damage of some form occurs in train operation, railway facilities, passengers, employees, etc.
- Accident risk refers to an event that has not led to an accident as a result, but has a high possibility that it might turn to an accident.
- DSDT is an abbreviation of an urban railway.
- Urban railway accident refers to an accident in which trains collide with each other or other objects, derail, overturn, or failures of railway facilities, causing troubles in train operation and damage to human life or health or to an asset.
- Urban railway transport trouble means a problem that affects the railway operation, but does not result in damage to human life or health or to an asset.
- Prompt report means immediate reporting or communication of occurrence of an accident or the like, and corresponds to the prompt report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Interim report means reporting of status of investigation into an accident or the like as well as
emergency countermeasures or the like, and corresponds to the description of the interim report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

- Final report means reporting of results of investigation into an accident or the like as well as permanent measures or the like, and corresponds to the final report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

Chapter 2 Reporting

2.1 Reporting methods of prompt, interim, and final reports

When reporting on an urban railway accident and an urban railway transport trouble as well as an accident accompanied by grave damage, human death or injury, etc. as a prompt, interim, or final report, the Manager (OU) or the Deputy Manager (OU) should go off to HQ and make a report or explanation in writing to the Manager (HQ) and the Deputy Manager (HQ) in charge. Nonetheless, if a special instruction is issued by the Manager (HQ) or the Deputy Manager (HQ) in charge, it should be observed.

2.2 Method of reporting to OCC

Reporting to OCC should be made with the first priority on speed but accurately using telephone each time in principle. Care should be taken to make a report or explanation clear in consideration of 5W1H (when, where, who, why, what and how) so that it can be correctly communicated with words alone. However, as need arises, a written report, drawings, photos, and so on should be separately sent so as to facilitate understanding by other party.

Example: 8.1 Tues 10:15, at Line 2A Ha Dong Station, a signal device failure caused stop signal to continue to be indicated on No. 1 signal of the inbound line.

Chapter 3 Sharing

3.1 Information sharing in the electric division on accidents or the likes that occurred within the division

- The Manager (OU) should quickly promote information sharing within the electric division after reporting an accident or the like that has occurred to HQ. The Manager should fully use e-mail, network folders, etc. to deploy material such as written reports, drawings, photos and the likes. The Manager should add explanations, remarks and the likes to the material so as to facilitate understanding by those who are not familiar with the equipment, the location, etc. at issue.

- The Manager (HQ) should quickly promote information sharing within the electric division according to the preceding provision, if an administrative agency and competent authorities give a guidance, etc. when reporting to them the accident or the like that occurred.

3.2 Information sharing in the electric division on accidents or the likes that occurred in other divisions

- The Manager (OU) and the Deputy Manager (HQ) should promptly collect grave information related to accidents and the likes that occurred in other divisions and information related to the electric division, and promote information sharing within the electric division. The Manager should fully use e-mail, network folders, etc. to deploy material such as written reports, drawings, photos and the likes. In actual deployment, analysis should be made on points to make note of by assuming that they are related to the division where the Manager or the Deputy Manager belongs, and then these points should be added to
matters to give guidance on later. The Manager should add explanations, remarks and the likes to the material so as to facilitate understanding by those who are not familiar with the equipment, the location, etc. at issue.

- The Manager (OU) and the Deputy Manager (HQ) should promptly provide other divisions with grave information related to the division where the Manager or the Deputy Manager belongs and information related to the electric division. Especially, information of an accident should be provided with the highest priority to a division that is deeply associated with the accident.

3.3 Meeting to share information on accidents and the likes

The Manager (HQ) should periodically (once a month or so) hold a “meeting of the electric division to share information on accidents and the likes.” It is intended to prevent occurrence or recurrence of accidents and the likes by promoting information sharing and strengthening awareness of safety. If information sharing is urgently required, a meeting should be held on a temporary basis.

Organization of this meeting should be assumed by a person (HQ) in charge of planning.

3.4 Report of sharing information on accidents and the likes

The Manager (HQ) should (once a month, a half year or a year or so) issue a “report of sharing information on accidents and the likes in the electric division.” It is intended to prevent occurrence or recurrence of accidents and the likes by promoting information sharing and deepening knowledge and understanding of members of the division. If it is urgently required to make information widely known or give guidance on it, a report should be issued on a temporary basis.

This report should be prepared by a person (HQ) in charge of planning.

The Manager (OU) and the Deputy Manager (HQ) should teach content of the report and lead discussions about it in the workplace.

Chapter 4 Others
Volume 2: Rules on making the database of equipment failure information

Table of contents
Chapter 1 General rule
  1.1 Purpose
  1.2 Scope of application
  1.3 Explanation of terms
Chapter 2 Mechanism and formats
Chapter 3 Input, check and storage
Chapter 4 Others

Chapter 1 General rule

1.1 Purpose
These rules are formulated here for the purpose of specifying a policy to make the database of accidents and the likes that have occurred in order to pave the way for safe, reliable, and secure passenger transport in the electric division of HMC. These rules shall be based on correspondence to “The rules of response to urban railway accident and transport trouble” of HMC, and to “The electric division’s internal regulations concerning response to urban railway accident and transport trouble” and “The rules of information sharing” of the electric division of HMC.

1.2 Scope of application
These rules apply to the equipment sections of HQ and OU.

1.3 Definition of terms
- HQ stands for the Head Quarters
- OU stands for the Operation Unit.
- Personnel of the electric division refer to all staff members belonging to the electric division of HQ and OU.
- Accident refers to an event in which damage of some form occurs in train operation, railway facilities, passengers, employees, etc.
- Accident risk refers to an event that has not led to an accident as a result, but has a high possibility that it might turn to an accident.
- DSDT is an abbreviation of an urban railway.
- Urban railway accident refers to an accident in which trains collide with each other or other objects, derail, overturn, or failures of railway facilities, causing troubles in train operation and damage to human life or health or to an asset.
- Urban railway transport trouble means a problem that affects the railway operation, but does not result in damage to human life or health or to an asset.
- Prompt report means immediate reporting or communication of occurrence of an accident or the like, and corresponds to the prompt report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Interim report means reporting of status of investigation into an accident or the like as well as emergency countermeasures or the like, and corresponds to the description of the interim report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Final report means reporting of results of investigation into an accident or the like as well as permanent measures or the like, and corresponds to the final report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

Chapter 2 Mechanism and formats

2.1 Mechanism
Each time an accident or the like occurs, its outline should be input to the database. (If no dedicated software is prepared during initial phases, Excel files can be used for work and saving.) For details, paper documents or separate data folders should be referred to. A storage place of the paper documents or the separate data folders should be described in the database.

2.2 Paper documents and data folders
As described in the preceding paragraph, reports of accidents and the likes, drawing, photos, etc. should be kept in paper documents and data folders.
### 2.3 Database format

<table>
<thead>
<tr>
<th>Occurrence date</th>
<th>Category of accidents and the likes</th>
<th>Organization in charge</th>
<th>Line</th>
<th>Station, etc.</th>
<th>Overview</th>
<th>Storage place of paper documents</th>
<th>Storage place of data folders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 2, 2017</td>
<td>Urban railway accident</td>
<td>Electric machine</td>
<td>2A</td>
<td>Ha Dong Station</td>
<td>A station fire caused by ventilation system trouble</td>
<td>Book-room shelf a-23</td>
<td>[Network addresses, etc.]</td>
</tr>
<tr>
<td>Oct. 5, 2017</td>
<td>Urban railway transport trouble</td>
<td>Signal</td>
<td>2A</td>
<td>Cat Linh Station to La Thanh Station</td>
<td>A failure in signal data transmission equipment</td>
<td>Book-room shelf b-104</td>
<td>Ditto</td>
</tr>
<tr>
<td>Feb. 25, 2018</td>
<td>Accident AFC</td>
<td>Power</td>
<td>2A</td>
<td>Thai Ha Station</td>
<td>An automatic ticket gate failure</td>
<td>Book-room shelf c-245</td>
<td>Ditto</td>
</tr>
<tr>
<td>Dec. 20, 2018</td>
<td>Accident risk</td>
<td></td>
<td>2A</td>
<td>Lang Station</td>
<td>Wrong wiring of distribution lines</td>
<td>Book-room shelf d-50</td>
<td>Ditto</td>
</tr>
</tbody>
</table>

### Chapter 3 Input, check and storage

3.1 Input

| Input to the database should be assumed by the Section Engineer (OU). |

3.2 Check (approval)

| A check (approval) on content of input to the database by the Section Engineer (OU) should be assumed by the Deputy Manager (OU). |

3.3 Storage

| After the Deputy Manager (OU) confirms (approves) content of input to the database by the Section Engineer (OU), the Section Engineer (OU) should store it. |

### Chapter 4 Others
Chapter 1 General rule

1.1 Purpose
These rules are here formulated for the purpose of specifying improvement methods by active use of information on accidents and the likes that have occurred in order to pave the way for safe, reliable, and secure passenger transport in the electric division of HMC. These rules shall be based on correspondence to “The rules of response to urban railway accident and transport trouble” of HMC, and to “The electric division’s internal regulations concerning response to urban railway accident and transport trouble,” “The rules of information sharing,” and “The rules of making the database of equipment failure information” of the electric division of HMC.

1.2 Scope of application
These rules apply to the electric division of HMC.

1.3 Explanation of terms
- HQ stands for the Head Quarters.
- OU stands for the Operation Unit.
- Personnel of the electric division refer to all staff members belonging to the electric division of HQ and OU.
- Accident refers to an event in which damage of some form occurs in train operation, railway facilities, passengers, employees, etc.
- Accident risk refers to an event that has not led to an accident as a result, but has a high possibility that it might turn to an accident.
- DSDT is an abbreviation of an urban railway.
- Urban railway accident refers to an accident in which trains collide with each other or other objects, derail, overturn, or failures of railway facilities, causing troubles in train operation and damage to human life or health or to an asset.
- Urban railway transport trouble means a problem that affects the railway operation, but does not result in damage to human life or health or to an asset.
- Prompt report means immediate reporting or communication of occurrence of an accident or the like, and corresponds to the prompt report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Interim report means reporting of status of investigation into an accident or the like as well as
emergency countermeasures or the like, and corresponds to the description of the interim report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

- Final report means reporting of results (of investigation into an accident or the like) as well as permanent measures or the like, and corresponds to the final report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

Chapter 2 Mechanism and formats

2.1 PDCA (the PDCA cycle)

- Make use of PDCA for improvement where information on accidents and the likes is actively used.
  
  Plan (planning) → Do (execution) → Check (assessment) → Act (improvement)

- The object and the awareness of an organization can be made clear by setting KPI (Key Performance Indicators) as an improvement index.

2.2 Active use of PDCA

How to make use of PDCA is explained here by presenting case examples after Figure 1 and 2.

Due to use of case examples, the explanation is described along with the process of

Check → Act → Plan → Do → Check → Act.

Figure 1. Monthly statistics of the accidents and the likes that occurred as attributable to the electric division in fiscal 2020

Check

- Figure 1 shows monthly statistics of the accidents and the likes that occurred as attributable to the electric division in fiscal 2020. The fiscal year total was 14 cases, while the number of occurrence in each moth was in a range between 0 and 4. It was confirmed (analyzed) that the months with high occurrence frequency are September (3 cases) and February (4 cases).

- In September, three cases of equipment failures occurred due to inundation of stations on typhoon days.

- In February, four cases of equipment failures occurred due to mishandling of subcontractor’s workers in subcontracted construction work.
Act
+ Response to inundation
   → It was concluded based on analysis that the causes were the occurrence of the inundation in the stations and the installation locations of equipment that were affected by the inundation.
   ⇒ Countermeasures were taken with prevention of inundation of the stations and relocation of the equipment to locations that would not be affected by inundation.
+ Response to subcontracted construction work
   → It was concluded based on analysis that the causes were a lack of personnel mobilization capacity of the subcontractor due to the increased number of construction work in February and a lack of prevalence of OU’s supervision and guidance.
   ⇒ As a countermeasure, numbers of construction works for each month were equalized so that works did not concentrate in February.

Plan
+ Response to inundation
   → The civil engineering and construction division planned construction work so as to prevent inundation.
   → The electric division planned equipment relocation to avoid an influence of inundation.
   → The term “zero cases of inundation damage per year” was set to KPI.
+ Response to subcontracted construction work
   → A plan for subsequent construction orders was reviewed on the premise of equalization over months.
   → The term of “10 cases per month for the number of construction work orders” was set to KPI.

Do
+ Response to inundation
   → The civil engineering and construction division executed construction works so as to prevent inundation.
   → The electric division executed equipment relocation to avoid an influence of inundation.
+ Response to subcontracted construction work
   → The numbers of the following construction work orders were equalized over months.

Check
+ Response to inundation
   ⇒ The yearly occurrence number of inundation damage became zero. (KPI satisfied)
   → It was confirmed that there was no fear of occurrence of inundation as a result of patrol made in the stations at issue during typhoons.
   → It was confirmed that there would be no influence on installation locations of equipment if inundation should occur in the stations at issue as a result of patrol made in the stations.
+ Response to subcontracted construction work
   ⇒ It was confirmed that the numbers of construction work orders were equalized as the number per month became 9 to 10. (KPI satisfied)
   → The number of mishandling caused by subcontractor’s workers in subcontracted works in February reduced from four to one.
Figure 2. Classification statistics of the accidents and the likes that occurred as attributable to the electric division between fiscal 2017 and 2019

<table>
<thead>
<tr>
<th>Fiscal year</th>
<th>Power facility failure</th>
<th>Electro-mechanical equipment failure</th>
<th>Signal equipment failure</th>
<th>Communication equipment failure</th>
<th>AFC equipment failure</th>
<th>Attributable to workers</th>
<th>Attributable to passengers</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2018</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2019</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Check

Figure 2 shows classification statistics of the accidents and the likes that occurred as attributable to the electric division between fiscal 2017 and 2019.

It shows frequent occurrence of accidents that were attributable to workers.

Act

+ Response to accidents attributable to workers
  → It was concluded through analysis that workers had insufficient understanding of equipment and work procedures.
  ⇒ A countermeasure against insufficient understanding by workers about equipment was taken so as to reinforce training in the workplace within OU.
  ⇒ A countermeasures against insufficient understanding by workers about work procedures was taken so as to review content of the maintenance manual.

Plan

+ Response to accidents attributable to workers
  → Planning was made on programs and schedules of training in the workplace within OU.
  → Revision of the maintenance manual was planned while assigning persons in charge and setting a schedule.
  → The term of “five cases or less per year for the number of accidents attributable to workers that occur after taking countermeasures” was set to KPI.

Do

+ Response to accidents attributable to workers
  → Training in the workplace within OU was carried out in a systematic manner for one year.
  → Revision of the maintenance manual was carried out in a systematic manner, taking one year.

Check

+ Response to accidents attributable to workers
  ⇒ The number of accidents attributable to workers became five cases after taking the countermeasure. (KPI satisfied)
Act
   + Response to accidents attributable to workers
   → It was concluded from analysis that KPI was satisfied and improvement was achieved but further improvement was needed.
   ⇒ A countermeasure against insufficient understanding about equipment was planned so as to reinforce training in the workplace within OU.
   ⇒ A countermeasure against insufficient understanding about work procedures was planned so as to further improve content of the maintenance manual.

2.3 PDCA format
   The format is presented below.
PDCA sheet (example descriptions in blue)
Organization in charge: Persons of HQ in charge

<table>
<thead>
<tr>
<th>Preview of Check</th>
<th>Date of filling out</th>
<th>Apr. 5, 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Three cases of equipment failures occurred due to inundation of stations on typhoon days in September of fiscal 2020.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preview of Act</th>
<th>Date of filling out</th>
<th>Apr. 5, 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>- According to results of analysis, the causes were that the stations were inundated and equipment was placed in locations that were affected by inundation. + Countermeasures were planned to prevent inundation of the stations and relocation of the equipment to locations that would not be affected by inundation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan</th>
<th>Date of filling out</th>
<th>Apr. 20, 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPI Zero occurrence per year of inundation damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- The civil engineering and construction division made planning of construction work to prevent inundation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- The electric division made planning to relocate the equipment so as to avoid an influence of inundation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do</th>
<th>Date of filling out</th>
<th>Jan. 15, 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The civil engineering and construction division carried out and completed the construction work to prevent inundation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- The electric division carried out and completed the equipment relocation work to avoid an influence of inundation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Check</th>
<th>Date of filling out</th>
<th>Mar. 5, 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Zero occurrence per year of inundation damage (KPI satisfied)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- It was confirmed that there was no fear of inundation as a result of patrol in the stations at issue during typhoons.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- It was confirmed that there would be no influence on equipment installation locations if inundation should occur in the stations at issue as a result of patrol in the stations.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Act                                                   | Date of filling out | —            |
Chapter 3 How to carry on PDCA

PDCA is a continuous activity. It is desirable for parties concerned to periodically check and share its progress by holding meetings, etc. For example, they may put in practice a method of having a person in charge report progress in writing in the meeting to share information on accidents and the likes, which is discussed in the Rules of Information Sharing (3.3 Meeting to share information on accidents and the likes).

Chapter 4 Others
Line 2A facilities management ledger

Policy for preparing a facility management ledger

- With the aim of achieving the purposes of managing the asset value and managing the useful life and attribute, a facility management ledger shall be prepared.

- Since two properties and applications are required for the facility management ledger, two types of ledger shall be prepared as follow.
  
  + The purpose of an asset value management ledger is to contribute to preparation of a financial statement and a balance sheet and management of the facility value (it shall be prepared or entered according to the finance division’s instructions).
  
  + A facility useful life/attribute management ledger shall be utilized when providing information for the formulation of a business plan for the facility inspection/repair processes and searching for equivalent facility to be replaced with.

- The electric division shall prepare a “facility useful life/attribute management ledger.” Create a format, and as soon as facility information is obtained, make entries.

- The format of the facility management ledger shall be created for each line and be shared among the respective staff in charge.

- To manage the facility’s useful life, a facility useful life management ledger shall be prepared apart from the facility management ledger.

- For the saving of data into an electronic database of a facility management ledger and facility useful life management ledger, it is necessary to observe the laws/regulations and the company’s rules.
### Format for a facility management ledger (for each line/common among respective staff in charge)

<table>
<thead>
<tr>
<th>Order</th>
<th>Name of staff in charge (1)</th>
<th>Name of facility (2)</th>
<th>Year of purchase (3)</th>
<th>Years of service (4)</th>
<th>Useful life (5)</th>
<th>Installation site (6)</th>
<th>State of facility</th>
<th>Purchase cost (12)</th>
<th>Manufacturer (13)</th>
<th>Facility code (14)</th>
<th>Year of manufacture (15)</th>
<th>Executing company (16)</th>
<th>Remarks (17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Broken down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Policy for preparing an equipment useful life management ledger
- Preparation of an equipment useful life management ledger has the aim of managing equipment specifically from the viewpoint of its useful life.

Format of an equipment useful life management ledger

<table>
<thead>
<tr>
<th>Order</th>
<th>Name of staff in charge (1)</th>
<th>Name of equipment (2)</th>
<th>Useful life (3)</th>
<th>Remarks (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Staff in charge of signal equipment</td>
<td>Switch</td>
<td>10 years</td>
<td>Body overhaul : 5 years</td>
</tr>
<tr>
<td>02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 8-6-7-1-A(A) Structure of an AFC System (Equipment)

AFC (Automatic Fare Collection) means the automatic fare collection using IC cards. An AFC system consists of station service systems installed in the station and used by passengers and data processing servers that process data, all of which constitute an information processing network system. The AFC system generally has a five or six level hierarchy structure as shown in Figure 6-7-1, where the former uses the line server also as the operator server.

i) Level 5: Intercompany fare clearing system (CCHS)
ii) Level 4: Operator server
iii) Level 3: Line server
iv) Level 2: Station server
v) Level 1: AFC equipment
vi) Level 0: IC card

![Fig. 6-7-1 AFC hierarchy model](image)

The AFC system of Line 2A has Levels from 0 to 3. The operator server can be substituted by the line server of Line 2A until other lines such as Line 3 starts business. Table 6-7-1 shows the equipment used for each layer.

Table 6-7-1 Main AFC equipment

<table>
<thead>
<tr>
<th>Layer</th>
<th>Relevant group</th>
<th>Main equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Clearing Center</td>
<td>Clearing server</td>
</tr>
<tr>
<td>4</td>
<td>O&amp;M company</td>
<td>Operator server</td>
</tr>
<tr>
<td>3</td>
<td>Line operation group</td>
<td>Line server</td>
</tr>
<tr>
<td>2</td>
<td>Station</td>
<td>Station server</td>
</tr>
<tr>
<td>1</td>
<td>Station service equipment</td>
<td>Automatic ticket gate (AG)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Staff terminal (TOM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add value machine (AVM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automatic ticket vending machine (ATVM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Uninterruptible power supply (UPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yard AFC network equipment</td>
</tr>
<tr>
<td>0</td>
<td>Passenger</td>
<td>IC train ticket</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rechargeable IC card</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single ride IC ticket</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Token</td>
</tr>
</tbody>
</table>

Besides the equipment included in these layers, we need to consider equipment for issuing IC cards and devices and equipment for educating and training staff. The former needs strict security control under an independent group, whereas the latter need specifications for education and training. In this survey report, we assume that relevant groups maintain and
conserve these devices and equipment under appropriate standards, and deal with maintenance relevant to the equipment shown in Table 6-7-1.

**Appendix 8-6-7-1-B(A) Basics of the Maintenance of AFC Equipment**

1. Maintenance means all measures and actions to ensure continued operation of equipment and restore failures and defects. If equipment never malfunctions, no maintenance is needed. Almost all equipment, however, degrades its performance with the passage of operation time as shown in Figure 6-7-2 and eventually becomes inoperable.

![Fig. 6-7-2 Equipment operation and degradation](image)

2. As shown above, maintenance is closely connected to failures, on which it focuses. It is important to take preventive measures before failures occur. Costs to prevent failures are generally lower than those to correct failures. As shown in Figure 6-7-3, preventing failures from occurring through maintenance is important. There are many types of failures. According to IEC 60050, major failure modes are defined as shown in Table 6-7-2. AFC equipment combines mechanical and electric devices to produce a desirable function, and hence a complex combination of the failures of component parts causes the equipment to fail. Consequently, periodic overhauling has been believed to be effective to prevent failures.
### Table 6-7-2 Failure modes

<table>
<thead>
<tr>
<th>No.</th>
<th>Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gradual failure</td>
<td>Failures occurring due to gradual change in equipment characteristics over time</td>
</tr>
<tr>
<td>2</td>
<td>Drift failure</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Deterioration failure</td>
<td>Gradual and partial failures</td>
</tr>
<tr>
<td>4</td>
<td>Aging failure</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Wear-out failure</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Catastrophic failure</td>
<td>Sudden failures causing all required functions of equipment to completely malfunction</td>
</tr>
<tr>
<td>7</td>
<td>Sudden failure</td>
<td>Failures unpredictable by means of pretesting or monitoring</td>
</tr>
<tr>
<td>8</td>
<td>Random failure</td>
<td>Failures randomly occurring after an initial failure period and before a wear-out failure period</td>
</tr>
<tr>
<td>9</td>
<td>Intermittent failure</td>
<td>Failures where equipment repeats a cycle of malfunctioning for a period and spontaneously restoring to its normal state</td>
</tr>
<tr>
<td>10</td>
<td>Single failure</td>
<td>Failures due to a single cause</td>
</tr>
<tr>
<td>11</td>
<td>Primary failure</td>
<td>Failures not directly or indirectly caused by the failures of other equipment, devices, etc.</td>
</tr>
<tr>
<td>12</td>
<td>Secondary failure</td>
<td>Failures directly or indirectly caused by the failures of other equipment, devices, etc.</td>
</tr>
<tr>
<td>13</td>
<td>Misuse failure</td>
<td>Failures occurring when equipment operates beyond its normal capacity, those due to design defects caused by the misuse of components, materials, etc., or those due to improper planning/implementation of tests, use, maintenance, etc.</td>
</tr>
<tr>
<td>14</td>
<td>Mishandling failure</td>
<td>Failures due to mishandling of equipment or lack of attention</td>
</tr>
</tbody>
</table>
In 1978, however, the survey report published by United Airlines clarified that overhaul was not effective on electromechanical equipment, but that condition-based maintenance was effective on it. Table 6-7-3 shows the results. The failure mode f) is found mostly in electromechanical equipment, accounting for 68% of all failures and having a high initial failure rate. Overhaul restores equipment to its initial state with a high failure rate, and hence it is not useful to prevent failures.

<table>
<thead>
<tr>
<th>Type of failure mode</th>
<th>Relation between failure rate and operation time</th>
<th>Occurrence ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Bathtub type</td>
<td>![Bathtub type graph]</td>
<td>4%</td>
</tr>
<tr>
<td>b) Initially constant and later gradually increasing type</td>
<td>![Initially constant and later graph]</td>
<td>2%</td>
</tr>
<tr>
<td>c) Continuously increasing type</td>
<td>![Continuously increasing type graph]</td>
<td>5%</td>
</tr>
<tr>
<td>d) Initially increasing and then constant type</td>
<td>![Initially increasing and then constant graph]</td>
<td>7%</td>
</tr>
<tr>
<td>e) Constant type</td>
<td>![Constant type graph]</td>
<td>34%</td>
</tr>
<tr>
<td>f) Initially decreasing and then constant type (failure mode found mostly in electromechanical equipment)</td>
<td>![Initially decreasing and then constant graph]</td>
<td>68%</td>
</tr>
</tbody>
</table>

3. Classification of Maintenance

Figure 6-7-4 shows a maintenance structure. Each component is defined as follows:

(1) Preventive maintenance
Aiming to prevent equipment from failing during use, we carry out preventive
maintenance based on specified intervals or criteria, and make a proposal on the
functional deterioration or failure probability of equipment.

1) Scheduled maintenance:
   Preventive maintenance performed according to schedule.
   a) Fixed time maintenance: Preventive maintenance conducted at a fixed
time interval.
   b) Age-based maintenance: Preventive maintenance conducted when the
cumulative operation time of equipment reaches a predetermined time.

2) Condition-based maintenance:
   Actions to check equipment use and operating conditions during its use, detect
the tendency of deterioration, identify failures and defects, and monitor operating
values and their tendencies at certain time points to record the development of
failures and for follow-up. Monitoring is conducted continuously, indirectly, or
periodically by means of inspection, testing, measurement, and warning.

(2) Corrective maintenance:
   Maintenance to restore the functions of equipment to the required operational level
after detecting the failure.
   1) Emergency maintenance: Maintenance conducted to restore the functions of
      preventive maintenance equipment when it fails.
   2) Normal corrective maintenance: Maintenance to restore the functions of non-
      preventive maintenance equipment when it fails.
Fig. 6-7-4  Maintenance structure
Appendix 8-6-7-1-C(A) Maintenance Operation and Management

Maintenance is carried out through a system known as the PDCA cycle. The PDCA cycle shown in Figure 6-7-5 consists of the steps below. Implementing them one by one, we aim to improve the level of maintenance.

1. **P: Plan**  [Development of a maintenance plan]
   Making a plan to implement the measures studied in the technical management below, we carry out design, estimation, order, and construction management needed for plan implementation. Preparation of an annual maintenance plan is also important.

2. **D: Do**  [Implementation of equipment inspection, diagnosis, and maintenance]
   (1) To prevent the failure of equipment, some or all parts of it are disassembled or, if necessary, sent to a repair yard for maintenance in accordance with its installation/operating conditions or as necessary. Qualified persons must conduct the work based on predetermined specifications.
   (2) We diagnose the deterioration level and signs of failure of equipment by measuring its state quantity. The results enable us to take measures before a serious failure occurs.

3. **C: Check**  [Collection and analysis of maintenance information]
   Based on the results of collecting and analyzing the effects of maintenance implementation (improvement of failure rates and failures intervals) and the state quantity after maintenance, we develop policies to improve equipment reliability. The formats of collected data need to be standardized and stored as a database to facilitate quantitative and statistical processing.

4. **A: Act**  [Technical management]
   Based on various diagnosis data on deterioration state and their analysis results, we develop an annual maintenance plan including measures to improve maintenance quality and cost. The asset management of equipment is also important.

---

Fig. 6-7-5 PDCA management cycle of maintenance
Appendix 8-6-7-1-D(A) Organizational Functions to Implement Maintenance

1. General
Since circulating the PDCA cycle above enables the improvement of maintenance quality, we need the following organizations for implementing the PDCA cycle:

   A: Technical management and planning: Planning group
   P: On-site technical organization for equipment monitoring and diagnosis: Equipment technology group
   D: Maintenance construction: Equipment construction group
   C: Technology for equipment data integration and analysis: Equipment technology group

As described below, AFC equipment requires the unique characteristics of maintenance that are different from those for other equipment. We hence need to establish organizations responsive to these requirements.

(1) Being responsive to equipment operating for many hours without a break.
   To contribute to society and support civic life as a social infrastructure, urban railways operates from early morning to late at night throughout the year with no break. It is hard to stop equipment operation to have maintenance time. An organizational approach to plan and implement highly effective work systems, such as nighttime work shifts and hierarchical maintenance, is thus needed.

(2) Emergency response to failures.
   Failures occurring especially in the morning and evening commuting time have a high possibility of causing passenger flows serious trouble, and hence need to be immediately repaired. To this end, staff and work systems quickly responsive to failure occurrence are essential in addition to ordinary preventive maintenance systems.

(3) Availability of the same quality maintenance services for all train stations.
   The network of Hanoi Urban Railway covers all of the metropolitan area. Consequently, all pieces of AFC equipment installed in train stations along the lines with 20 - 30 operation kilometers per line are dispersed and operated in the wide metropolitan area, and maintenance staff need to travel long distances. Means, such as locating the branch offices of the maintenance group at train stations distant from it, are essential to provide rapid and quality maintenance.

(4) Being responsive to simultaneous failures over a wide area.
   Each piece of AFC equipment installed in train stations is connected to a large-scale network constituting the Hanoi Urban Railway network. An equipment failure may
therefore spread to a wide area through the network. Monitoring and controlling the network is hence important.

(5) Safe management of security data.

An AFC system handles a variety of valuable data such as fare information, clearing information, negative data, etc. Equipment malfunctions and failures may result in damaging, losing, and leaking these data, having enormous effects on passengers and railway operation companies. It is therefore essential to maintain the system highly effectively.

(6) Being capable of preventing theft and destruction.

As described in the previous paragraph, AFC equipment handles valuable data and holds data on its security maintenance. The equipment is, however, installed at a passenger-accessible location, i.e., it has high risks of theft and destruction. Besides security equipment, such as a shutter, to reduce these risks, systems for detecting and reporting equipment abnormality on a 24-hour basis are needed.

Figure 6-7-6 shows an example of the responses to AFC equipment failure installed in a train station and necessary organizational functions. (Most of AFC equipment is installed in a train station, and passengers use such equipment.)

When a failure of AFC equipment in a train station occurs, responses are as described below. It should be noted that, in addition to the repair of the equipment, passengers and operations are sometimes need to be dealt with. In such cases, a mechanism that relevant groups immediately work together with each other is needed.

(1) A failure of the AFC equipment occurs.

(2) The maintenance and control group receives a failure occurrence report from the train station.

(3) The maintenance and control group implements the following:
1) Instructing all maintenance construction groups to repair the failure.
2) Reporting the failure occurrence to the AFC equipment group.
3) Reporting to the train operation control group.
4) Reporting to the business group.

(4) The construction group rushes to the failure site for repair.
(5) In the case of a significant accident or failure, the technical group supports the activity.
(6) Train stations respond to passengers. In the case of a significant accident or failure, the business group supports the activity.
(7) When congestion in train stations increases and platforms are filled with passengers, the train operation control group carries out measures such as limiting train operations.

2. Organizations to Implement Maintenance
   (1) Organization Structures

   The previous section described the requirements for organizational functions. Many types of organizations can realize these functional requirements. Figure 6-7-7 shows a structure of major organizations relevant to AFC equipment maintenance by referring to the organization structure of Tokyo Metro, one of the world’s largest urban railway companies (Tokyo Metro’s company outline 2013). This organization structure covers all functions required for AFC equipment maintenance, where the telecommunications equipment group takes primary responsibility for AFC equipment management.

   located over a wide area, taking account of geographical or other factors.

Fig. 6-7-7 Organization structure
The maintenance construction group is shown separately. In many cases, a subsidiary company or outsourcing can better carry out the maintenance of AFC equipment.

(2) Staff allocation

1) Staff of Telecommunications Equipment Department

AFC equipment maintenance consists of the work requiring technical expertise and that requiring management skill such as technical management analysis and planning, and the construction management of Maintenance Construction Group conducted for appropriating expenses. In the case of the organization structure described in the previous section, the Station Service Section needs a minimum of two persons: one for technology and another for planning and business management. The allocation of management resources, such as equipment renewal and investment, should be adjusted and planned based on the overall policy of the Telecommunications Equipment Department. The Planning Section under the direct control of the general manager of the Department takes charge of the work. The Section gradually increases the number of staff in accordance with the expansion of the urban railway network like the opening and extension of lines.

2) Staff of Maintenance Construction Group

This group implements inspection, diagnosis, check, and repair based on maintenance plans. During business hours, passengers use AFC equipment. In rush hour, it is hard to stop equipment for preventive inspection due to tremendous congestion. It is hence desirable to carry out maintenance during nighttime after the closing of operations, where efficient work can be done. When a large-scale failure occurs in AFC equipment and when replacing or moving equipment, a large number of staff should be mobilized. Normal maintenance work, however, uses a relatively small number of staff. Setting the number of staff based on such cases results in having more staff than needed at normal times. It is therefore better to adopt shift work systems to allocate the number of staff needed.
for normal work and mobilize a necessary number of staff in an emergency such as the occurrence of accidents. There are many types of shift work systems. Since the Vietnamese Labor Law (10/2012/QH13) limits work hours to eight hours per day, the basis would be the four teams three shifts system. Table 6-7-4 shows an example of work shift systems.

Table 6-7-4 Four teams and three shifts system (example)

<table>
<thead>
<tr>
<th>Work hours</th>
<th>Mo</th>
<th>Tu</th>
<th>We</th>
<th>Th</th>
<th>Fr</th>
<th>Sa</th>
<th>Su</th>
<th>Mo</th>
<th>Tu</th>
<th>We</th>
<th>Th</th>
<th>Fr</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00-15:00</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>14:00-23:00</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>22:00-7:00</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Absence</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

The number of assigned staff depends on the number of AFC equipment and maintenance work. Table 6-7-5 shows the number of major AFC equipment in Line 2A specified in the design plan of the line. The planned number of train stations is 12. The average number of AFC equipment per station is 25.

Maintenance work rules will be described later. Assuming here that the average time required for normal preventive maintenance work is one hour per unit, the required time per station is 25 hours.

Since AFC equipment is operated by passengers and its usage frequency is extremely high, the cleaning and checking of the equipment are important maintenance jobs. Periodic inspection is carried out at a cycle of about two months for equipment with the shortest maintenance interval. The maintainable number of train stations in the case of two months, i.e., 480 hours, is shown below. We can conclude that the period of two months can cover all train stations of Line 2A. It seems we have some surplus time, but such time is appropriate. The reasons are that equipment other than those listed in Table 6-7-5 is installed, and that we need to take account of the reduction in work efficiency during preparation for starting and finishing work, travel time, and business hours, and of mealtimes and breaks.
Table 6-7-5 Major AFC equipment of Line 2A and the number of the equipment

<table>
<thead>
<tr>
<th>AFC equipment</th>
<th>Number of equipment</th>
<th>Number of equipment/station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of train stations</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Train station server</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Train station monitor</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Ticket server</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Automatic ticket gate</td>
<td>139</td>
<td>12</td>
</tr>
<tr>
<td>Automatic ticket vending machine</td>
<td>96</td>
<td>8</td>
</tr>
<tr>
<td>Semi-automatic ticket vending machine</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>295</td>
<td>25</td>
</tr>
</tbody>
</table>

● Maintainable number of train stations in two months

\[
480 \text{ hours} \div 25 \text{ hours/station} = 19.2 \text{ stations}
\]

When having the four teams and three shifts work system shown above, at least three persons/team should be allocated as shown in Figure 6-7-9.

![Fig. 6-7-9 Staff allocation at AFC System Section (in case of 3 persons/team)](image)

Consequently, the total number of staff is 12. This number does not count that of absentees due to sick and vacation leaves. To avoid trouble in maintenance due to absences, allocating three persons per team to the position in charge of construction makes the total number 16. Allocating two staff members to the positions of business planning and operation management in the AFC Maintenance Construction makes the total number 18, which is the same number as that of the Line 2A staff allocation plan prepared by VNRA.
3) Staff of Control Group

All pieces of AFC equipment are connected to the network and constitute the AFC system shown in Figure 6-7-10. IC train ticket management data and boarding data are transmitted to this network, where the server of each layer processes data. Since network troubles may have effects on the entire network, we need to monitor equipment operation status, predict troubles, and carry out a rapid response.

Besides various work to be performed during business hours, the Control Group is responsible for data processing, such as clearing, after the closing of operations and for inspection before starting operations. It therefore needs a 24-hour control system.

It is better to perform AFC system control in the same group and place with other control organizations, such as OCC, rather than doing it alone, because cooperation with relevant groups is essential for troubleshooting.

Establishing a 24-hour system requires to allocate staff under the group leader of OCC. The minimum number of the staff is four, assuming that one person per one team. Taking account of absentees due to sick and vacation leaves, it is desirable to allocate five or six persons. The persons other than four mentioned above carry out work such as the management of the AFC control team as well as planning and data management on control.
### Table 6-7-6 Structure of the AFC Control Group

<table>
<thead>
<tr>
<th>Control work group</th>
<th>Number of staff</th>
<th>Work system</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC control team leader</td>
<td>1</td>
<td>Normal work (filled when vacant)</td>
</tr>
<tr>
<td>AFC control staff</td>
<td>4</td>
<td>Shift work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 person/team x 4 teams, 3 shifts</td>
</tr>
</tbody>
</table>
Appendix 8-6-7-1-E(A)  Organization Rules

1. In a broad sense, AFC equipment is electromechanical equipment. To establish consistent reliability for the functions provided by electromechanical equipment, rules for the maintenance of AFC equipment should be developed based on common policies and concepts with mechanical equipment. Figure 6-7-11 illustrates this concept.

Fig. 6-7-11 System of AFC maintenance rules

2. Electromechanical Equipment Rules
   (1) Objective of Rules
   Aiming at the safety and sound management of railway transportation services, we establish rules to introduce proper equipment, operate it effectively, and maintain its normal functions.
   (2) Scope of Rules
   The Rules specify the procedures for the new construction, improvement, and maintenance of electromechanical equipment. Equipment asset management, equipment investment, etc. not included in the Rules shall comply with relevant rules specified separately.
   (3) Definition of Terms
   Electromechanical equipment is specified by Company Equipment Classification Table prepared separately. It does not include electric power machinery, communications equipment, medical equipment, and civil engineering machinery.
   (4) Maker of Rules
   General manager of Headquarters (HQ) Electric Signal Communications Department (train station equipment) shall establish the Rules.
   (5) Duties and Authority of the Maker of Rules on Rule Establishment
   1) Maker of Rules shall establish the following rules:
      a) Electromechanical Equipment Maintenance Rules
b) Electromechanical Equipment Operation Rules

2) Maker of Rules may establish standards on the following:
   a) Design, scale (number of equipment, capacity), and technical systems for the new construction and improvement of equipment.
   b) Construction such as the installation, renewal, abolition, and maintenance of equipment.
   c) Work systems of technical management, such as equipment diagnosis, for maintenance.
   d) Operation (handling) methods of equipment.

3) Maker of rules shall specify the enforcement period the Rules.

3. Electromechanical Equipment Maintenance Rules

(1) Objective of Rules
   Maker of Rules shall establish the objective in accordance with the objective and rules specified in Electromechanical Equipment Rules.

(2) Scope of Rules
   The Rules specify the maintenance of electromechanical equipment. The management of measuring instruments such as measurement equipment for maintenance and the appointment of the person responsible for equipment asset management not included in the Rules shall comply with rules specified separately.

(3) Definition of Terms
   1) Maintenance means the following:
      Maintaining the normal functions of equipment and improving its reliability and functions in accordance with the definition in 60050.
   2) Technical management means the following:
      a) Collecting and managing equipment data on the characteristic, deterioration state, and failures and their causes.
      b) Analyzing equipment data for the development and implementation of plans to facilitate its life extension, reliability enhancement, and functional improvement.

(4) Person Responsible for Maintenance
   General manager of Electric Signal Communications Maintenance Department in Passenger Transportation Group (OU).

(5) Duties and Authority of Person Responsible for Maintenance
   1) Management responsibility
      The person responsible for maintenance shall properly manage responsible equipment in accordance with the objective of the Rules.
2) Establishment of maintenance manuals
   The person responsible for maintenance shall establish manuals on the maintenance practices of responsible equipment.

3) Improvement of maintenance efficiency and quality.
   The person responsible for maintenance shall make efforts to improve the maintenance of equipment such as life extension, reliability enhancement, and functional improvement bases on the results of technical management.

4) Development of equipment management systems
   The person responsible for maintenance shall establish and implement the systems on the following to ensure the completeness of maintenance work:

   a) Management using the classification and identification code of equipment
      • The person responsible for maintenance shall manage equipment using classes, models, names, identification numbers, and applicable codes (Tables 6-7-7 and 6-7-8) under the system that can uniquely identify equipment in accordance with rules for equipment asset management.
      • The person responsible for maintenance shall mark the classification and identification code on all equipment.

   Table 6-7-7 Classification and identification code format (example)

<table>
<thead>
<tr>
<th>Class</th>
<th>Model</th>
<th>Name</th>
<th>Identification number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>-</td>
<td>3 4 5 6 7 8 9 0 A</td>
</tr>
</tbody>
</table>

   Table 6-7-8 Classification and identification code (example)

<table>
<thead>
<tr>
<th>Class</th>
<th>Model</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Station equipment</td>
<td>10 AFC equipment</td>
</tr>
<tr>
<td>20</td>
<td>Electric power</td>
<td>20 Communications equipment</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>12 One-way automatic ticket gate</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>20 Automatic ticket vending machine</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>30 Automatic add value machine</td>
</tr>
</tbody>
</table>

   b) Designation of important equipment
      • The person responsible for maintenance shall designate the equipment assuming an important role in passenger transportation service as important equipment.
The person responsible for maintenance shall take special measures to maintain the functions of important equipment.

c) Management of records

- The person responsible for maintenance shall register all equipment and properly store the drawings and technical documents of the equipment concerned.
- The person responsible for maintenance shall properly record and store all maintenance data and the history of all equipment.

5) Responses to serious accidents and failures

When a serious accident or failure occurs, the person responsible for maintenance shall immediately report the accident or failure to the general manager of Headquarters (HQ) Electric Signal Communications Department (trains station equipment), and carry out detailed survey reporting.

6) The person responsible for maintenance shall specify the enforcement period of the Rules.
4. Electromechanical Equipment Operation Rules

(1) Objective of Rules
Maker of Rules shall establish the objective in accordance with the objective and rules specified in Electromechanical Equipment Rules.

(2) Scope of Rules
The Rules specify procedures for the on-site use, installation, renewal, and abolition of equipment. Procedures for the abolition of unnecessary equipment not included in the Rules shall comply with relevant rules specified separately.

(3) Definition of Terms
1) The general manager of Headquarters (HQ) Equipment Group means the general manager of Electric Signal Communications Department (train station equipment) taking charge of equipment management, such as train station equipment, at Headquarters (HQ).
2) The general manager of Passenger Transportation Group (OU) means the general manager of the group taking charge of passenger transportation under control of Headquarters. Train stations with equipment belong to this Group, and their stationmasters are responsible for the station equipment at the point of use. Electric Signal Communications Maintenance Department is also belongs to the Group, and its general manager is responsible for maintenance.

(4) Management Responsibility for Equipment Operation
1) Responsibility of Headquarters Equipment Group
   - Headquarters Equipment Group shall correctly understand the locations and operating status of all units of equipment, and manage them to ensure normal operation.
   - Headquarters Equipment Group shall develop and manage plans for the operation (idling) and renewal of equipment.
2) Responsibility of Passenger Transportation Group
   - The person responsible at the point of use shall appoint a person in charge for important equipment.
   - The person responsible for maintenance shall instruct persons in charge of the points of use to operate equipment correctly.
   - The person responsible for maintenance shall immediately take necessary measures when equipment operation is determined to be dangerous, and may order the person responsible at the point of use to stop operating the equipment.
The person responsible for Passenger Transportation Group shall immediately report to the person responsible for Headquarters Equipment Group when idle or defective equipment is found.

- The person responsible for Passenger Transportation Group shall develop an abolition plan when equipment is found to be unnecessary, and dispose of the equipment in accordance with rules for asset disposition following the instruction of Headquarters Equipment Group.

3) The general manager of Headquarters Equipment Group shall specify the enforcement period of the Rules.

5. Equipment Maintenance Rules (AFC)
   (1) General Rules
   1) Roles of Groups
      The organizations responsible for the work and construction required for AFC maintenance are Headquarters (HQ) Electric Signal Communications Department (train station equipment) and Electric Signal Communications Maintenance Department (OU) of Passenger Transportation Group. Work and construction that railway business operators cannot handle are sometimes outsourced to external contractors. In such cases, Electric Signal Communications Maintenance Department of Passenger Transportation Group shall take the role of the client as shown in Figure 6-7-12.

![Fig. 6-7-12 Roles of relevant groups in maintenance construction](image-url)
2) Scope of Rules
   AFC equipment maintenance shall be carried out in accordance with the Rules

3) Relevant Laws and Regulations
   Maintenance shall be carried out in accordance with the statutes established by Vietnam and Hanoi City in addition to the Rules, as well as the rules below separately provided by the railway business operator (Hanoi Metro) mentioned in the previous section.
   a) Electromechanical Equipment Rules
   b) Electromechanical Equipment Maintenance Rules
   c) Electromechanical Equipment Operation Rules

   The followings are relevant Japanese statutes. We should verify the Vietnamese statues concerned.
   a) Construction industry Law
   b) Building Standards Law
   c) Labor Standards Law
   d) Fire Services Law
   e) Air Pollution Control Law
   f) Water Pollution Control Law
   g) Noise Regulation Law
   h) Vibration Regulation Law
   i) Industrial Accident Prevention Organization Law
   j) Measurement Law
   k) Industrial Safety and Health Law
   l) Waste Disposal and Public Cleaning Law
   m) Ministerial Ordinance for Determining Technical Standards for Electrical Appliances

   Since maintenance work includes construction in the places close to business lines, the work should comply with the construction rules of the lines, in addition to the above.

4) Priority Order
   When the rules, specifications, and design documents used for the maintenance of AFC equipment conflict with each other, determine priorities following the priority order below.
a) Priority order of Rules documents
   i. Electromechanical Equipment Rules
   ii. Electromechanical Equipment Maintenance Rules
   iii. Equipment Maintenance Rules (AFC)

b) Priority order of technical documents used for maintenance construction
   i. Documents on on-site explanations and questions and answers
   ii. Design drawings and special instruction documents
   iii. Equipment Maintenance Rules (AFC)

5) Definition of Terms

a) Maintenance construction

   Maintenance construction means the construction to take measures
   (inspection, adjustment, repair, replacement, etc.) needed for maintaining
   the normal functions of equipment and improving its reliability and
   functions in accordance with the definition in IEC 60050.

b) Supervisor

   The supervisor means the supervisory staff whose appointment is required
   by the Japanese Construction Industry Law. Appointed by the person who
   instructs (order) maintenance construction, the supervisor takes charge of
   supervising the construction concerned so that it is carried out complying
   with the design, plan, and rules concerned. Passenger Transportation Group
   (OU) assigns its staff as a supervisor when outsourcing maintenance work
   and construction.

c) Site representative

   The site representative means the supervisory staff dispatched from the
   contractor whose appointment is required by the Japanese Construction
   Industry Law. Stationed in the construction site, the site representative takes
   charge of labor, process, and safety management. The contractor undertaking
   maintenance work and construction assigns its staff as a site representative.

d) Chief engineer

   The chief engineer means the supervisory staff dispatched from the
   contractor whose appointment is required by the Japanese Construction
   Industry Law. The chief engineer takes charge of construction plan
   preparation, process management, quality control, and other technical
   management, as well as technical instructions to persons engaged in
   construction. The persons have an obligation to follow the instructions of the
chief engineer. The contractor undertaking maintenance work and construction assigns its staff as a chief engineer.

c) Supervising engineer

The supervising engineer means the supervisory staff dispatched from the contractor whose appointment is required by the Japanese Construction Industry Law. The contractor shall appoint a supervising engineer when subcontracting construction with an amount exceeding a specified value to a subcontractor. Its duties are the same as those of the chief engineer. The contractor undertaking maintenance work and construction assigns its staff as a supervising engineer.

f) Special instruction document

The special instruction document means an instruction document describing the matters needed for maintenance construction, not mentioned in the Rules.

(2) Qualifications

AFC equipment is connected to a network and processes data for selling IC tickets to passengers, fare collection, access control to and from station yards, transactions, and passenger identification, and its failure and trouble have a tremendous effect on passenger transportation work. For this reason, persons with sufficient skills, experiences, and expertise specific to duties shall engage in maintenance construction. We shall therefore establish a qualification system to have the staff of Passenger Transportation Group (OU) certified by the general manager of Headquarters Equipment Group performs maintenance work corresponding to his or her qualifications. Table 6-7-9 shows examples of qualifications and corresponding duties.

<table>
<thead>
<tr>
<th>Qualification classification</th>
<th>Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC chief engineer</td>
<td>Supervising the AFC competent engineer to instruct technology and safety management in maintenance construction.</td>
</tr>
<tr>
<td>AFC competent engineer</td>
<td>Being assigned to each work group of maintenance construction as the person in charge of the group, and managing and supervising the group to perform construction safely and on accordance with the design, plan, and rules concerned. Taking a task as a supervisor in a construction site.</td>
</tr>
</tbody>
</table>
(3) Procedures Specified in Statutes

1) Notification
   In Japan, construction such as equipment installation in maintenance construction, for example, is classified as the construction work specified in the Construction Industry Law (machinery installation work). After notifying the authorities of construction, the contractor shall carry out construction complying with the statutes concerned. The general manager of Electric Signal Communications Maintenance Department of Passenger Transportation Group (OU) has a responsibility to submit necessary notifications to the authorities concerned in accordance with the relevant Vietnamese statutes.

2) Attendance
   In the case where statutes require the various inspections of maintenance construction by the concerned authorities, the AFC competent engineer shall attend the inspections.

(4) Management of Construction Sites
   The AFC competent engineer has responsibility and authority to manage the construction site following the instructions of the AFC chief engineer in accordance with the Rules.

1) Clean, tidy, and organize
   The AFC competent engineer shall organize, tidy, maintain, inspect, and clean materials, machines, and appliances to ensure maintenance construction with a high degree of safety.

2) Prevention of accidents, disasters, and pollution
   a) Ensuring work site safety
      i. Work site safety inspection
      ii. Use of safety equipment and safety protective equipment
   b) Items to check instructions to workers and implementation by workers
      i. Health check and clothes check
      ii. Correct and clear instruction of work contents and methods
      iii. Confirmation of correct methods to use tools and protective equipment
      iv. Instruction of safety procedures for train operations
      v. Instruction of prohibiting damage to architectural structures
      vi. Instruction of passenger safety measures during construction
vii. Instruction of preventive measures in the case of possible damage to architectural structures

viii. Instruction of a roll call in the cases of work in the vicinity of a business line, carrying in and out heavy loads, and high place work

ix. Clear indication of the classification of work under railway track closing as well as safety measures based on rules.
   • Heavy load carrying work on the platform likely to enter into the construction limit performed during business hours. In this case, take measures such as placing a guard following the instruction of the person responsible for railway track closing.
   • The similar work after the closing of operations is outside the classification of work under railway track closing. Entry into the construction limit is, however, prohibited.

c) Complaints from third persons
   When third persons complain about construction, correctly understand the complaints, report to the supervisor, and discuss and implement proper measures.

d) Industrial waste
   Industrial waste shall be disposed of in accordance with relevant laws and regulations. (In Japan, industrial waste disposal slips are stored for five years.)

3) Measures for the occurrence of accidents, disasters, and pollution
   a) Worker
      When accidents, disasters, or pollution occur, or they are likely to occur, and when urgent measures are required, workers shall immediately take proper measures and report to the supervisor, and follow his or her instructions.

   b) Supervisor
      The supervisor shall properly instruct workers, and report the circumstances to the AFC chief engineer and the general manager of Electric Signal Communications Maintenance Department, seeking their instructions.

   c) AFC chief engineer
      Based on the report from the supervisor, the AFC chief engineer shall consult with the general manager of Electric Signal Communications Maintenance Department to quickly issue necessary instructions.
d) General manager of Electric Signal Communications Maintenance Department
The general manager shall report to the general manager of Headquarters Telecommunications Department, seeking the instructions to handle the matters and successively reporting the results to the latter. In the stage of bringing them under control, the former shall submit to the latter a detailed report on the accidents, disasters, or pollution concerned with recurrence prevention measures.

e) General manager of Electric Signal Communications Department
Based on the report, the general manager shall issue instructions to relevant groups as necessary. The general manager shall also review the report in detail, examine the site if necessary, and take measures to improve future maintenance work.

4) Placement of supervisory staff

a) In light of relevant Vietnamese laws and regulations, the client shall place a supervisor in the site as defined in the Japanese construction Industry Law, and the contractor shall place a site representative, a chief engineer, and a supervising engineer in the site.

b) In accordance with relevant Vietnamese laws and regulations, the contractor shall report the names of its site representative, chief engineer, and supervising engineer to the supervisor before the start of construction.

5) Management of machinery and appliances
The responsible person shall carefully store and maintain machines and appliances needed for maintenance construction. Their handling and maintenance shall be carried out following the instructions of an experienced AFC competent engineer.

6) Management of electric power, gas, kerosene, and water
The responsible person shall apply in advance for the approval of the use of electric power, gas, kerosene, and water used for construction.

7) Preservation of the environment
The responsible person shall carry out the work described below to prevent damage to architectural structures under construction and preserve a safe
environment in the site. The AFC competent engineer shall instruct staff to carry out the work and take responsibility for implementing the work.

a) Curing
Curing shall be carried out before the start of construction to prevent damage to and contamination of architectural structures.

b) Clearing
Clearing, cleaning, and the removal of temporary construction shall be completed during the construction period.

c) Disposal of construction waste
Disposal of construction waste shall be carried out during the construction period.

8) Material management

a) Devices/materials
Maintenance construction shall use devices and materials with the quality, shapes, dimensions, properties, and functions enabling the maintenance and improvement of the functions of AFC equipment.

b) Approval of use
Maintenance construction shall use the devices and materials listed in the construction plan document, design document, and maintenance procedure manual prepared by the AFC chief engineer of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU), and approved by the general manager of the Department.

c) Management of supplied materials
When accepting the materials supplied by other groups, the AFC chief engineer shall prepare a receipt listing the name, quality, shape, quantity, place of receipt, date and time of receipt, person in charge of supply, and person in charge of receipt, and Electric Signal Communications Department of Passenger Transportation Group (OU) shall manage the materials. The general manager of the Department shall report to Financial Accounting Group of Passenger Transportation Group (OU) at the end of the term.

9) Construction

a) Plan document
The AFC chief engineer shall develop a plan document on AFC equipment construction quarterly, and the general manager of Electric
Signal Communications Maintenance Department shall obtain the approval of the general manager of Headquarters (HQ) Electrical Signal Communications Department for the document. In the case of emergency response to failures or troubles, the general manager of Electric Signal Communications Maintenance Department shall be able to instruct construction. Even in this case, the general manager shall report to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment).

b) Change in the plan document
When changing the plan document, the general manager of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU) shall immediately report the proposed change to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment), seeking the approval of the latter for the change.

c) Construction plan document
The AFC chief engineer shall prepare a construction plan document before the start of construction, and obtain the approval of the general manager of Electric Signal Communications Maintenance Department of Passenger Transportation Group (OU) for the document. When the construction may have effects on passenger safety, train operations, and station work, the general manager of Electric Signal Communications Maintenance Department of Passenger Transportation Group (OU) shall explain the plan to relevant groups before the start of construction, and take measures in corporation with the concerned groups.

d) Change in the construction plan document
When making a change in the construction plan document, the AFC chief engineer shall immediately report to the general manager of Electric Signal Communications Maintenance Department (OU) and obtain the approval of the general manager for the change.

e) Maintenance construction
i. Details of construction
   Equipment-wise inspection, adjustment, and their methods shall follow the maintenance procedure manual for each equipment separately specified.

ii. Duties of AFC competent engineers
• The AFC competent engineer shall prepare a construction plan document listing the date and time of construction, location of installation, name, and identification number of equipment by the day before construction, and obtain the approval of the general manager of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU) for the document.

• The AFC competent engineer shall seek the approval of the person responsible for the point of use of equipment for access and construction.

• When stopping equipment operation during business hours, the AFC competent engineer shall seek instructions from the person responsible for the point of use.

• As for items whose inspection is difficult after the completion of construction, the AFC competent engineer shall decide as a supervisory person whether to carry out testing and inspection, and carry out testing and inspection during construction if necessary.

• As for the testing and inspection and important items mentioned above, the AFC chief engineer shall decide as a supervisory person whether to carry out testing and inspection under the attendance the AFC chief engineers.

iii. Important construction

In the case of important construction having significant effects on passengers and train operations, the AFC chief engineer shall report to the general manager of Headquarters (HQ) Electric Signal Communications (station equipment) in advance and seek instructions from the general manager, under the instructions of the general manager of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU).

iv. Reporting during construction

• Based on the instructions of the AFC competent engineer, construction workers shall write the details of the day’s work in a report and submit it to the AFC competent engineer.
• The AFC competent engineer shall report the progress and details of construction to the AFC chief engineer.
• The AFC chief engineer shall report the progress and details of construction depending on the degree of importance to the general manager of Electric Signal Communications Maintenance Department.

v. Construction completion report
• At the time of construction completion, construction workers shall submit a report describing the details of construction, measurement values, and judgment results to the AFC competent engineer as a supervisory person.
• The details of consultations and instructions and their progress shall also be recorded.
• As for the items whose inspection is difficult after the completion of construction and conducted during construction, their inspection reports and data shall be attached to the report.

f) Completion inspection
i. The AFC chief engineer and the general manager of Electric Signal Communications Maintenance Department shall check the completion report and submit it to Headquarters (HQ) Electric Signal Communications Department (station equipment) for inspection.
ii. Headquarters (HQ) Electric Signal Communications Department (station equipment) shall perform site inspection as necessary.

6. Technical Certification Rules
(1) General Rules
1) Objective
Aiming to accomplish the objective of AFC equipment maintenance, the Rules intend to certify the staff with proper technical expertise as an engineer and have only qualified persons carry out technical work. The qualification certification system also encourages staff to learn technical skills.

2) Scope of Rules
Technical certification of the staff engaged in AFC equipment maintenance.

3) Definition of Terms
a) Maintenance management capability
The maintenance management capability means the knowledge and management capability required for maintenance management such as construction technology, quality, process, safety, and data management.

b) Technical skills for maintenance
The technical skills for maintenance mean the technical skills required for maintenance construction such as the mechanistic understanding, inspection, disassembly, improvement, repair, assembly, control, testing and adjustment of AFC equipment.

(2) Qualification Types
Table 6-7-10 shows the technical qualifications required for engagement in maintenance construction.

<table>
<thead>
<tr>
<th>Qualification type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief maintenance engineer</td>
<td>Person with the maintenance management capability of AFC equipment</td>
</tr>
<tr>
<td>Competent maintenance engineer</td>
<td>Person with the technical skills for maintenance of AFC equipment as well as the capability to perform the duties required for a supervisory person in a construction site</td>
</tr>
<tr>
<td>Maintenance engineer</td>
<td>Person with the technical skills for maintenance of AFC equipment as well as the capability to accomplish maintenance construction under the instructions of a competent maintenance engineer</td>
</tr>
</tbody>
</table>

(3) Requirements for Acquiring Qualifications
Expert knowledge as well as the experiences and problem solving capability acquired in maintenance sites are important for maintenance work, and hence they are essential for acquiring maintenance qualifications. Applicants, therefore, shall not be able to meet requirements for senior level qualifications until they accumulate a certain amount of experience at each level of qualification. Tables 6-7-11 to 6-7-13 show requirements for the each qualification above.
1) Chief maintenance engineer

Table 6-7-11 Qualification requirements for the chief maintenance engineer

<table>
<thead>
<tr>
<th>Career</th>
<th>Academic career</th>
<th>Work experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person with the qualification of AFC competent maintenance engineer</td>
<td>University graduate of a telecommunications-related technical course</td>
<td>2 years</td>
</tr>
<tr>
<td></td>
<td>Person other than the above and accepted as having expert knowledge similar to the above</td>
<td>3 years</td>
</tr>
</tbody>
</table>

2) Competent maintenance engineer

Table 6-7-12 Qualification requirements for the competent maintenance engineer

<table>
<thead>
<tr>
<th>Career</th>
<th>Academic career</th>
<th>Work experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person with the qualification of AFC maintenance engineer</td>
<td>University graduate of a telecommunications-related technical course</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Person other than the above and accepted as having expert knowledge similar to the above</td>
<td>5 years</td>
</tr>
</tbody>
</table>

3) Maintenance engineer

Table 6-7-13 Qualification requirements for the maintenance engineer

<table>
<thead>
<tr>
<th>Career/Age</th>
<th>Academic career</th>
<th>Work experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person from 18 to 30 years old, regardless of career(*)</td>
<td>University graduate of a telecommunications-related technical course</td>
<td>1 year</td>
</tr>
<tr>
<td></td>
<td>Person other than the above and accepted as having expert knowledge similar to the above</td>
<td>2 years</td>
</tr>
</tbody>
</table>

(*) On the assumption that there is no person with experience because Vietnam introduces AFC systems for the first time.
4. Aptitude Test
   It is required for performing maintenance work to pass a necessary medical aptitude test.

5. Academic examination
   1) Qualification for examination
      a) Person who has passed the aptitude test, and completed pre-examination training,
      b) The general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) conducts pre-examination training.
   2) Examination coverage
      a) General knowledge on Hanoi Metro
      b) Basic knowledge on the maintenance of electromechanical equipment
      c) Knowledge on rules, procedures, and contact methods for maintenance construction
      d) Knowledge on maintenance construction
      e) Knowledge on various types of equipment for maintenance construction
      f) Knowledge on safety rules and ensuring safety
   3) Judgment criteria
      The passing mark of the academic examination is an accuracy rate of 60% or more.

6. Qualification certificate
   1) Application
      The persons who passed the academic examination shall apply for the certificate to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) with a certification application, a passing certificate of academic examination, and a personal history.
   2) Issue
      The general manager of Headquarters (HQ) Electric Signal communications Department (station equipment) shall review the application and the examination results on the basis of documents, and issue a certificate after qualification is confirmed.
   3) Scope of application
      The certificate is applicable to the maintenance construction of Hanoi Metro’s AFC equipment.
4) Period of validity
The period of validity is three years from the date of issue.

5) Qualification renewal
A qualified person who wants to renew his qualification shall apply for certificate renewal after completing the training provided by the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) and obtaining a certificate of completing the training.

6) Reissue
a) In the case of loss, damage, change in description of a certificate, the person concerned shall apply for reissue to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment).

b) If a qualified person could not renew his qualification by the expiration date due to an inevitable cause, the person shall apply for reissue to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) adding a letter of explanation.

7) Revocation of qualifications
When a qualified person has caused a major accident in construction in which the person has been engaged, or has run a risk of a serious accident, the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) may revoke the certificate issued to the concerned person.

8) Expiration of qualifications
When the period of validity of a certificate expires, the concerned certificate becomes invalid.

7. Special Measures
1) Technical certification at the time of the incorporation of Hanoi Metro
It is the first time for Vietnam to introduce an AFC system into the country. At the time of the incorporation of Hanoi Metro, there is no one who has experienced the work described in qualification requirements for technical staff. We therefore take special measures to qualify the staff in charge of AFC maintenance construction for Line 2A that starts business first when they finish training in China and OJT training on Line 2A equipment. On the other hand, we shall carry out an academic examination and an aptitude test to prove that the staff members are technically qualified to perform their duties.

2) Specially appointed technical advisor
In the initial stage of introducing an AFC system and starting business, technical specialists from supporting countries need to instruct and advise the staff as a technical advisor. In such cases, the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) may define the scope of duties and authority of the advisors concerned, certify them as specially appointed advisors, and have them perform their duties.

7. Maintenance Management System
To effectively carry out AFC equipment maintenance, we establish a management system based on the knowledge of the maintenance engineering described in the previous chapter. We develop a state monitoring system that facilitates effective maintenance. The system specifically monitors the conditions of equipment such as operating status, deteriorating status, etc. Table 6-7-14 shows the maintenance management system. Equipment diagnosis means the work to collect and analyze data required for state monitoring. Maintenance I and Maintenance II conduct preventive maintenance work to inspect equipment status and carry out necessary adjustment and parts replacement. Maintenance III conducts corrective maintenance to repair failures. Maintenance IV is the work to improve equipment functions to extend its life.

Table 6-7-14 Maintenance management system

<table>
<thead>
<tr>
<th>Work classification</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment diagnosis</td>
<td>Collecting and analyzing various data on equipment conditions to normalize and improve maintenance.</td>
</tr>
<tr>
<td>Maintenance I</td>
<td>Preventive maintenance to check and adjust functions without disassembling equipment when maintenance is needed.</td>
</tr>
<tr>
<td>Maintenance II</td>
<td>Corrective maintenance to conduct function check, parts replacement, and adjustment by disassembling equipment based on a specified method when maintenance is needed.</td>
</tr>
<tr>
<td>Maintenance III</td>
<td>Corrective maintenance performed when equipment failure or trouble occurs.</td>
</tr>
<tr>
<td>Maintenance IV</td>
<td>Maintenance conducted to improve the reliability, maintainability, and functions of equipment.</td>
</tr>
</tbody>
</table>

8. AFC Equipment Maintenance Rules
(1) We establish equipment-wise maintenance construction criteria for major AFC equipment based on the maintenance management system (Table 6-7-14). The table (Table 6-7-15) is an example of such a system. Various AFC systems exist because of technical development and different system structures. We must therefore establish
rules for AFC equipment by type and function. We must also specify equipment to be managed taking account of the pieces of equipment constituting an AFC system. In the case of Hanoi Metro, we need to know the details of the AFC equipment installed for Line 2A, the first line to start business, and establish the rules in accordance with the equipment.

(2) The equipment-wise construction details mentioned in the previous paragraph shall be specified in accordance with the “equipment-wise maintenance standards” provided separately, and construction shall be carried out based on the standards.

Table 6-7-15 Equipment-wise maintenance construction criteria (form example)

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Equipment name</th>
<th>Type/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Specialized ticket gate/Model EGI-1/Manufacturer N</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Specialized ticket collection machine/Model EGC-1/Manufacturer N</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Ticket checking and collection machine/Model EGB-1/Manufacturer N</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Wide ticket checking and collection machine/Model EGWB-1/Manufacturer N</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Specialized ticket gate/Model EGI-1/Manufacturer O</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Specialized ticket collection machine/Model EGC-1/Manufacturer O</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic ticket gate</td>
<td>Ticket checking and collection machine/Model EGB-1/Manufacturer O</td>
</tr>
<tr>
<td>I, II</td>
<td>Operator terminal</td>
<td>Function integrated machine/Model TOMA/Manufacturer T</td>
</tr>
<tr>
<td>I, II</td>
<td>Automatic add value machine</td>
<td>Coin and bill acceptor/Model AVMM/Manufacturer T</td>
</tr>
<tr>
<td>I</td>
<td>Station server</td>
<td>Manufacturer H</td>
</tr>
</tbody>
</table>

(3) Structural Example of Equipment-wise Maintenance Standards (Automatic Ticket Gate/Model EGI-1/Manufacturer N)

1) Scope of application
   Applicable to Specialized Automatic Ticket Gate/Model EG-1/Manufacturer N.

2) Definition of Terms
   a) Device
      The device means a component classified for each major part and each block.
b) Part  
The part means an inspection location classified for each equipment.

c) Maintenance point  
The maintenance point means a major inspection point expressed by part name.  
The coverage of an inspection point may change depending on the accumulated number of inspection.

d) Maintenance interval  
The maintenance interval means an interval at which periodic maintenance is performed.

e) Maintenance item  
The maintenance item means an individual checking or adjustment work item.

f) Maintenance method  
The maintenance method means a construction method for each maintenance point.

   i. Visual check/confirmation work  
      Check of the appearances, conditions, and operating conditions of equipment visually or by touch.

   ii. Confirmation work  
      Confirmation of operating conditions and adjusted values of equipment.

   iii. Confirmation or adjustment  
      Checking operating conditions and adjusted values, and carrying out readjustment of equipment misadjusted or using wrong adjustment criteria.

   iv. Cleaning and confirmation  
      Cleaning of contamination and check of conditions.

   v. Replacement and adjustment  
      Periodic parts replacement and adjustment.

   vi. Confirmation test  
      A test conducted operating equipment in the maintenance mode (if this mode exists). Adjustment is carried out if trouble is found.

 g) Important item  
An important inspection point where maintenance such as adjustment is conducted with special care.
h) Criterion value
   A criterion value for adjustment

i) Procedure
   A detailed description of an adjustment method and work such as lubrication.

3) How to conduct maintenance
   a) Inspection and adjustment shall basically be conducted according to the maintenance manual of the model concerned.
   b) When trouble is found through confirmation work, adjustment or parts replacement shall be performed.
   c) Construction shall be carried out in accordance with a construction procedure document prepared following the form shown in Table 6-7-16

4) Handling of replacement parts
   a) When equipment is severely deteriorated or adjustment is difficult, conduct parts replacement.
   b) If parts replacement cannot be judged at the time of inspection, describe it in a report, and conduct it after obtaining the approval of the AFC competent engineer and the AFC chief engineer.
   c) When the replacement of a major component bearing an important function of equipment such as a block or a unit, prepare a report and carry it out after obtaining the approval of the AFC competent engineer and the AFC chief engineer except in an emergency.

5) Report
   a) Make a format of maintenance construction reports to include all reporting items.
   b) Prepare a report immediately after the completion of construction, and submit it to the AFC competent engineer and the AFC chief engineer. The AFC chief engineer shall properly record and store the data to make them available for technical management, and report them to Headquarters (HQ) Electric Signal Communications Department.
<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Device name</th>
<th>Type/Function</th>
<th>Maintenance point</th>
<th>Maintenance interval</th>
<th>Maintenance item</th>
<th>Maintenance method</th>
<th>Important item</th>
<th>Criterion value</th>
<th>Procedure and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance I</td>
<td>Automatic ticket gate</td>
<td>Specialized ticket gate/Model EGI-1/Manufacturer N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Device</th>
<th>Part</th>
<th>Maintenance point</th>
<th>Maintenance interval</th>
<th>Maintenance item</th>
<th>Maintenance method</th>
<th>Important item</th>
<th>Criterion value</th>
<th>Procedure and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>User interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01 Operation/display</td>
<td>01 Guide display LCD</td>
<td>Check display</td>
<td>Cleaning and confirmation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>part</td>
<td>02 LCD</td>
<td>Check display</td>
<td>Cleaning and confirmation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>03 Passing indicator light</td>
<td>Check display</td>
<td>Cleaning and confirmation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Door part</td>
<td>01 Door unit</td>
<td>Check operation work</td>
<td>Confirmation work</td>
<td></td>
<td>Tightening torque</td>
<td>No backlash Check tightening torque</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>02 Door flap</td>
<td>Check operation/ loose/crack</td>
<td>Confirmation work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>03 Door axis cover</td>
<td>Off-position, loose</td>
<td>Confirmation work</td>
<td></td>
<td></td>
<td>Undamaged</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>04 Flap cover</td>
<td>Off-position, loose, installed condition</td>
<td>Confirmation work</td>
<td></td>
<td></td>
<td>Undamaged</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Human detection part</td>
<td>01 Transmission type sensor</td>
<td>Contamination, check</td>
<td>Cleaning and confirmation</td>
<td></td>
<td>Removing the cover and cleaning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>02 Reflection type sensor</td>
<td>Contamination, check</td>
<td>Cleaning and confirmation</td>
<td></td>
<td>Removing the cover and cleaning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6-7-16 Equipment-wise maintenance construction procedure document (form example)

Note: The descriptions in the table are for the explanation of the form only. Determine the contents corresponding to the specific equipment used.
Appendix 8-6-7(A)  Requirements for Staff of AFC Related Divisions

With reference to descriptions presented here, the requirements should be occasionally changed in line with actual conditions of equipment and maintenance methods planned for the 2A Line.

### Division
- **Main Job Duty**
- **Academic Qualifications**
- **Age**
- **Health Conditions**
- **Experiences**
- **Requirements for New Staff prior to Training**
- **Eduational Goals of New Staff**

### New Staff Equipment Division
- **Job Category**
- **Main Job Duty**
- **Academic Qualifications**
- **Age**
- **Health Conditions**
- **Experiences**
- **Requirements for New Staff prior to Training**
- **Eduational Goals of New Staff**

<table>
<thead>
<tr>
<th>Job Category</th>
<th>Main Job Duty</th>
<th>Academic Qualifications</th>
<th>Age</th>
<th>Health Conditions</th>
<th>Experiences</th>
<th>Requirements for New Staff prior to Training</th>
<th>Educational Goals of New Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC system manager</td>
<td>AFC system manager</td>
<td>Bachelor’s degree in electronics, computer science, or related fields</td>
<td>35 or younger</td>
<td>Good health</td>
<td>2 years of experience in electronics or computer science</td>
<td>Must have basic knowledge of technical details of the AFC equipment to be introduced and installed.</td>
<td>Able to understand and apply technical knowledge of the AFC equipment.</td>
</tr>
<tr>
<td>AFC maintenance manager</td>
<td>AFC maintenance manager</td>
<td>Master’s degree in electronics, computer science, or related fields</td>
<td>40 or younger</td>
<td>Good health</td>
<td>5 years of experience in electronics or computer science</td>
<td>Must have basic knowledge of technical details of the AFC equipment to be introduced and installed.</td>
<td>Able to understand and apply technical knowledge of the AFC equipment.</td>
</tr>
<tr>
<td>AFC operator</td>
<td>AFC operator</td>
<td>Bachelor’s degree in electronics, computer science, or related fields</td>
<td>25 or younger</td>
<td>Good health</td>
<td>1 year of experience in electronics or computer science</td>
<td>Must have basic knowledge of technical details of the AFC equipment to be introduced and installed.</td>
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</tr>
</tbody>
</table>

### AFC Maintenance Division
- **Job Category**
- **Main Job Duty**
- **Academic Qualifications**
- **Age**
- **Health Conditions**
- **Experiences**
- **Requirements for New Staff prior to Training**
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<tr>
<th>Job Category</th>
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### AFC Operation Division
- **Job Category**
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<tr>
<td>AFC system manager</td>
<td>AFC system manager</td>
<td>Bachelor’s degree in electronics, computer science, or related fields</td>
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</tr>
</tbody>
</table>
Appendix 8-6-7-2-A(A) Number of Staff Required for AFC Equipment Maintenance Work

1. General

Hanoi Metro consists of Headquarters Group (HQ) and Group responsible for passenger transportation work (OU). They have their own organizations with respective functions for AFC equipment maintenance as shown in Figure 6-7-13. They need to secure the number of staff required for these functions.

![Figure 6-7-13: Roles of relevant groups in maintenance construction](image)

Fig. 6-7-13 Roles of relevant groups in maintenance construction

2. Headquarters (HQ)

In Headquarters, the Station Service system Section is mainly responsible for the planning and management of AFC equipment maintenance. Its duties are as follows:

1. Items on approvals and licenses from authorities relevant to the work concerned
2. Items on construction contracts and construction entrustment/commitment contracts relevant to the work concerned
3. Items on the demand and supply of necessary materials
4. Items on the prevention, investigation, and reporting of accidents relevant to the work concerned
5. Items on the management of the maintenance of station service system equipment
6. Items on the survey, planning, design, and construction of station system equipment for new installation and improvement
To perform these roles, Hanoi Metro shall have the organizational structure shown in Figure 6-7-14. At the time of the business start of Line 2A, however, Hanoi Metro operates only one line, and the scales of 12 stations and the AFC system are small. It is therefore sufficient to assign one person for the above work instead of setting up a section. The same applies to the planning work, where a person in charge of planning and a person in charge of the AFC system cooperate with each other to perform their duties. As the number of operating lines increases and the AFC system scale becomes larger, the number of staff is increased.

3. Passenger Transportation Group (OU)
   (1) AFC equipment group in Passenger Transportation Group establishes Electric Signal Communications Maintenance Department with the major roles of maintaining and improving the functions of AFC equipment installed in the points of use such as train stations. It has the following duties:

   1) Items on maintenance construction management work
   2) Items on maintenance construction work
   3) Items on outsourcing contracts
   4) Items on equipment lease contract
   5) Items on On-Call >>> Whether the control office deals with it. (To be discussed)

To perform these roles, the Department has the organizational structure shown in Figure 6-7-15. The number of staff described here is that needed to handle Line 2A only, and the number needs to be increased as the number of lines increases.
(2) The chief engineer (AFC) in the figure mainly carries out maintenance construction management and contract work under the instructions of the deputy general manager, and manages, supervises, and instructs the team in charge of construction.

(3) The person in charge of construction in the figure performs maintenance construction at the point of use of equipment or in a maintenance factory. As explained in the previous chapter, the maintenance of AFC equipment must be carried out on a 24-hour basis. The work system, however, must be structured in accordance with the rules stipulated in the Labor Law (10/2012/QH13).

*Each number indicates the number of persons in charge

Fig. 6-7-15 Organizational structure of Electric Signal Communications Maintenance Department

(4) Rules on work hours stipulated in the Labor Law

The law specifies labor hours, overtime work hours, midnight shift, and paid time off in detail as follows:

1) Ordinary work hours shall not exceed 8 hours a day and 48 hours a week. Work not exceeding 10 hours a day is, however, allowed if work hours a week do not exceed 48 hours.

2) The midnight shift is defined as any shift with a scheduled starting time on and after 22:00 and before 07:00 the next day.

3) The overtime work shall not exceed the 50% of work hours of a day. The overtime work hours shall not exceed 12 hours a day, 30 hours a month, and 200 hours a year.
4) When working for 8 hours or continuously working for 6 hours, the worker shall be allowed at least a 30 minute paid break. In the case of the midnight shift, the worker shall be allowed a 45 minute paid break.

5) The worker engaged in shift work shall be allowed a 12 hour break before starting the next work.

6) A worker shall be allowed at least a 24 hour continuous break a week. If a worker cannot have weekly time off due to a work system, the worker shall be entitled to have 4 days of time off a month.

7) If a worker works for the same employer for a year, the person shall be entitled to have 12 days of paid time off.

8) Besides the above, workers may take the national holidays specified in the Labor Law as a paid time off.

(5) Study on the work system of persons in charge of construction

The shift work system known as the four teams and three shifts system enables 24-hour maintenance construction and complies with the rules specified in the Labor Law. Table 6-7-17 shows its example. It consists of four teams from Teams A to D, and sets work hours as shown in the table. The Time columns show the break time each team can take before it starts its respective shift work. The system meets the conditions of a 12 hour break before the start of shift work, a 24 hour continuous break a week, the midnight shift from 22:00 to 07:00 the next day, work for 8 hours or less a day, and 48 hours or less a week.

The actual application of the system needs to the personnel management group specialized in work systems, referring to other laws and regulations including the detailed rules of the Labor Law.
Study on the necessary number of staff

1) The four team and three shift system requires four teams.
2) As described in the section on the regulations for AFC maintenance construction, a supervisory person (a chief engineer) needs to be allocated in a construction site. At least one person in each team must be qualified as a competent maintenance engineers. The number of persons in charge of construction under the instructions of this supervisory person needs to be two or more from the viewpoints of heavy load carrying work, hazard prevention, and mutual help. Taking account of the sickness absence of one person, the number of persons needed to continue construction work is set to three. Figure 6-7-16 shows the resultant organization of each team. The total number required for four teams is 16.

The above staff allocation cannot ensure proper responses in the events of the sickness absence of two or more persons due to an epidemic of influenza and a vacancy caused by paid time off. It is thus necessary to add team leaders in charge of on-site construction to the system as the staff for preparing and coordinating work plans, managing the preparation of application forms and...
reports, and responding to the above cases and the occurrence of accidents. In the case of Line 2A, the planned number of staff is 18, and hence the additional number of staff is two.

(7) Study on the validity of the amount of work and the allocated number of staff

The above study was conducted from the viewpoints of organizational functions and labor management in the case of Line 2A. We then need to verify whether this staff allocation enables accomplishing the AFC equipment maintenance work of Line 2A. This study requires clarifying the following items explained in the previous section:

1) Number of train stations
2) Types and number of AFC equipment
3) Maintenance construction criteria for each equipment
4) Maintenance construction procedure and standard construction time for each equipment

Presently (as of November 2013), data for items a) and b) are available from the Line 2A project, but data for items c) and d) lack information on devices and equipment. The latter data must be prepared after they are fixed and become available. We therefore make trial calculations on certain assumptions to show calculation methods using information on Tokyo Metro and other railway operation companies, though different models are used.

1) Number of train stations: 12
2) Types and number of major AFC equipment (from TECHNICAL DESIGN):

Table 6-7-18 shows the types and number of major AFC equipment. Automatic gates and automatic ticket vending machines account for the majority of equipment, indicating that maintenance for them constitute the majority of maintenance.

<table>
<thead>
<tr>
<th>AFC equipment</th>
<th>Station server</th>
<th>Station monitor</th>
<th>Ticket server</th>
<th>Automatic ticket gate</th>
<th>Automatic ticket vending machine</th>
<th>Semi-automatic ticket vending machine</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of equipment</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>139</td>
<td>96</td>
<td>24</td>
<td>295</td>
</tr>
</tbody>
</table>

47
3) Construction criteria must be set based on data such as utilization rates, model-wise failure modes, and failure rates even for the same type of equipment. Table 6-7-19 lists the general features of each type of AFC equipment, where periodic inspection intervals are just for reference. Ticket gates and automatic ticket vending machines that account for the majority of equipment may need about two months of preventive maintenance interval.

<table>
<thead>
<tr>
<th>AFC equipment</th>
<th>Main inspection point</th>
<th>Periodic inspection interval for reference（※）</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticket gate (AG)</td>
<td>Door section</td>
<td>About 2 months of interval for points with a high failure rate</td>
</tr>
<tr>
<td></td>
<td>Human detection sensor</td>
<td></td>
</tr>
<tr>
<td>Ticket vending machine (AVM, ATVM)</td>
<td>Bill processor</td>
<td>About 2 months of interval for points with a high failure rate</td>
</tr>
<tr>
<td></td>
<td>Mechanical parts such as a card processor</td>
<td></td>
</tr>
<tr>
<td>TOM</td>
<td>Bill processor</td>
<td>About 2 months of interval for points with a high failure rate</td>
</tr>
<tr>
<td></td>
<td>Mechanical parts such as a card processor</td>
<td></td>
</tr>
<tr>
<td>Station Controller</td>
<td>Security functions</td>
<td>About 6 months of interval if installed a proper environment</td>
</tr>
<tr>
<td></td>
<td>Installation conditions, wiring</td>
<td></td>
</tr>
</tbody>
</table>

4) Estimated maintenance construction time is about one hour/equipment in the case of the maintenance of installed equipment (Maintenance I explained in the previous section).

5) On the assumption of the above, the trial calculations below conclude that the present staff plan for Line 2A is valid.

   a) Total number of construction hours is 25 hours/station (25 units x 1 hour).
   b) Construction during business hours is conducted in an undesirable environment and makes operating equipment unusable, causing passengers inconvenience. It is desirable to conduct construction outside business hours as much as possible. Such work system means working eight hours from 22:00 to 07:00 of the next day. Other hours are used for disassembly maintenance and failure repair in the maintenance factory. In the above case, 480 hours can be used for maintenance in two months.

   \[2 \text{ months} = 480 \text{ hours} (8 \text{ hours} \times 60 \text{ days})\]
c) The number of stations maintainable during two months is 19 (480 hours ÷ 25 hours), and thus the periodic inspection of Line 2A (number of stations = 12) is workable.

6) From the above result some extra time seems to be available. We only used major equipment for calculation, assuming a maintenance time of 1 hour/equipment, and ignoring the degrees of proficiency of persons in charge. Besides, taking account of the necessity of the emergency call of staff for immediate recovery from accidents and failures, the above calculated number of staff is valid.
Appendix 8-6-7-(A)  

Maintainable and Practical Maintenance Items in Vietnam

1. General

In Vietnam, Line 2A is the first line to introduce an AFC system to its railway system. Technical accumulation begins from the start of the business of Line 2A. Since the market of AFC equipment has not existed in Vietnam, neither AFC equipment suppliers nor its maintenance companies exist. At the initial stage after the start of business, therefore, the railway company may not be able to handle some technical items. Maintenance is, however, not limited to technical items alone. The types of work in the P, C, and A phases of the PDCA cycle are management, and hence the staff properly completed the education and training such as shown in Table 6-7-20 can carry out the work.

Table 6-7-20 Items that can be handled in the country

<table>
<thead>
<tr>
<th>PDCA cycle</th>
<th>Work</th>
<th>Implementation in Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAN</td>
<td>Planning</td>
<td>Development of maintenance plans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practicable after completing proper training</td>
</tr>
<tr>
<td>DO</td>
<td>Implementation</td>
<td>Implementation of equipment inspection, diagnosis, and maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Detailed study required</td>
</tr>
<tr>
<td>CHECK</td>
<td>Recording and analysis</td>
<td>Collection and analysis of maintenance information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practicable after completing proper training</td>
</tr>
<tr>
<td>ACTION</td>
<td>Feedback</td>
<td>Technical management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practicable after completing proper training</td>
</tr>
</tbody>
</table>

2. Study on Technical Work Items

Technical work items include the equipment diagnosis described in the previous section and construction work from Maintenance I to Maintenance IV. Equipment diagnosis, Maintenance I, and Maintenance II require in-condition or in-factory implementation, and therefore must be carried out in Vietnam; otherwise, the AFC system is inoperable. We need human source development and facilities for this purpose. On the other hand, Maintenance III (corrective maintenance and failure repair) and Maintenance IV (maintenance for improvement and improvement of equipment functions) include the items that cannot be handle in Vietnam alone depending on the types of work.
(1) Maintenance III (corrective maintenance and failure repair)

1) The case of parts and replaceable units

In the case of replacement of parts and units for restoration, work can be carried out in Vietnam by storing them in the country. Sometimes, however, repairing these parts and units requires advanced failure analysis technology, profound understanding of electronic and mechanical product technologies, and fabrication capability of high-precision parts. In such cases, outsourcing to manufacturers is needed. In some cases, the manufacturers send the parts and units to technical centers outside the country for repair.

2) Failures of the parts that cannot be replaced

In this case, equipment mostly needs to be completely overhauled and restructured. Such repair requires a variety of measurement equipment, parts, materials, and engineers with high-level technology. In many cases, therefore, the manufacturing and technical departments of equipment manufacturers carry out the repair at first.

(2) Maintenance IV (maintenance for improvement and improvement of equipment functions)

1) The case of “Kaizen”

In the case of the improvement known as “Kaizen,” where employees propose and implement improvement on the process of daily work, employees themselves can often carry out improvement, or in many cases improvement can be made using domestic equipment and technology.

2) The case of the improvement of basic functions

In the case of the improvement rooted in the results of technical development such as the improvement of materials, mechanisms, and functions, the knowledge, experiences, and know-how of equipment and products are mostly required, and hence in many cases only equipment manufacturing companies having such technical skills can handle this kind of work initially. The planning and proposals for improvement is, however, mostly created in the practical operations of railway business, and therefore, we can expect a great contribution of the Vietnamese side.

Table 6-7-21 summarizes the above. The items that can be handled in Vietnam will increase significantly as technical accumulation increases and human resource development advances in the country.
Table 6-7-21 Study on the feasibility of conducting Maintenance III and IV domestically

<table>
<thead>
<tr>
<th>Maintenance work</th>
<th>Implementation in Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement of parts and units</td>
<td>Mostly possible if parts and units inventory and work manuals exist.</td>
</tr>
<tr>
<td>Parts and units</td>
<td>Mostly impossible because advanced equipment and technology are needed.</td>
</tr>
<tr>
<td>Repair of parts that cannot be replaced</td>
<td>The same as above</td>
</tr>
<tr>
<td>“Kaizen”</td>
<td>Mostly possible.</td>
</tr>
<tr>
<td>Improvement of basic functions</td>
<td>Sometimes difficult.</td>
</tr>
</tbody>
</table>
Appendix 8-6-7-2-C(A)  Information on Standard Market Prices for Maintenance Items

1. Calculation of Prices for Equipment Maintenance Work
   “Prices” do not only mean the prices for Hanoi Metro’s outsourcing work to external companies. In the case where Hanoi Metro directly carries out maintenance construction, “prices” have the same meaning with “construction costs.”

2. Cost Structures
   The technical design document for Line 2A (TECHNICAL DESIGN, OCT 2013) lists the appliances, installations, devices, and equipment shown in Table 6-7-22. Unit prices for their maintenance are generally composed of the following costs:
   (1) Material costs
       Cost of parts for repair and replacement, unit costs, and utilities costs for electricity, gas, and water used for construction
   (2) Equipment costs (fixed costs)
       Allocated fixed costs for machinery and appliances, measurement equipment, and buildings
   (3) Personnel costs
       Personnel costs for maintenance construction
   (4) Outsourcing costs
       Outsourcing costs in the case of outsourcing part of maintenance to external companies
   (5) Administrative costs
       Allocation costs from indirect groups
<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Appliance, installation, equipment</th>
<th>Number of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Train station</td>
<td>Cabinet (including distribution board, mount base)</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Train station</td>
<td>Station server</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Train station</td>
<td>Emergency warning system</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Train station</td>
<td>L3 switch</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Train station</td>
<td>Light-metal conversion module</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>Train station</td>
<td>Work station</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>Train station</td>
<td>UPS (30KVA)</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>Train station</td>
<td>Battery storage box (with 0.5 hr power feeding battery)</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Train station</td>
<td>Duplex power switch box</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>Train station</td>
<td>Grounding end box</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>Operation control room</td>
<td>Monitoring work station</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>Operation control room</td>
<td>Network printer</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>Station equipment room</td>
<td>Ticket work station</td>
<td>12</td>
</tr>
<tr>
<td>14</td>
<td>Station equipment room</td>
<td>Network printer</td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>Station equipment room</td>
<td>IC card ticket counter</td>
<td>12</td>
</tr>
<tr>
<td>16</td>
<td>Station equipment room</td>
<td>IC card ticket count, packaging device</td>
<td>12</td>
</tr>
<tr>
<td>17</td>
<td>Station equipment room</td>
<td>Bill counter</td>
<td>12</td>
</tr>
<tr>
<td>18</td>
<td>Station equipment room</td>
<td>Coin counter</td>
<td>12</td>
</tr>
<tr>
<td>19</td>
<td>Station equipment room</td>
<td>IC ticket storage, cash storage box R/W for identifying opening and closing control ID</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>Station equipment room</td>
<td>IC card ticket storage box (spare)</td>
<td>24</td>
</tr>
<tr>
<td>21</td>
<td>Station equipment room</td>
<td>Bill storage box (spare)</td>
<td>88</td>
</tr>
<tr>
<td>22</td>
<td>Station equipment room</td>
<td>IC ticket, bill storage box cabinet</td>
<td>88</td>
</tr>
<tr>
<td>23</td>
<td>Station equipment room</td>
<td>File cabinet</td>
<td>12</td>
</tr>
<tr>
<td>24</td>
<td>Station equipment room</td>
<td>Carrying caster</td>
<td>12</td>
</tr>
<tr>
<td>25</td>
<td>Station yard</td>
<td>L2 network switch</td>
<td>48</td>
</tr>
<tr>
<td>26</td>
<td>Station yard</td>
<td>Ether I/O controller</td>
<td>24</td>
</tr>
<tr>
<td>27</td>
<td>Station yard</td>
<td>Ticket checking and collection machine</td>
<td>115</td>
</tr>
<tr>
<td>28</td>
<td>Station yard</td>
<td>Wide ticket checking and collection machine</td>
<td>24</td>
</tr>
<tr>
<td>29</td>
<td>Station yard</td>
<td>Suspended information sign</td>
<td>139</td>
</tr>
<tr>
<td>30</td>
<td>Station yard</td>
<td>Automatic ticket vending machine</td>
<td>88</td>
</tr>
<tr>
<td>31</td>
<td>Station yard</td>
<td>Automatic fare adjustment machine</td>
<td>24</td>
</tr>
<tr>
<td>32</td>
<td>Station yard</td>
<td>Ticket window ticket vending machine</td>
<td>24</td>
</tr>
<tr>
<td>33</td>
<td>Station yard</td>
<td>Portable inspection machine</td>
<td>24</td>
</tr>
<tr>
<td>34</td>
<td>Station yard</td>
<td>Bill counter</td>
<td>24</td>
</tr>
<tr>
<td>35</td>
<td>Maintenance work area</td>
<td>Work station</td>
<td>3</td>
</tr>
<tr>
<td>36</td>
<td>Maintenance work area</td>
<td>Network printer</td>
<td>3</td>
</tr>
<tr>
<td>37</td>
<td>Maintenance work area</td>
<td>Portable PC</td>
<td>3</td>
</tr>
<tr>
<td>38</td>
<td>Maintenance yard</td>
<td>Portable recording media</td>
<td>3</td>
</tr>
<tr>
<td>39</td>
<td>Maintenance yard</td>
<td>Portable maintenance device</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>Maintenance yard</td>
<td>Maintenance appliance</td>
<td>3</td>
</tr>
<tr>
<td>41</td>
<td>Maintenance yard</td>
<td>Appliance cabinet</td>
<td>3</td>
</tr>
</tbody>
</table>
3. Calculation of Costs
   Since material costs depend on contract conditions such as equipment, equipment suppliers, purchase time, and quantity, they can be calculated when these conditions are materialized. Equipment, personnel, and administrative costs can be calculated when organizations, number of staff, and assets are determined. Outsourcing costs can be calculated when its details and conditions such as taxes, transportation charges, and insurance premiums are determined. In the case of abroad, the conditions for CIF (cost, insurance, and freight) prices that include the costs for freight and insurance or FOB (free on board) prices that sellers bear the costs needed until loading cargo on board the ship are also considered in calculation. At the stage of preparing this interim report, these conditions have not been determined. Cost calculation can be made when the company is incorporated and these conditions are set.

4. Outsourcing
   (1) Since AFC equipment consists of many advanced electronic devices, outsourcing part of maintenance to external companies with expertise is appropriate as an option.
   (2) Outsourcing by model (manufacturer) and by case or project should be avoided, especially in the case of taking emergency measures. The following system should be developed and operated.

   1) Outsource all equipment by area (one-stop service).
   2) Share standard construction prices under a basic contract and perform construction for an appropriate price.
   3) When a case occurs, instruct starting construction, and take rapid measures.
Appendix 8-6-7-2-D(A)  Calculation method of the number of AFC equipment maintenance personnel

1. Procedure to calculate the number of the maintenance personnel
   (1) Specify the standard inspection time (*) required for inspection of each machine type.
   (2) Specify the number of the personnel for each unit of work.
   (3) Sum up the maintenance time required in a year for each machine type and each inspection cycle to determine the yearly total maintenance time.
   (4) Specify the yearly scheduled working time per maintenance worker (covering both leaders and workers).
   (5) Determine the total number of the necessary maintenance personnel based on the yearly total maintenance time and the yearly scheduled working time.

*) The standard inspection time means standard working hours necessary for the inspection work that is specified in the maintenance manual.

By adding to this time travel time to a maintenance site, the time needed for maintenance can be obtained. The attached table presents reference values only, so that the specification must be made based on equipment to be actually installed.

2. Example of calculating the number of maintenance workers

   Though this example uses information obtained in terms of AFC equipment used on the 2A Line, it should be reviewed after detailed information is obtained. This material should be used only for learning the calculation method.

   (1) Assumptions of the calculation

   1) The number of units of equipment (Table 6-7-23)

<table>
<thead>
<tr>
<th>Station No.</th>
<th>Ticket gate</th>
<th>Automatic Ticket Machine</th>
<th>Ticket office machine</th>
<th>Semi-Automatic Ticket Machine</th>
<th>Station controller</th>
<th>Train line server</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32</td>
<td>12</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>80</td>
<td>26</td>
<td>26</td>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

2) The number of yearly working days is set to 290 on the premise of the following days off.

3) Days off:
a. Non-working days per year: 53
b. Public holidays: 10 days. Since maintenance work should be carried out even on public holidays, shift workers are excluded from the calculation.
c. Paid holidays: 12 days

4) The working hours are set to 8 hours/day.

Travel time is not included in the table. This is because the urban railways have only total length of about 20 km, and travel time has no significant influence on calculation results. However, when formulating a daily maintenance plan, a loss due to travel time must be kept down by avoiding travelling as much as possible.

The standard inspection time varies substantially depending on equipment specifications, skill and proficiency levels of workers and so on. The standard time used here assumes that workers with less experience are in charge.
## Formulation of an AFC equipment maintenance plan (Example)

1) **Standard inspection time** (Table 6-7-24): Specify standard inspection time for each piece of equipment, and calculate the necessary maintenance time. When determining the standard inspection time, working time of staff concerned should be measured. The time indicated below is an example. With an increase in the proficiency level of a worker, the maintenance work can be completed in a shorter time, and there will be no need for the worker to be always paired with a leader.

### Table 6-7-24 Standard inspection time

<table>
<thead>
<tr>
<th>Inspection location</th>
<th>Inspection item</th>
<th>Number of inspections</th>
<th>Required maintenance time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticket Office</td>
<td>Power supply unit</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Control unit</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Operation display unit</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Disk array</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Staff operating portion</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Display unit</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Exterior</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Overall functions</td>
<td>2</td>
<td>60</td>
</tr>
</tbody>
</table>

### Appendix 8-6-7-(A)
2) Time for maintenance work for each location (Table 6-7-25)
   - Calculate the time necessary for maintenance work in each location at a station and the Line center based on the standard inspection time.

Table 6-7-25 Required Maintenance Time in Inspection Work for Each Maintenance Location based on Standard Inspection Time* (Example)

<table>
<thead>
<tr>
<th>Location</th>
<th>Equipment</th>
<th>Number of yearly inspections</th>
<th>Standard inspection time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station 1</td>
<td>Ticket gate</td>
<td>12</td>
<td>2 hours 50 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>2 hours 50 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>2 hours 50 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>2 hours 50 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>2 hours 50 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>2 hours 50 minutes</td>
</tr>
</tbody>
</table>

*Table 6-7-25 Required Maintenance Time in Inspection Work for Each Maintenance Location based on Standard Inspection Time* (Example)
3) Yearly working time of workers

- Establish a work system for maintenance workers and decide the yearly working time for each worker.
- The following table is an example where a system of 3 shifts with 4 teams is adopted to make the maintenance work possible for 24 hours a day.
- It is necessary to monitor the train line server continuously for 24 hours a day, 365 days a year. Because expertise in the server is also necessary, a group of personnel in charge of the maintenance of station facilities is considered separately.
- If a work system is decided, the yearly working time can be calculated.

Table 6-7-26 Manpower calculation in the AFC maintenance division in a system of 3 shifts with 4 teams (Example)

A case where the number of the OU maintenance workers on the 2A Line is assumed to be 18.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of workers</th>
<th>Weekly working time (hr.)</th>
<th>Required working time (hr.)</th>
<th>Yearly working time (hr.)</th>
<th>Yearly required number of the personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of Station Facilities</td>
<td>72</td>
<td>200</td>
<td>2080</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>200</td>
<td>2080</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

4) Number of maintenance personnel

- The necessary number of personnel to be engaged in maintenance work is determined based on the total standard inspection time needed for maintenance work and yearly working time of workers.
- For vacancies due to accidents, failures, illness of workers, or paid holidays, two staff members in charge of technical management, repair, etc. in the maintenance division should respond to the situation in a “day work (8:00-17:00)” system at a maintenance base.
- The total number of maintenance personnel is 18 with workers (including leaders) for inspection and monitoring and two day-work staff members, as shown in the Table below.

Table 6-7-27 Number of maintenance personnel

<table>
<thead>
<tr>
<th>Category</th>
<th>Required working time (hr.)</th>
<th>Yearly working time (hr.)</th>
<th>Yearly required number of the personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of Station Facilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leader</td>
<td>7684</td>
<td>2080</td>
<td>4</td>
</tr>
<tr>
<td>Worker</td>
<td>7684</td>
<td>2080</td>
<td>4</td>
</tr>
<tr>
<td>Monitoring of Train Line Server</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leader</td>
<td>8760</td>
<td>2080</td>
<td>4</td>
</tr>
<tr>
<td>Worker</td>
<td>8760</td>
<td>2080</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix 8-6-7-3-A(A) Acquisition of Planning Methods for Equipment Renewal

1. Rules for the Durable Years of Equipment

   (1) Basic Concept of Durable Years

   Equipment ages with time and the amount of use after starting operation, and eventually becomes impossible to meet the purpose of its use, and finally reaches the end of life. This period is called life or durable years. IEC 60050 uses the term “Useful Life” and defines it as “under given conditions, the time interval beginning at a given instant of time, and ending when the failure intensity becomes unacceptable or when the item is considered unrepairable as a result of a fault.” The unacceptable failure intensity means the failure intensity with a repair cost increased to an uneconomic level. Software does not wear out, but the time point when it cannot meet required functions is the end of its life. As shown in Figure 6-7-17, two types of life exist: life due to deterioration, and life due to obsolescence because of increase in required functions.

![Fig. 6-7-17 Factors determining life (durable years)]](image)

(2) Deterioration and Life (Durable Years)

Equipment consisting of one part or unit, or that whose parts and units have the same life has to be disposed of when it reaches the end of life. AFC equipment, however, consists of many parts and units with different deterioration life. Replacing the parts constituting equipment to extend its life as a whole is therefore economically meaningful.

As the deterioration of parts and units increases and the necessity of their repair increases, repair costs also increase. We therefore need to compare the costs required for repair with those for renewal to new equipment, making an advantageous choice.
from the viewpoint of life cycle costs. The failure modes of major parts and units shown in Table 6-7-3 are important in making the judgment.

(3) Obsolescence and Life
When existing equipment becomes impossible to meet the increased levels of functions required by its user, it becomes obsolete and reaches the end of its life. Quantitatively predicting the tendency of increasing level of requirements is difficult due to unpredictable change in social environment. The tendency, however, has a significant effect on the life of many electronic circuit products used in AFC equipment mentioned below.

(4) Life Defined in Public Accounting Law/Accounting Standards
Assets of 30 million VND or more are defined as fixed assets by the Vietnamese Accounting Law (03/2003/QH 11) and the Accounting Standards (45/2013/TT-BTC) and depreciable. The Accounting Standards (169/1999/QD-BTC) define depreciation periods on the basis of the straight-line method. Depreciation must be calculated following the Accounting Standards.
We believe that AFC equipment belongs to the Items C (Measurement/Test Apparatus) and E (Control Apparatus) in the Annex to the Accounting Standards. Each division of equipment is subdivided, and the shortest depreciation period is three years and the longest ten years. Since depreciation is recorded as an expense, companies determine depreciation periods from a business point of view. Longer depreciation periods reduce annual depreciation costs and ease the administrative burden.
If the depreciation period of a ticket gate is set to seven years, for example, the equipment must continue to operate for seven years to contribute to the company, because the expenses are continuously generated. Except in most unusual circumstances, the company does not replace the equipment in less than 7 years considering from a business point of view. In other words, equipment life (durable years) must be at least the depreciation period or longer. On the other hand, equipment with completed depreciation basically contributes to the company’s revenue without generating expenses. The company continues to use the equipment until its failure repair costs exceed an allowable level and its functions become obsolete.

(5) Viewpoint of Electronic Parts
1) Viewpoint of reliability life
As described in the previous section, many pieces of AFC equipment are built on the basis of advanced electronics technology. The failures of electronic circuits, therefore, lead to the loss of the main functions of AFC equipment. In the inside of the automatic ticket gate shown in Figure 6-7-18, for example, many circuits and devices are mounted: an electronic control circuit for controlling the door mechanism, LED and LCD panels and their control circuits for displaying information to passengers, an central processing electronic circuit for processing data and controlling the whole equipment, and devices and a reader/writer for safely coding and encoding IC card ticket information.

Electronic circuits consist of semiconductor integrated circuits (LSIs), capacitors, resistors, coils, electronic circuit boards, cables, and connectors. The lives of these components have significant effects on the life of AC equipment. In general, electronic components have a bathtub type failure mode. As they approach the end of life, their failure modes change from the random type to the wear-out type, and their failure rates rapidly increase. Electronic components are generally manufactured on the assumption of a life span of about 10 years. Some special use products guarantee a longer life, but they are expensive and unusable for general use. Consequently, the failure rate of AFC equipment may increase after 10 years of use. Then the utilization rate of equipment decreases to increase repair expenses.

2) Viewpoint of the product life (obsolescence) of electronic components

Electronics technology typified by semiconductor integrated circuit technology has greatly advanced after the invention of semiconductor devices in 1947 and that of integrated circuit technology in 1958, changing civilization revolutionarily in less than 70 years. The computer ENIAC, the first computer operated in the USA in
1946, was a huge system with a width of 30 m, a height of 2.4 m, and a depth of 0.9 m. Now we have a handy smartphone with a highly advance computer and a weight of only a little over 100 g. The development of semiconductor technology has been realized along with the prediction known as Moore’s Law stating “the number of transistors on integrated circuits doubles approximately every 18 months.”

Moore’s Law \( N = 2^{n/1.5} \)

(Example: The number of elements has increased millionfold in 30 years.)

Electronics technology has been rapidly and continuously developing, resulting in an extremely short life of its applied products. Many people renew their cell phones about every two years. Few people use the same personal computers for five years or more. New products with new functions and a low price are put into market one after another. They become obsolete in a very short period. As a result, the generation of electronic components changes rapidly and manufacturers discontinue old products. AFC equipment, one of electromechanical equipment, is affected by this tendency. Even if the functions of equipment satisfy us and it has a low failure rate, it is highly possible that we cannot obtain the parts needed for repair. Ensuring service parts enables us to cope with this situation to some extent. It would be very expensive, however, to store all parts for repairing the failures of equipment after using it for 10 years or more, taking account of the life of electronic devices. Obsolescence also affects the life of AFC equipment.

(6) Rules on Durable Years

As described above, many factors affect the life of AFC equipment, and hence it is not advantageous to specify the durable year of AFC equipment in a uniform way.

1) Concept of rules on durable years
   ① Durable years shall be the same as or longer than depreciation period.
   ② Continuous use if life cycle cost for maintenance is less than renewal cost)

Judgment shall be made comparing a renewal cost of equipment with its life cycle cost including increased repair cost due to increase in failure rate (plus cost to obtain service parts) and increased equipment cost due to decrease in utilization rate.

Such judgment requires the collection, management, and analysis of maintenance data on failure occurrence, repair and recovery time, repair points, used parts, and repair costs as described in the previous section.
③ Prevention of obsolescence
Maintenance cannot be carried out if service parts and consumable parts become unavailable. It is therefore necessary to make maintenance agreements with equipment manufacturers on parts supply.

④ Guideline on durable years
Making rules in a uniform way is difficult. As described in the previous section, electronic circuits realize major functions of AFC equipment. Since the durable years of equipment are determined by the components constituting its electronic circuits, a guideline to judge the durable years of AFC equipment is 10 years, a general life of electronic parts. The utilization rate of equipment should be given attention. Assuming that all stations use the same types and models of equipment, the utilization rate of equipment installed in a city center or a terminal station attracting many passengers is very high, whereas that of equipment installed in a small and empty suburban station is very low. Consequently, even the same models of equipment greatly differ in durable years due to different deterioration progress. The basic rules therefore put the basis on the life cycle costs and renewal costs needed for maintenance.

(7) Methods of Equipment Renewal
In the case where AFC equipment reaches its durable year and is renewed, the following points shall be considered to determine its renewal method:

1) Simultaneous renewal
A method to renew the same types and models of equipment at the same time

2) Separate renewal
A method to renew equipment based on separate judgment on individual piece of equipment.

Table 6-7-28 compares the advantages and disadvantages of the two methods. Both have merits and demerit, and have no definite superiority over the other. When Hanoi Metro’s cash flow is severe, the separate renewal is preferable because of less administrative burden. The general manager of Headquarter Equipment Group needs to make a proposal of separate renewal and carry it out after obtaining the approval based on the rules for equipment investment.
Table 6-7-28 Comparison of equipment renewal methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simultaneous</td>
<td>1) Easy to suppress procurement costs because of volume order</td>
<td>1) Heavy investment in renewal puts a heavy burden on business.</td>
</tr>
<tr>
<td>renewal</td>
<td>2) Also easy to suppress maintenance costs</td>
<td>2) Simultaneous renewal also renews still usable equipment.</td>
</tr>
<tr>
<td></td>
<td>3) Installment of the same equipment throughout the line increases the usability of passengers.</td>
<td></td>
</tr>
<tr>
<td>Separate</td>
<td>4) Renewing individual equipment separately is effective to suppress investment value.</td>
<td>3) Smaller procurement quantity makes a unit purchase price higher.</td>
</tr>
<tr>
<td>renewal</td>
<td>5) Fixed costs decrease because of individual renewal judgment and possibility of using equipment until the end of its life.</td>
<td>4) Mixture of different generation equipment increases management costs due to the diversification of service parts.</td>
</tr>
</tbody>
</table>
Appendix 8-6-7-3-B(A)  
Rules for Criteria on the Number of Installed Equipment

1. The most important factor in determining the number of installed AFC equipment is for passengers to be able to safely and comfortably use urban railways utilizing AFC equipment. The following parameters are essential to ensure safe and comfortable railway use:
   (1) Number of passengers using AFC equipment
   (2) Time for AFC use

   Knowing these parameters enables determining the number of installed AFC equipment referring to equipment performance.

2. Calculation of the number of passengers using AFC equipment
   (1) The number of passengers using AFC equipment is a total of passengers coming to stations to take a train and arriving at stations to leave a train and go out of the station. Since a majority of passengers using urban railways are commuters, they tend to concentrate in stations during the morning and evening commuting time, or so called rush hours. The number of passengers reaches a peak during the commuting time, which is sometimes called peak time. AFC equipment must have a capacity to handle passengers in a safe and comfortable way during the peak time.
   (2) Train operation schedules also affect the number of passengers during peak time significantly. The number of passengers at the time of departure and arrival changes greatly depending on the operation intervals and sets of trains. In the case of train sets with a large number of vehicles, the peak numbers of arriving passengers tend to be larger than those in the case with a small number of vehicles, even when the operation intervals of the former is longer than those of the latter. When calculating the number of passengers, it is essential to clarify the peak numbers of passengers referring to train operation schedules, in addition to the daily number of passengers using stations.
   (3) Time for AFC use

   Time for AFC use means the time needed for processing when a passenger uses a ticket gate or an automatic ticket vending machine. For example, if we assume that the processing time of a ticket gate is 2 seconds per passenger, the gate can check the IC tickets of 30 passengers per minute. Knowing peak time periods and the number of passengers to be handled, the necessary number of ticket gates can be calculated based on the processing capacity of the ticket gate. Beside the processing ability of the equipment itself, the degrees of proficiency of passengers for using the equipment and variation in their walking speeds also affect overall processing capacity. Collecting necessary data based on the above consideration enables the
calculation for ticket gates. Automatic ticket vending machines and the processing at windows require different concepts. For example, the time needed for processing a passenger using an automatic ticket vending machine, the number of passengers per minute seeking to use the machine, and resultant average waiting time should be clarified. This kind of questions is known as a “queuing problem,” and solved using an M/M/n model. In this case, the waiting time becomes infinite unless the average utilization rate is 1.0 or less, resulting in filling the station yard with passengers. The numbers of installed equipment and windows must therefore be determined to make the average utilization rate sufficiently smaller than 1.0. The M/M/n model expresses the above as follows:

\[
\text{Average utilization rate} (\rho) = \frac{\lambda}{\mu \times N} \]

Average number of waiting passengers = \( \frac{\rho}{1 - \rho} \)

Average waiting time \( T_w = T_s \times \frac{\rho}{1 - \rho} \)

where,

N: Number of installed equipment (number of windows)
\( \lambda \): Average arrival rate (number of arriving passengers per unit time)
\( \mu \): Average service rate (number of passengers handled per unit time)
\( T_s \): Time used for a passenger

The average arrival time is, for example, means the figure of the number of passengers coming to the automatic ticket vending machine for taking a train at the station divided by the peak time duration. The average service rate means the number of passengers processed by the automatic ticket vending machine per unit time, and depends on equipment performance. The time used for a passenger (\( T_s \)) means the time needed for a passenger to purchase an IC ticket using the automatic ticket vending machine.

As an example, we assume that 12,000 passengers come to a station during one hour of peak time, and 50% of them use automatic ticket vending machines to purchase a single ticket. Assuming that the machine can process 240 persons/hour (15 seconds/person), the following expression must hold:
\[ \rho = \frac{6000}{240 \times N} \ll 1 \]

We can then conclude from the following that the number of required equipment is larger than 25.

\[ N \gg \frac{6000}{240} = 25 \]

Incidentally, we can also solve the problem as shown below. We assume that a number of P (persons) passengers come to the station during peak time, and that they can commute on time if the operation schedule is developed to transport the passengers within this time duration. For that purpose, N units of automatic ticket vending machines must perform processing at the speed below.

\[ N = \frac{P}{S} \]

*P* is the number of passengers coming to the station in 1 hour.  
*S* is the number of passengers processed per hour

Using the previous example and assuming that \( P = 6000 \) persons /hour, and \( S = 240 \) persons, we can obtain the result below, which is the same as that based on the queuing theory.

\[ N = \frac{6000}{240} = 25 \text{ (units)} \]

It must be noted here that the operation specifications of IC train tickets also affect the necessary number of equipment. For example, operation specifications require selling a single ticket with a deposit. In this case, passengers need to receive the deposit when arriving at their destination stations. Since automatic ticket vending machines or windows pay back deposits, the number of passengers coming to the machines or window increases compared to the case with no deposit, resulting in the increased number of installed AFC equipment.

3. Number of Installed AFC Equipment

Using the data collected following the concepts described in the previous sections (2) and (3) enables the calculation of the number of installed equipment. The following must be considered before finally determining the number of installed equipment:

(1) Consideration to disabled persons
Wheel chairs cannot pass the passage widths of standard type ticket gates. From a barrier-free viewpoint, at least one wide type ticket gate should be installed at a station gate.

(2) Consideration of backups

In the case of small stations and station gates where a small number of passengers is predicted, calculation of the necessary number of installed ticket gates may give the result that one unit is enough for each station gate. This result is, however, not appropriate because passengers cannot go in or out of the station if the equipment fails. The station needs to provide at least one passage even during failure time. In this case, therefore, the station needs to add one unit for entering and one for exiting, respectively.

(3) Reduction of the number of installed equipment using bidirectional ticket gates

For example, in the case of terminal stations, the number of passengers taking a train in the morning commuting time may be overwhelmingly larger than that leaving the train.

On the contrary, in the evening commuting time, the number of passengers leaving a train may be overwhelmingly larger than that taking the train. Handling such movement of passengers with one-way ticket gates (which can handle only one direction of passengers: entering or exiting) is not desirable from the viewpoint of the effective utilization of equipment, because most of exiting ticket gates are not used in the morning, and vice versa in the evening.

In such cases, installing bidirectional ticket gates, and setting a necessary number of them for entering in the morning and vice versa in the evening enables effective use of equipment.

The results of analyzing the movement of entering and exiting passengers by time duration must therefore be reflected in determining the number of installed equipment.

(4) Reduction of the number of installed equipment using multifunctional equipment

A minimum number of automatic ticket vending machines or add value machines would be satisfactory for small stations with a small number of passengers (backups are needed). In such cases, installing multifunctional AFC equipment with both functions of an automatic ticket vending machine and an add value machine would be better to reduce the number of installed equipment and save investment and maintenance costs and installation spaces than installing single function AFC equipment.
4. Number of installed equipment of Line 2A

When detailed data on the number of passengers of Line 2A and the processing capacity of AFC equipment are obtained; we will handle this issue for the training of practical calculation methods.

Appendix 8-6-7-3-C (A) Approach for formulating an equipment replacement plan

The AFC equipment is electronic machine equipment that is controlled electronically and equipped with plenty of electronic parts such as capacitors, resistors, semiconductor parts, switches, and batteries.

Service lives of these electronic parts are about 10 years, making the operating life of the AFC equipment shorter than that of other railway facilities. In addition, electronic technology advances significantly fast enough to allow the evolution to better facilities with higher cost-effectiveness. Therefore, it is necessary to keep an eye on technical trends in equipment replacement and proceed in a systematic manner

1. An equipment replacement plan should be formulated from a mid- and long-term viewpoint.

It should be prepared in line with the background above stated, taking into consideration the following points:

(1) Measures against failures in an early period after equipment installation and for quality improvement.

(2) The measure for quality improvement should be introduced into the equipment during an overhaul period after verification of its effectiveness.

(3) Planned replacement of aged parts that will be needed in the latter period of the equipment service life.

(4) Systematic promotion of equipment replacement that should be carried out after its service life is over (to be completed in one to two years).

1) If replacement is implemented in a short period of time, it would cause pressure on management due to a huge investment required in the short period.

2) However, if replacement is implemented over a long period of time, maintenance is required for both new and old types of facilities, resulting in higher maintenance costs.

2. An example of formulation of a plan is shown in Table 6-7-29 below:
### Table 6-7-29 Formulation of an equipment replacement plan

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Phase of Equipment</th>
<th>Quality Improvement Measures</th>
<th>Measures against Aging</th>
<th>Replacement with new equipment for the next term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period of initial failure occurrence/Period for equipment quality improvement</td>
<td>Defects liability period (subject to contract conditions)</td>
<td>Period of equipment aging/Period for studying next-generation equipment</td>
<td>Period for equipment replacement</td>
</tr>
<tr>
<td></td>
<td>Stable period/Check period</td>
<td>Period for paid maintenance (subject to contract conditions)</td>
<td>Period for paid maintenance (subject to contract conditions)</td>
<td></td>
</tr>
</tbody>
</table>

#### Quality Improvement Measures

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Items to be improved (example)</th>
<th>Measure against the problem of rapid wear on the shafts and frequent malfunctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic ticket gate</td>
<td>IC card verification software bugs</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
<tr>
<td></td>
<td>Malfunctions occur frequently at movable parts of the door and the ticket collection unit.</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
<tr>
<td></td>
<td>Aging proceeds rapidly at movable parts of the door and the ticket collection unit.</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
<tr>
<td></td>
<td>Sensors malfunction often.</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
<tr>
<td></td>
<td>Prone to corrosion.</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
<tr>
<td></td>
<td>Door materials are vulnerable and easy to break.</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
<tr>
<td></td>
<td>Structure making the maintenance work difficult.</td>
<td>▲ Measure against the problem of rapid wear on the shafts and frequent malfunctions ▲</td>
</tr>
</tbody>
</table>

#### Measures against Aging

<table>
<thead>
<tr>
<th>Failure causes</th>
<th>Period for replacement of aged parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failures tend to occur more frequently as each piece of equipment gets closer to the end of its service life. It is necessary to analyze failure information and formulate a replacement plan. E.g., Aging of the batteries mounted in the electronic circuits.</td>
<td>Planning and implementation of replacement plans (planning, performance and costs) for equipment for the next term.</td>
</tr>
</tbody>
</table>

#### Replacement with new equipment for the next term

<table>
<thead>
<tr>
<th>Requirements for equipment for the next term</th>
<th>Development and trial production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factory test</td>
</tr>
</tbody>
</table>

---

**Table continues with details on various equipment and their maintenance plans.**
Appendix 8-6-7-3-D(A) Concept of developing the standard for the number of AFC equipment installations

1. Basic concept of developing the standard for the number of installations

   The automatic fare collection (AFC) equipment is used to allow passengers to purchase train tickets and pass ticket gates, thus is deeply related to the safety and convenience of passengers. Accordingly, it is an underlying principle to emphasize these two aspects when determining the number of installations.

2. Method for determining the number of AFC equipment installations

   The AFC system are usually classified into six levels, as shown in the following figure, each of which has a different concept of determining the number of installations.

   ![Fig. 6-7-19 Structure and facilities of the AFC system](image-url)

   (1) **Level-5**

   A system to process data of multiple transportation operators. It is not under the jurisdiction of Hanoi Metro, and thus it is not covered in this study.

   (2) **Level-4 to Level-3**

   1) Computer systems for data processing and communication, consisting of the main bodies of computers, storage devices, workstations for operation, local area network facilities, and so on.

   2) Their system configuration is decided based on necessary processing capacity, memory capacity, etc. To secure their continued operation even at the time of failure or maintenance, multiplexing of equipment and other methods are adopted. However, basically, each system is handled independently, and usually only one system is installed.

   3) A business operator server at Level-4 influences the whole route if it fails to operate properly. For this reason, equivalent systems are sometimes built in two or more bases to allow for sustain functions of the business operator server even if a flood, a fire, or any
other disaster inflicts catastrophic damage on facilities. However, as it requires huge expenses, such measures should be judged before implementation in terms of risks and costs.

(3) Level-2

A station server is a computer system installed in each station to monitor ticket gates, ticket machines, and other station facilities, collect and process data from station facilities, distribute “Blacklist” data to the station facilities, and so on. If the number of passengers is extremely small and an amount of data to be processed is small in a station, a station server may not be installed there; instead, the station may be connected with a station server in another station. However, basically one system is installed in each station.

(4) Level-1

Station facilities include ticket gates, ticket machines, ticket office machines, and so on. Because the number of these machines installed is directly related to the safety and convenience of passengers, the number is usually determined based on the concepts described below:

1) Automatic ticket gate (AG)
   a. Basic concepts
      The number of installations should be determined to allow passengers to swiftly enter and exit from stations.
      In urban railways, passengers cannot enter or exit from station premises unless their IC tickets are verified at ticket gates. It means that if the processing capacity of the ticket gates is low, the station premises would be crowded with passengers who get off the train and, in the worst case, platforms would also be filled with passengers, which might cause accidents such as passenger’s contact with a train. In addition, under such conditions, passengers who have bought tickets and try to get on a train might miss the train. For this reason, it is important to have passengers swiftly enter and exit from station premises.
   b. Method for determining the number of installations (one example)
      i. In urban railways, students and workers who commute by train account for a large percentage of all the passengers. Accordingly, passengers are more likely to concentrate at morning and evening commuting times. Ticket gates need to have ticket processing capacity large enough to cope with passengers concentrated at peak times.
      ii. Obtain the number of passengers who enter the station premises (α) and the number of passengers who exit from the station premises (β) at peak
times for each station with reference to transportation plans and data on the number of passengers.

iii. Determine the processing capacity ($\lambda$) per ticket gate. At this step, it is necessary to regard as the ticket gate capacity the processing capacity obtained by subtracting a degree of passengers’ proficiency in dealing with ticket gates from the processing capacity of each ticket gate. In the cases, such as in Vietnam, where most passengers are going to use ticket gates for the first time, this subtracted number must be set large. With the number of installations $N$, the numbers of ticket gates for exiting from the station premises and for entering them are determined as below:

$$
N \text{ (the number of ticket gates for exiting)} = \alpha \div \lambda \\
N \text{ (the number of ticket gates for entering)} = \beta \div \lambda
$$

Where, if $N$ is smaller than 2 ($N < 2$), the value of $N$ should be regarded as 2 ($N = 2$).

The reason why $N$ should be equal to or larger than 2 is that if $N$ is one ($N = 1$), there is no checking tickets when the ticket gate malfunctions.

In addition, usually one special ticket gate with a wider path should be installed per entrance and per exit to handle passengers using wheelchairs or carrying large baggage.

c. Control measures on the number of installations

There may be a case where a trend of passengers varies greatly depending on hours (e.g., many passengers board the train at peak times in the morning, while many passengers get off the train at peak times in the evening. In such a case, by installing dual-purpose machines applicable to both entering and exiting passengers and using them for entering in the morning and for exiting in the evening, the total number of ticket gates installed can be reduced.

However, for some time after the operation is launched, it is not easy to grasp a trend of passengers’ behaviors, so that it is desirable to make a study of these measures when increasing the number of ticket gates or replacing related facilities.

2) Automatic ticket vending machine (TVM), automatic add value machine (AVM), ticket office machine (TOM), etc.

a. Basic concepts
The time for passengers to wait in line should be considered as an index to measure convenience of passengers. And then, the maximum passenger waiting time should be set, and the number of installations should be determined so as not to exceed this time. Even at peak times, the number of installations must be determined so that passengers can buy IC tickets or charge their IC cards within this maximum waiting time.

b. Method for determining the number of installations (one example)

i. Method

As a means to determine the number of installations based on the maximum waiting time, there is a method of using the queuing theory. Here, the M/M/1 model is explained as an example. Though the M/M/1 model is used when only one machine is used, it can be applied to the case with two or more machines on the assumption that passengers wait in a separate queue respectively. Among calculation models using the queuing theory, there is the M/M/S model that can be applied to the case where two or more (S) machines are installed but passengers wait in a single queue. It is very complicated to make calculations in this model, which requires calculations using computers. Since it is difficult to control how passenger form queues, it would be useful to make a comparison among two or more models.

ii. M/M/1 model and calculation

\[ N : \text{the number of machines to be installed} \]
\[ \mu : \text{the average service rate (the number of persons that can be processed in a unit time)} \]
\[ T_s : \text{the time needed to process one passenger} \]
\[ T_w : \text{average waiting time in queue} \]
\[ T : \text{total average waiting time to complete process} \]
\[ \gamma : \text{the average arrival rate (the number of passengers who arrive in a unit time)} \]
\[ \rho : \text{the average utilization rate (a rate of machines that are used)} \]

Average utilization rate: \[ \rho = \frac{\gamma}{\mu} \]

Average waiting time: \[ T = T_w + T_s = T_s \times \left( \frac{\rho}{1 - \rho} + 1 \right) \]

If the number of machines set up in a row is N and independent queues are formed for each machine as above stated, the arrival rate per queue
is between $\gamma$ and $\frac{\gamma}{N}$, and the average utilization rate is determined as below:

$$\rho = \frac{\gamma}{N \times \mu}$$

Now estimate the N using the above. For example, if 60 passengers arrive per minute (\(\gamma\)) and a machine can handle three passengers per minute (\(\mu\); Ts=20 sec), the corresponding number of machines is calculated as 21.4 with the maximum passenger waiting time of 5 minutes, as shown below. Through rounding up, the number of installations is determined as 22.

$$N = \frac{\gamma \times T}{\mu \times (T - Ts)} = \frac{60 \text{person/min.} \times 300 \text{sec}}{3 \text{person/min.} \times (300 \text{sec} - 20 \text{sec})} = 21.4$$

iii. Relation between the operation method of IC tickets and the number of machines

Here attention should be paid to the fact that the operation specifications of IC tickets have an influence on the necessary number of machines. For example, when single journey tickets (SJTs) are sold with deposits included, passengers use automatic ticket vending machines or come to the ticket office for a refund of the deposits. Therefore, in this case, more passengers use automatic ticket vending machines or the ticket office than in the case where deposits are required. As a result, the number of required AFC machines will be increased.

iv. Control of the number of installations by use of multifunctional machines

When installing machines with multiple functions, specifically the dual functions of an automatic ticket vending machine and an add value machine, instead of a single-function type of AFC machines, a per-unit cost increases. However, in most cases, it can reduce the number of installations, the amount of investments, maintenance costs, and the installation space.

So, it is thought that this is an issue to be studied when replacing the machines after data related to a trend of activities of passengers are accumulated following the launch of operation.

(5) Other equipment and facilities

In addition to the above stated machines, the AFC system includes the equipment to issue IC tickets and facilities to provide education and training for staff.
1) Equipment to issue IC tickets
   It consists of the IC card initializer, the registered-ticket face printer, the
   controller of these machines and so on.
   The number of installations of each machine is determined by dividing the number
   of IC tickets needed monthly by the processing capacity of each machine.
   However, because the issuance of IC tickets cannot be stopped even when the
   machines fail, backup machines should be prepared.

2) Facilities for education and training of staff
   These facilities are used to educate and train staff about operation of the AFC
   system. It is necessary to implement functions of the AFC equipment at Level-1 to
   Level-4. If the actual AFC system is used for training, there will be a risk of
   causing a trouble due to erroneous operations. Therefore, a separate system is
   necessary. But, if all the machines are installed, the cost burden will increase.
   Accordingly, there is an option to install station facilities and station servers of the
   minimum structure for two stations and emulate facilities at Level-3 and Level-4
   on the servers.
Appendix 8-6-7-4-A(A) Learning of Measures to Prevent Equipment Failures (AFC)

(Including formulation of the equipment operation safety manual that covers response actions to accidents)

It is often thought that realization of safe and highly reliable equipment, where failures seldom occur, is work that falls into a category of maintenance and preservation.

However, if material without good corrosion resistance is used as metallic material for chassis of equipment, it soon gathers rust on it in such an environment with high temperature and high humidity as Vietnam. Furthermore, as equipment such as automatic ticket gates are installed at places where many passengers come and go, they are exposed to not only dusts but also wind and rain depending on an installation environment. Without drip-proof and dust-proof design, it is difficult to reduce failures no matter how much efforts are made for maintenance and preservation.

As stated above, it can be understood that parties concerned must start their efforts from the phase of making the concept and design of equipment in order to realize equipment with safety and high reliability. On the other hand, it is important for staff to operate equipment in a correct and safe manner in order to prevent failures and realize highly reliable operation. It requires efforts with a focus on “human beings.”

Figure 6-7-20 indicates that efforts with a focus on “equipment” and “human resources” are an element for realizing equipment that is safe and highly reliable as discussed above.

![Figure 6-7-20 Elements for realizing safe and highly reliable equipment](image)

1. Efforts with a focus on equipment

1.1. Introduction of international standards

International standards related to safety and reliability are specified in a detailed manner according to usage of equipment. These standards prescribe contents internationally accepted as requirements for safety and reliability. Therefore, by introducing these standards requirements for equipment can be met.
Also, as a secondary effect of introduction of the standards, it can be easily confirmed if equipment meets appropriate requirements by defining the introduced standards. However, in most cases, provisions mentioned in standards are performance provisions that specify capability and performance to be fulfilled by equipment but not specification provisions. Unlike specification provisions, performance provisions do not uniquely define the design of equipment but allows various types of design even if they are based on the same standards. Therefore, it should be noted that if only adequate standards are applied, they cannot decide a level of safety and reliability of equipment. It should be noted that it is necessary to inspect and assess what design is made based on standards and whether target levels are met by safety and reliability that can be achieved by the design.

Incidentally, there are many standards concerning reliability and safety. Therefore, attention should be paid to a necessity of choosing and adopting standards by fully examining a particular field, usage, and other conditions of target equipment.

As shown in Figure 6-7-21, there are categories in standards related to reliability and safety of electromechanical system equipment. These categories are called (i) the basic safety standard that defines basic principles, (ii) the group safety standard applicable to a wide range of equipment regardless of fields, and (iii) the safety standard for each field that defines standards for specific fields.

i. Basic safety standards
   This standard prescribes basic concepts and design principles. It is also called the A Standard.

ii. Group safety standards
    This standard is related to safety, safety-related devices, etc. regardless of usage of equipment. Most of contents for mechanical systems are defined in ISO, and contents for electrical systems are defined in IEC. It is also called the B Standard.

iii. Safety standards for each field
     Because requirements to be met are different in each application (field) of equipment, a standard for each field is defined. In the railway field, the standard known as Railway RAMS falls into this category. It is also called the C Standard.

iv. Quality management standards
    This standard is related to quality management. A higher level of quality management
should be implemented in order to carry out design, development, manufacturing, installation, and operation of equipment with introduction of standards ranging from the basic safety standard to the safety standard for each field.

v. Ergonomics standards
   This is a standard based on ergonomics to prevent a mental load imposed on persons in charge of equipment from excessively increasing.

Table 6-7-30 lists international standards related to AFC, according to categories above mentioned. Incidentally, it should be noted that it does not covers all the standards, and specifically it does not indicate domestic laws, standards, and rules of Vietnam. Therefore, applicable standards must be selected by collecting the latest information.
Table 6-7-30 Examples of international standards related to reliability and safety of equipment

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<td>IEC Guide 104</td>
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<td>Insulation coordination for equipment within low-voltage systems - ALL PARTS</td>
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<td>Protection against electric shock - Common aspects for installation and equipment</td>
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<td>IEC 61508</td>
<td>Functional safety of electrical/electronic/programmable electronic safety-related systems</td>
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|                                | ISO 14123             | Safety of machinery -- Reduction of risks to health from hazardous substances emitted by machinery –  
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|                                | ISO 14159             | Safety of machinery -- Hygiene requirements for the design of machinery                                                                                                                                 |
|                                | ISO/TR 23849          | Guidance on the application of ISO 13849-1 and IEC 62061 in the design of safety-related control systems for machinery                                                                                       |
| Group safety standards         | IEC 13850             | Safety of machinery - Emergency stop - Principles for design                                                                                                                                                  |
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<td></td>
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<td>- Immunity limits (insofar as they do not fall under the responsibility of product committees)</td>
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<td></td>
<td>Part 4: Testing and measurement techniques</td>
<td>- Measurement techniques</td>
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<td>- Testing techniques</td>
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<td></td>
<td>Part 5: Installation and mitigation guidelines</td>
<td>- Installation guidelines</td>
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<td></td>
<td></td>
<td>- Mitigation methods and devices</td>
</tr>
<tr>
<td>Category</td>
<td>Standard No.</td>
<td>Scope of application</td>
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</table>
|          |             | Part 6: Generic standards  
|          |             | Part 9: Miscellaneous  
|          | IEC 61310  | Safety of machinery - Indication, marking and actuation –  
|          |             | Part 1: Requirements for visual, acoustic and tactile signals  
|          |             | Part 2: Requirements for marking  
|          |             | Part 3: Requirements for the location and operation of actuators  
|          | IEC 61496  | Safety of machinery - Electro-sensitive protective equipment –  
|          |             | Part 1: General requirements and tests  
|          |             | Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)  
|          |             | Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)  
|          |             | Part 4: Particular requirements for equipment using vision based protective devices (VBPD)  
|          | IEC 62046  | Safety of machinery - Application of protective equipment to detect the presence of persons  
|          | IEC 62061  | Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems  
|          | IEC 62513  | Safety of machinery - Guidelines for the use of communication systems in safety-related applications  
|          | IEC 61508  | Functional safety of electrical/electronic/programmable electronic safety-related systems  
|          |             | Part 1: General requirements  
|          |             | Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems  

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<thead>
<tr>
<th>Category</th>
<th>Standard No.</th>
<th>Scope of application</th>
</tr>
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<td></td>
<td>Part 3: Software requirements</td>
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<td>Part 4: Definitions and abbreviations</td>
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<td>Part 5: Examples of methods for the determination of safety integrity levels</td>
</tr>
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<td>Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3</td>
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<td>Part 7: Overview of techniques and measures</td>
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<td>IEC 60947</td>
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<td>Low-voltage switchgear and control gear –</td>
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<td>Part 1: General rules</td>
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<td></td>
<td>Part 2: Circuit-breakers</td>
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<td></td>
<td></td>
<td>Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units</td>
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<td>Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices</td>
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<td></td>
<td></td>
<td>Part 5-5: Control circuit devices and switching elements - Electrical emergency stop device with mechanical latching function</td>
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<td></td>
<td>Part 5-8: Control circuit devices and switching elements - Three-position enabling switches</td>
</tr>
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<td>Safety standards for each field (railway equipment)</td>
<td>IEC 62278</td>
<td>Railway applications - Specification and demonstration of reliability, availability, maintainability and safety (RAMS)</td>
</tr>
<tr>
<td></td>
<td>IEC 62278-3</td>
<td>Part 3: Guide to the application of IEC 62278 for rolling stock RAM</td>
</tr>
<tr>
<td></td>
<td>IEC 62279</td>
<td>Railway applications - Communications, signaling and processing systems - Software for railway control and protection systems</td>
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<tr>
<td></td>
<td>IEC 62425</td>
<td>Railway applications - Communication, signaling and processing systems - Safety related electronic systems for signaling</td>
</tr>
<tr>
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<td>Standard No.</td>
<td>Scope of application</td>
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<td>Quality management standards</td>
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<td>ISO 9001</td>
<td>Quality management systems -- Requirements</td>
</tr>
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<td></td>
<td>ISO 9004</td>
<td>Managing for the sustained success of an organization -- A quality management approach</td>
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</table>
| Ergonomics standards (related to mental workloads) | ISO 10075    | Ergonomic principles related to mental work-load --  
Part 1: General terms and definitions  
Part 2: Design principles  
Part 3: Principles and requirements concerning methods for measuring and assessing mental workload |
1.2. Individual mechanical safety standards in the railway sector (Railway RAMS)

Railway equipment is directly linked with safety of passengers, and railways are important social infrastructures that support social activities. Accordingly, it is requested to achieve a high level of safety and reliability. For this reason, each country has specified mechanisms and systems to achieve and maintain reliability and safety of railway equipment.

The safety standard for each field related to railway equipment consists of IEC 62278, IEC 62278-3, IEC 62279, and IEC 62425, as shown in Table 6-7-30 of the preceding Section. Among them, IEC 62278 occupies a key position.

These standards define a scheme called Railway RAMS, and it is thought that elements indicated in Figure 6-7-22 have influences on Reliability, Availability, Maintainability and Security. It is subject to an idea that reliability and safety of equipment are attained through integration of features of constituent elements.

In Railway RAMS, with a focus on these constituent elements through equipment life cycles, efforts to control RAMS indexes (reliability and safety) of equipment are pursued by implementing the following processes.

i. Classify equipment life cycles into phases.

ii. Categorize equipment into constituent elements (subsystems and constituent parts).

iii. Index RAMS targets at each phase of a life cycle of each constituent element.

iv. Proceed with phases of a life cycle while demonstrating fulfillment of required items.

As shown in Table 6-7-31, a life cycle consists of 14 phases. To set RAMS targets, a fault tree analysis (FTA) and a hazard analysis are performed for clarification of processes. And, it follows a scheme where third parties evaluate target setting, implementation details and results so as to objectively assess their adequacy.

In most cases, countries newly starting to develop urban railways have not enough accumulation of domestic technologies and human resources with good experiences. In such a case, they have to introduce technologies from abroad.

Generally speaking, knowledge such as technology assets and experiences is divided into (i) formal knowledge, explicitly indicated in documents, graphic charts, mathematical expressions, and so on, and (ii) implicit knowledge such as experiences and intuitions that cannot be explicitly indicated. It is easier to handle formal knowledge in the transfer of knowledge. It goes the same way when introducing technologies to establish reliability
and safety in railways; the more technological knowledge is in the form of formal knowledge, the easier to transfer.

The basis of Railway RAMS is indexing of targets, clarification of processes, and work based on documents. It also defines processes for evaluation and assessment by third parties. In addition, due to the background stated above, there are an increasing number of cases of adopting Railway RAMS in countries starting to newly construct railways.
Fig. 6-7-22 Elements that influence Railway RAMS
Table 6-7-31 Definition of life cycle in RAMS

<table>
<thead>
<tr>
<th>No.</th>
<th>Each phase of a life cycle</th>
<th>Objective of each phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concept</td>
<td>Definition of system objectives and scope of tasks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Define the system's mission and features, the scope of hazard analysis, RAMS policies, objectives, operation, maintenance policies, and interfaces with other systems, a safety plan, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Define the scope of the target system. (Define the boundary.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Define impact conditions on the target system that influence features of the system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. Define the scope of a hazard analysis of the system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e. Define the RAMS policy concerning the target system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f. Formulate a safety plan (*) of the target system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(*) A safety plan is a plan document with descriptions of milestones and implementation items along with a time axis so as to set up an organization, an accountability system, work procedures, implementation contents, and response capability for the purpose of making target equipment ensure safety requirement items specified in a prescribed contract or project.</td>
</tr>
<tr>
<td>2</td>
<td>System definition and applicable conditions</td>
<td>Perform a hazard analysis and a risk assessment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Specify hazards related to the target system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Specify events that may lead to occurrence of a hazard.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Identify risks accompanying hazards.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. Setup a process to continuously control risks.</td>
</tr>
<tr>
<td>3</td>
<td>Risk analysis</td>
<td>For the whole target system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Clarify RAMS requirement items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Define RAMS demonstration acceptance criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Make up a RAMS program to manage RAMS work to be conducted at each phase in the successive life cycles.</td>
</tr>
<tr>
<td>4</td>
<td>System requirement items</td>
<td>a. Allocate the items to prescribed subsystems, constituent parts, and external equipment, and define the RAMS acceptance criteria for prescribed subsystems, constituent parts, and external equipment.</td>
</tr>
<tr>
<td>5</td>
<td>Allocation of system requirement items</td>
<td>For RAMS requirement items of the whole target system,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Allocate the items to prescribed subsystems, constituent parts, and external equipment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Define the RAMS acceptance criteria for prescribed subsystems, constituent parts, and external equipment.</td>
</tr>
<tr>
<td>6</td>
<td>Design and implementation of a RAMS plan</td>
<td>a. Make subsystems and constituent parts that conform to RAMS requirement items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Demonstrate that the subsystems and the constituent parts meet the RAMS requirement items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Make a plan relating to RAMS for the next phase of the life cycle.</td>
</tr>
<tr>
<td>7</td>
<td>Manufacturing</td>
<td>a. Manufacture subsystems and constituent parts whose conformance to RAMS has been demonstrated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Define methods of quality assurance and quality maintenance in manufacturing processes based on RAMS.</td>
</tr>
<tr>
<td>8</td>
<td>Installation</td>
<td>a. Assemble and install the target system using the subsystems and the constituent parts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Start a maintenance system for the target system.</td>
</tr>
<tr>
<td>9</td>
<td>Confirmation of system validity</td>
<td>a. Confirm conformity to the RAMS requirement items by activating the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Include a acceptance of safety and commissioning.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Confirm that the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined conforms to the comprehensive RAMS requirement items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. Start commissioning of the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e. Collect and assess data.</td>
</tr>
<tr>
<td>10</td>
<td>System acceptance</td>
<td>a. Activate the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined assess its conformance to the comprehensive RAMS requirement items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Accept the target system to start operation.</td>
</tr>
<tr>
<td>11</td>
<td>Operation and maintenance</td>
<td>a. Operate, maintain, and support (within a specified limit) in a manner to keep conformity of the combination of all the subsystems, the constituent parts, and external risk reduction means and the RAMS requirement items.</td>
</tr>
<tr>
<td>12</td>
<td>Monitoring of performance</td>
<td>a. Collect necessary information and data, and monitor the target system to ensure RAMS performance of the system is maintained.</td>
</tr>
<tr>
<td>13</td>
<td>Repair and replacement</td>
<td>Manage repair of the system and additional work so as to sustain the RAMS requirement items of the system.</td>
</tr>
<tr>
<td>14</td>
<td>Abolition and dismantling</td>
<td>a. Manage work for abolition and dismantling of the system.</td>
</tr>
</tbody>
</table>
1.3. Relation between the AFC equipment and Railway RAMS

As for Railway RAMS, in the phase 5 of the life cycle, safety functions are allocated to subsystems that constitute equipment and then levels (security integrity level; SIL) corresponding to their degrees of safety are set. This concept is based on IEC 61508.

IEC 61508 is a provision related to functional safety of electrical, electronic, and programmable electronic (E/E/PE) systems. The AFC equipment is E/E/PE-system equipment, so that it is within the scope of application of this standard. However, this standard is just a standard related to functional safety of E/E/PE systems, and thus the other constituent parts are out of the scope of application.

IEC 61508-1 (Part1) has two modes: the low-frequency demand mode of operation and the high-frequency demand mode of operation. And as shown in Table 6-7-32, it defines four levels of safety degrees in each mode (1 – 4). The low-frequency demand mode of operation is a mode where an operation demand of safety functions is issued only once or so per year. For example, life-saving automotive air-bags fall into this mode. The high-frequency demand mode of operation is a mode where such a demand is issued once or more per year. As for the AFC equipment, considering that it is equipment accessed by users from the start to the end of daily service without interruption, it can have an opportunity to activate safety functions once or more per year. Therefore, it seems appropriate to categorize it into the high-frequency demand mode.

A value given to each SIL is a probability of a failure in functional operation when a demand of operation of safety functions is issued. It is expressed with a failure per hour (FPH: /h) in the case of the high-frequency demand mode of operation. The following table includes SIL 0, though IEC 61508 has no description of SIL 0. It was added here for convenience in terms of safety, since it is intended to handle equipment with risk low enough to make setting of a security level unnecessary.

<table>
<thead>
<tr>
<th>Security Integrity Level (SIL)</th>
<th>Average frequency (per hour) of a failure of safety functions on the risk side</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Lower than $10^{-9}$/h to $10^{-8}$/h</td>
</tr>
<tr>
<td>3</td>
<td>Lower than $10^{-8}$/h to $10^{-7}$/h</td>
</tr>
<tr>
<td>2</td>
<td>Lower than $10^{-7}$/h to $10^{-6}$/h</td>
</tr>
<tr>
<td>1</td>
<td>Lower than $10^{-6}$/h to $10^{-5}$/h</td>
</tr>
<tr>
<td>0</td>
<td>$10^{-5}$/h or higher</td>
</tr>
</tbody>
</table>

To consider what security level the AFC equipment should achieve, an outline of a basic...
approach to safety and risk will be given with reference to ISO/IEC Guide 51 and IEC 61508.

Guide 51 defines that “Safety means being free from intolerable risk.” It is necessary to pay attention to the fact that Safety is assessed in its relation with risk, and risk exits even in a “Safe” state. This is a different point from the definition of “Safety” in general knowledge.

Figure 6-7-23 shows an approach to safety based on Guide 51 and IEC 61508. The safe region consists of the “acceptable risk” and “tolerable risk” regions.

i. “Acceptable risk”
   It is risk of a minor failure if it occurs or risk of a significant failure with extremely low possibility of occurrence. This region is considered unnecessary for measures to be taken for safety. But, there is a need to confirm that a risk remains within this region.

ii. “Tolerable risk”
   It is risk as low as reasonably practicable (ALARP) as shown in the above figure. Though there is a non-negligible risk, it is risk that is impossible to reduce or difficult to reduce due to cost-benefit performance, meaning it is risk in the level acceptable to current social standards. In other words, it is risk that is judged to be acceptable in consideration of the risk level and convenience.

In the AFC system, there is no denying a risk that a passenger has his/her body caught by the gate of an automatic ticket gate. However, a risk that becomes fatal to humans or causes severe impairment is extremely low, so that risks related to the AFC equipment are thought to be “acceptable risks.” And, in most cases, they are ranked as SIL0, and thus evaluation and assessment of their safety levels are not required.

One of the effective methods to decide SIL is the risk graph. In the risk graph, a risk is expressed as below:
Appendix 8-6-7-(A)

\[ R = f(C, F, P, W) \]

\( R \): Risk  \( f \): Function  \( F \): Exposure frequency and time to a danger
\( C \): Result after a dangerous event happens  \( P \): Possibility to avoid a danger
\( W \): Event probability of an undesired event

Where, \( C \), \( F \), \( P \), and \( W \) are called risk variables.

Table 6-7-33 Risk variables and risk elements

<table>
<thead>
<tr>
<th>Risk variable</th>
<th>Risk element</th>
<th>Meaning of element</th>
<th>Risk reduction request class</th>
<th>Safety integrity level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result after a dangerous event occurs</td>
<td>C1</td>
<td>Minor</td>
<td>*</td>
<td>No safety requirement items</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>Severe injury or death</td>
<td>a</td>
<td>No special safety requirement items</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>Multiple deaths</td>
<td>b, c</td>
<td>SIL 1</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>Many deaths</td>
<td>d</td>
<td>SIL 2</td>
</tr>
<tr>
<td>Exposure frequency and time to a danger</td>
<td>F1</td>
<td>Rarely to often</td>
<td>c, f</td>
<td>SIL 3</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>Frequently to permanently</td>
<td>g</td>
<td>SIL 4</td>
</tr>
<tr>
<td>Possibility to avoid a danger</td>
<td>P1</td>
<td>Possible depending on conditions</td>
<td>h</td>
<td>Insufficient only with E/E/PE safety-related measures</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>Almost impossible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event probability of an undesirable event</td>
<td>W1</td>
<td>Minute</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W2</td>
<td>A little</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W3</td>
<td>Relatively high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6-7-24 shows an example of application of the risk graph. Tables 6-7-33 and 6-7-34 show risk elements and risk mitigation requirement classes, respectively.

The AFC equipment is allocated to a category of SIL 0, “No safety requirement items,” when estimating its risk following this application example. However, this estimation is introduced here only to show how to use the risk graph with reference to the example. In reality, estimation must be made after reanalyzing risk elements.

[Example in case of the AFC equipment]

i. Result after a dangerous event occurs: A risk of damage at a level relevant to severe injury or death is negligibly small. Damage is inferred to be minor. ⇒ C1

ii. Event probability of an undesired event: Except for automatic ticket gates, there is almost no possibility for passengers to be damaged by equipment mechanisms. At automatic ticket gates, there is a fairly high frequency for passing passengers to be blocked by the gates. However, it is thought that a possibility is very low for passengers to fall down when blocked or be hurt when caught by the gates. It is presumed that the possibility is “a little.” ⇒ W2

Assuming “i” and “ii” as described above, the risk reduction requirement class is judged to be “*” from the risk graph. Accordingly, “No safety requirement items” is allocated to the AFC equipment.

In analyses as shown in the example, SIL 0 is often allocated to the AFC equipment. Then, there will be no need for management, verification, assessment, etc. based on methods specified in Railway RAMS such as IEC 62278. However, they are often applied as a means to manage the AFC equipment status, since they have features that make management easier through indexing the equipment status.
2. Efforts with a focus on human beings

The preceding Section described efforts to make equipment safe and highly reliable; in other word, efforts to realize safe equipment that never fails. This Section introduces efforts with a focus on human beings who operate equipment.

2.1. Regulations related to work safety

Regulations are a basis for performing work safely. In Japan, the following laws are prescribed. In Vietnam, it is necessary to investigate contents of similar laws and identify items that are related to business management of urban railways. After clarifying regulations, business rules and manuals should be developed so as to observe these laws and operate equipment safely.

i. Industrial Safety and Health Act

ii. Order for Enforcement of Industrial Safety and Health Act

iii. Ordinance for Enforcement of the Industrial Safety and Health Act

iv. Labor Standards Act

When applying laws or regulations, business structure should be broken down to each work unit, and a method of confirming existence of applicable laws to each constituent work should be adopted. And then, omission of the application can be prevented.

2.2. How to practice safety management work

Safety management of equipment is required for its safe operation. The most important concept here is that troubles (disasters) never occur to equipment despite risk and hazardous properties, if any, so long as human beings never involved. It can be better understood in the following example: “If a dangerous animal like a tiger exists, there is no risk of being hurt or damaged by the animal so long as a person is not present.” It is significantly different from the efforts with a focus on equipment discussed in the preceding Section, as those efforts do not pay attention to relation between “human beings” and equipment.

(1) System maintenance

Safety management work begins with maintenance of a management system. For this
-purpose, it is important for the top of an organization to demonstrate clearly his/her
determination. It is because safety management needs involvement of all business
divisions and these divisions need to proactively participate toward their objectives. In
efforts concerning the AFC equipment, it is important to formulate the structure as an
organization that can tackle safety management with involvement of all organizations
related to the AFC equipment.

(2) Business operation

Business is pursued in the following PDCA cycle.

1) Plan

Formulate a plan for safety management including the following items. Related
divisions are required to set their objectives and measure their achievement levels.

i. Safety vision

ii. Risk assessment and measures

iii. Objectives and implementation plans

2) Do

Implementation and operation. Each division should make an effort toward their
objects.

3) Check

Inspection. The achievement levels toward objectives and the methods for making
efforts should be inspected and recorded.

4) Action

Measures for improvement. Inspection results should be reviewed and reflected to the
formulation of a plan.

2.3. Risk assessment

The core of safety management is risk assessment. Risk assessment is an effort to develop a
structure that predicts danger by a systematic method and reduces the danger, without relying
on experiences and attention of individuals. Risk assessment consists of the following tasks.

(1) Identification of a target scope

The scope of risk assessment should be defined. For the AFC system, it covers from
station facilities such as automatic ticket gates installed in a station to operator servers that are upper level systems. Furthermore, there are a wide range of equipment types and operation locations, including stations, the headquarter office, the settlement division, the maintenance center, etc. It is necessary to define a target scope, such as “equipment operation in stations” or “work in the maintenance center.”

(2) Identification of hazard sources
Hazardous nature and hazardous properties should be identified by breaking down business into work units. In doing so, the following points should be noted.

1) It is necessary to conduct identification work with reference to work manuals and work procedures. If they are not prepared, their documentation is needed by writing down actual work contents for each work unit. This is because hazard sources exist in work manuals and work procedures themselves. Documentation is required to manual work contents to achieve safety assurance without relying on workers.

2) When identifying hazard sources, it must be conducted on the following premises: “Is there any risk in work? Equipment could fail; and human beings could make operation mistakes.”

(3) Estimation of risk
A risk estimation method begins with identification of hazard sources, degrees of damage caused by the hazard sources, and inference of a possibility of accessing or encountering the hazard sources.

1) Category of degrees of damage
Table 6-7-35 Division of degrees of damage (Example)

<table>
<thead>
<tr>
<th>Degree of damage</th>
<th>Category</th>
<th>Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>×</td>
<td>Death or a permanent physical disorder. Long-term absence from work, or many victims are involved.</td>
</tr>
<tr>
<td>Moderate</td>
<td>△</td>
<td>Short-term absence from work, or multiple victims are involved.</td>
</tr>
<tr>
<td>Mild</td>
<td>○</td>
<td>No absence from work, and a minor injury occurs</td>
</tr>
</tbody>
</table>

2) Category of possibility of accessing or encountering hazard sources
Table 6-7-36 Category of possibility of accessing or encountering hazard sources (Example)

<table>
<thead>
<tr>
<th>Degree of possibility</th>
<th>Category</th>
<th>Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>×</td>
<td>Accessing/encountering occurs frequently every day. Getting involved despite of substantial attention.</td>
</tr>
</tbody>
</table>
Possible  △ Accessing/encountering occurs in irregular work such as repair or adjustment of equipment. Getting involved when attention spans are lowered.

Very low  ○ No accessing/encountering in regular work. Not getting involved in a normal state.

3) Risk category

Table 6-7-37 Risk category (Example)

<table>
<thead>
<tr>
<th>Degree of risk</th>
<th>Category</th>
<th>Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unacceptable and grave</td>
<td>III</td>
<td>Grave enough to suspend work till countermeasures are taken. Immediate response should be taken with the highest priority.</td>
</tr>
<tr>
<td>To be swiftly reduced</td>
<td>II</td>
<td>It is desirable to suspend work till countermeasures are taken. Response should be taken preferentially.</td>
</tr>
<tr>
<td>To be reduced if possible</td>
<td>I</td>
<td>A degree that response is possible or response may as well be taken if it is necessary depending on the situation.</td>
</tr>
</tbody>
</table>

4) Estimation of risk

Table 6-7-38 Estimation of risk (Example)

<table>
<thead>
<tr>
<th>Possibility of accessing or encountering danger</th>
<th>Category</th>
<th>Degree of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Fatal</td>
<td>III</td>
</tr>
<tr>
<td>Possible</td>
<td>Moderate</td>
<td>III</td>
</tr>
<tr>
<td>Very low</td>
<td>Mild</td>
<td>II</td>
</tr>
</tbody>
</table>

2.4. Risk reduction measures

Risk reduction measures are taken along with priority decided in estimation of risk. The following approach is a basis for implementation of the measures.

(1) Implementation of items specified in laws

It is a requisite to observe laws.

(2) Essential countermeasures

It is a basis to take essential countermeasures to remove causes of risk, such as elimination of dangerous work.

(3) Engineering countermeasures

These countermeasures mean to take measures on equipment and reduce risk. For example, in order to prevent users from falling down or being caught by the gates of automatic ticket gates, a new method of closing the gates might be introduced, or material of the gates might be changed to a soft type. These measures fall into engineering countermeasures.

(4) Managerial countermeasures
These countermeasures mean to enhance the ability of “human beings” through education and training, or achieve safe work and operation by use of work manuals and workflows without relying on “human ability and experiences.” For example, in handling the AFC equipment, there is work to load a unit with cards into an automatic ticket machine or retrieve a unit with proceeds from the machine. Cards and money are valuables, and these units are heavy, therefore there may be risks of theft and injury if a unit drops. For this reason, it is necessary to realize safe work (and prevent equipment failure) by preparing work manuals and providing education and training so that work can be carried out in line with the manuals.

(5) Personal protection measures
These measures are intended, even in the worst case, to protect workers when they encounter a danger. For example, according to these measures, workers carrying heavy loads are requested to wear protective footwear and gloves.

2.5. Evaluation of performance
(1) Effects of risk assessment and risk reduction measures should be evaluated to verify whether risk is lowered as intended. Through this verification, adequacy of the risk assessment and the risk reduction measures is confirmed. If risk is not reduced as intended, necessary countermeasures should be taken, and at the same time residual risk should be made widely known to parties concerned.

(2) All of risk assessments, risk reduction measures, and their results must be documented for record keeping purposes. This is for the purpose of accumulating them as formal knowledge for application and avoiding repetition of similar events. To effectively use records, the following points should be noted, in addition to document management provisions of ISO 9001/ISO 9002.

1) Keep records in an identifiable and traceable state.

2) Standardize procedures concerning records.

• Identification of records: forms and record names
• Storage: divisions, places, and persons in charge
• Protection: a rule to prevent damage, taint, degradation and loss
• Confidentiality: confidentiality levels (disclosed, internal use only, confidential, strictly confidential) and handling rules
• Search: filing and indexing methods
• Retention period: a rule concerning retention period
• Disposal: a rule on procedures for waste disposal (disposal methods and procedures for approval of disposal)

2.6. Other important efforts

(1) Review by division heads

Division heads should confirm that safety management activities (risk management activities) are properly conducted in their own divisions and these activities are effective. With this confirmation, division heads can grasp, on their own initiatives, details of those activities, and it is confirmed in the divisions that safety management activities are efforts the division heads commit themselves to.

(2) Accident prediction training

In general, there exists residual danger. Accident prediction training is an activity to make staff find, grasp (understand), and solve a danger, so that their sensitivity to danger is enhanced, their ability to solve problems is improved, and that they can prevent occurrence of accidents. In Japan, it is called “Kiken Yochi Training (KYT).” In English, they call it “Accident Prediction Training.” As a well-known implementation method, there is the basic 4 R method where problem solution is tried through the following rounds:

1) Grasping the present situation: What danger hides?
2) Pursuing the nature: This is a point of danger!
3) Establishing countermeasures: What will you do?
4) Target setting: We will do this way.

3 Safety rules

In order to pursue safe work without accidents through standardization of work but without largely relying on individual ability and experiences of “human beings,” it is necessary to prepare documented rules and manuals concerning safety.

An example of a structure of a safety rule considered to be related to the AFC equipment is presented below. Though the AFC equipment is not yet used in Vietnam, it is electromechanical equipment and also E/E/PE equipment. It is important to do the research about laws and safety
rules related to electromechanical equipment and E/E/PE equipment in Vietnam and develop rules and manuals with reference to them.

3.1 General matters

(1) General instruction to staff

Specify the most basic instructions to staff, including orderly disposition (seiri in Japanese [hereinafter the same]), tidying (seiton), cleaning (seiso), cleanliness (seiketsu), and discipline (shitsuke; behavior) that are so-called 5S in Japanese.

(2) Restrictions on engagement

Specify work, such as those requiring qualifications, which staff other than those designated by a head of an organization cannot be engaged in.

(3) Work to accommodate new workers

Specify procedures for allocating new workers to maintenance work and the like. Also include registration and education for safe operation.

(4) Orderly disposition and tidying

Provide specific rules in terms of orderly disposition and tidying in maintenance of workplaces and so on. Also include how to place articles, a means to prevent overturning of high-pressure vessels, sorting and storing of hazardous chemical substances, and so on.

(5) Fire prevention

Include how to handle fire extinguishers, water for firefighting and flammable substances as well as rules concerning smoking and patrols.

(6) Traffic

Include rules concerning traffic such as prohibition of running, temporary stops at exits or turning points, prohibition of passing under loads suspended during work in high places, pointing and calling when crossing a railway track, etc.

(7) Passages

Clarify passage areas and formulate rules of restriction on work in passages.

(8) Clothing

Include clothing rules on wearing uniforms (if any), safety hats, safety footwear, etc. and rules such as prohibition of waring a glove over another.

(9) Protective equipment
Formulate rules to wear protective equipment in high-place work, electric work and jobs in environments with high temperature and big noise. Include safety hats, safety footwear, insulating gloves, light shielding spectacles, dust and gas masks, etc.

(10) Safety devices

Define rules on how to handle safety devices mounted on equipment.

3.2 General work

(1) Work using hand tools

Specify rules on how to handle hammers, spanners, pairs of pliers, and other hand tools. Include bans on the use of tools for purposes other than the original intent, methods of storage, safe methods of using tools, etc.

(2) Work with electric equipment and pneumatic tools

Include safety checks and handling rules of tools using electricity or air pressure as power.

(3) Machine operation

Specify rules related to safe operation of machine equipment, such as designation of operators, wearing protective goggles, inspection at the start and the end of work.

(4) Welding operation

Probably there is no welding operation for the AFC equipment even in maintenance. However, spot welding may be required when repairing a chassis. Formulate rules on welding operation just in case. The rules should cover working clothing, protective tools such as protective goggles and gloves, preparation of fire extinguishers, and ventilation. In addition, as it is hard to expect gas welding and laser welding to be applied to AFC, formulate a rule related to electric welding, such as an operation procedure of electric shock prevention.

(5) Electric work

The AFC equipment is electromechanical equipment and electric work is required very frequently. Accordingly, it is necessary to especially carefully specify rules from the following viewpoints.

1) General work

Specify general rules related to safety, such as a ban on clothing wet or tainted with oil, a necessity to display a sign of “Under Inspection Work” on equipment
whose power supply is cut off, and work to be done by qualified persons.
2) Electric equipment

Specify rules on power activation, electric shock prevention, wearing protective equipment, insulation, response to an ignition accident.
3) Switches and power distribution panel

Specify rules on contents to be displayed such as names of persons in charge of the switch box, switch operation, measures to prevent wrong switching operation during an inspection, prohibition of use of fuses that do not meet specifications, and other necessary items.
4) Work under or close to overhead wires

Though it is unlikely that a need arises for work under or close to overhead wires in handling the AFC equipment, there is a possibility that workers come close to overhead wires when moving or carrying equipment. Therefore, rules should be specified on this issue.
   - Specify rules to keep the safe distance decided based on voltage to avoid electrification; hold lengthy goods such as a ladder sideways when carrying them under overhead wires; use heavy machinery for construction whose boom height is mechanically limited, and so on. Also specify rules on grounding or use of protective equipment in the case where there is a possibility of electric induction.
5) Work with power outage

Because work with power outage may cause a significant trouble if wrong operation is performed, it is necessary to make a work process clear. Formulate rules on prior notice of a power outage plan to parties concerned in an area to be influenced by the power outage, confirmation of approval (consent), a procedure for voltage check, a grounding procedure, etc.
6) Work around high-tension circuits

Formulate rules on opening and closing of the doors of power distribution panels, wearing protective gloves, cutting off of high-tension circuits, a procedure for applying voltage, control of entry to a working area during work-in-progress, etc.
(6) Painting operation

It is rare that painting operation is required for the AFC equipment. However, there
may be a case where painting is required on a chassis that has damage caused in maintenance work. Specify rules on exhaust ventilation, prevention of catching fire and solvent inhalation, measures for splash prevention of paint waste and coating material.

(7) Crane operation

There may be a possibility of operating crane when moving or carrying heavy loads. Formulate rules such that crane operation should be carried out by qualified persons, and specify other rules on crane’s rated load, crane’s operating radius, prevention of contact with overhead wires, protection of overhead wires, and arrangement of staff to keep watch on trains in the case of operation in the proximity to a track.

(8) Slinging work

Slinging work is for suspending a heavy load from the hook of a crane. In Japan, the Industrial Safety and Health Act specifies that slinging work with 1 ton or more of a load must be done by workers who have completed the skill training course. Specify rules on outfits such as safety hats, whistles, and hand flags, weight of lifted loads and rated load, sling angles, ropes used in a method with two or more hanging ropes, how to exchange signs with a crane operator and other work procedures.

(9) Handling of heavy loads

In order to handle heavy loads safely, specify rules on use of appropriate transporting machine, a necessity for two or more workers to be engaged, use of the word as signs to others, working postures, procedures for loading and unloading, etc.

(10) Operation of forklifts

In Japan, the Industrial Safety and Health Act specifies that operation of forklifts is allowed only for those who completed the skill training course for forklift operation and the operation special training. Here, specify rules on safety operation, including prevention of uneven loading, operation at the time of operator’s leaving the seat, compliance with limit load, running speed, fork operation, etc.

(11) Operation of business automobiles

Formulate rules on general instructions concerning safe driving of vehicles. Specify rules on brakes and lights, rear-view mirrors, tire pressure, the amount of fuel remaining, superimposed load, uneven loading, check of speed limits, a ban on one-hand driving, moving at a crawl, and other matters related to driving operation.
(12) **High-place work**

Work at the height of about 2 meters or more is regarded as high-place work. Specify rules on high-place work, including methods to secure safety and work procedures. Accidents happen in high-place work more often than in other types of work. Therefore, safety should be assured by specifying work procedures in a detailed manner. Specify rules on methods of laying out the framework, wearing safety belts, stepladder operation procedures, etc.

(13) **Operation of vehicles for high-place work**

In Japan, the Industrial Safety and Health Act specifies that driving of vehicles for work at height is allowed only for those who completed the skill training course. To be specific, a vehicle for high-place work means a service vehicle whose working floor is 10 meters high or more. As for the AFC equipment, it looks like quite rare to conduct high-place work of more than 10 meters. However, there can be a case where such work is required when moving equipment from an elevated station. So, it is better to specify such rules. Specify rules on making work plans, installation of supervisors, wearing safety belts, clear indication of work areas and entry control, the out-trigger mechanism to make a service vehicle stable, the withstand load, electric shock prevention measures in case of work in the proximity of overhead wires, etc.

(14) **Safety equipment at opening sections**

Opening sections mean ports for lifting and lowering materials and the like. Specification of rules on related work procedures is necessary because prevention of accidental fall by use of safety equipment is required. The rules should include installation of handrails at the whole circumferences of opening sections during work, display of “No Entry” signs at unused opening sections, installation of covers and safety net devices, wearing safety belts during work, use of hooked rods when taking in loads, etc.

(15) **Drilling and chipping work**

For the AFC equipment, this work is not conducted in ordinary time. However, when installing new equipment or replacing old equipment, this work is required in laying power cables or communication wires under the floor. Rules are required to be specified, since there is a possibility of injury on human eyes with scraps flying apart or damage on buried objects if drilling and chipping are conducted without enough care. Specify rules on wearing protective gloves and goggles, a prior check on buried objects, a check on tools, and safe operation methods.
(16) **Pipe processing work**

For the AFC equipment, this work is required when laying down pipes for installing or relocating power cables and communication wires. When performing threading at a connection part between a metallic pipe and a joint, chips might fly apart and harm human eyes. Furthermore, when connecting a metallic pipe with a joint, a wrench might spin around vainly by mistake, causing injury on the human body. Therefore, it is necessary to specify rules on work procedures. Specify rules on use of protective goggles and suitable tools.

(17) **Transport work**

As transportation work is conducted frequently, rules should be specified on work procedures in a specific and detailed manner. Specify rules on a need to lock wheels of a lorry on loading and unloading, a right method of handling freight, a right posture to avoid hurting a back when manually carrying freight, a right method of driving a power lorry, etc. Especially, formulate a rule such that a lorry equipped with a stopper or a brake should be used when using it on the platform.

(18) **Cleaning work**

Cleaning is work to be conducted to wash out a stain from parts mainly when performing overhaul maintenance of the AFC equipment. Specify rules on instructions on wearing protective gloves and goggles and ventilation, rules on safe handling of cleaning fluid in chemical cleaning and in cleaning with gasoline or light oil, a check on the injection tip and washing apparatuses in the case of vapor washing or high-pressure jet washing, etc.

### 3.3 Maintenance work

(1) **Common matters**

1) Communicate in advance with stations where the AFC equipment is used, a data center of each line, the data center of the operating company, education and training centers, the IC card issuing center, etc. and ask them to send persons in charge of handling the equipment before and after maintenance work.

2) Display a sign such as “Under Maintenance” on the control panel of a power distribution panel during work so as to avoid operation by mistake.

3) Do not touch movable parts during operation of equipment.

4) When there are two or more pieces of equipment in use, perform maintenance
with confirmation of target machines for maintenance with reference to specifications and a maintenance plan.

5) Qualified persons should be made engaged in work, and safety precaution should be intensively observed.

6) When performing collaborative work, it should be observed that switching operation such as power activation is done only after checking actual response from the other party.

7) When inspection is completed, equipment should be delivered after their functions are checked.

(2) Inspection of ticketing work

1) Display signs such as “Under Adjustment” or “At Work” during work.

2) Put a workplace in order and tidy it up.

3) Take note of tool boxes and materials around automatic ticket gates so that they never obstruct passage of people.

4) Do not put objects such as hardware that might fall on automatic ticket vending machines or charging machines.

5) Before starting work, check whether there are fallen objects, and, if any, remove them and then start work.

6) When installing or removing a unit, first check whether the power supply is ON or OFF.

7) When carrying a heavy load such as a unit, a number of workers enough to handle the weight and the shape of the load should be engaged in the work.

8) When a worker moves during work, he should first check the surrounding before moving.

3.4 Work on commercial lines

Workers never come in the proximity of a commercial line because the AFC equipment is installed at a point distant from the platform even when it is used as station service equipment. However, there is no denying that equipment is carried over a commercial line for maintenance work, or workers come in the proximity of a commercial line when they conduct wiring work with power cables or communication wires. Therefore, rules on work in the proximity of a
commercial line should be specified. The rules are not unique to the AFC equipment, but their particulars are common to the overall work to be done in the proximity of a commercial line. Accordingly, they should be subject to the standard rule on commercial line construction and operational safety that is expected to be specified for maintenance of track.

(1) General rules

1) Apply the standard rule on commercial line construction and operational safety (confirmation required)

2) Confirm clearance gauge.

This gauge means a range where building structures that can be an obstacle to operation of trains are not allowed to be situated, whether or not they are movable. If a worker enters this range, it can directly lead to an accident with a train, so it is important to make this gauge completely known to all the parties concerned.

3) Make a construction line section completely known to all the parties concerned.

4) Make a place for temporarily storing materials completely known to all the parties concerned.

5) Thorough implementation of trace confirmation after completion of work

"Trace confirmation" means a check to be made after completion of maintenance work and the like. It means to check whether or not instruments or tools are left behind after completion of work.

(2) Allocation and duties of construction workers

Specify rules on allocation and duties of workers required for work (construction), as specified below. Only qualified persons can be engaged in the following work assignments.

1) Supervisor

The supervisor should be in charge of implementation management and personnel allocation in the worksite.

2) Trace confirmation personnel

The trace confirmation personnel is in charge of confirmation after completion of work. If a lorry or the like left behind is within clearance gauge, it might be hit by a train, resulting in a big accident.
3) Person in charge of line closing

Line closing means to stop trains from coming into a construction line section to ensure safe work. A person in charge of line closing should perform line closing, a check on trains, etc. If there is a mistake in line closing, a big accident, such as an accident resulting in injury or death, might happen. Therefore, a person in charge of line closing should follow specified procedures to apply and obtain approval for line closing. He should also grasp train operation status during line closing.

4) Train picket

A train picket is in charge of keeping guard against trains during construction work. When trains are approaching, he should give signs according to procedures which are separately specified.

5) Conductor

When using heavy machinery for construction, vehicles for construction, and road-rail vehicles, a conductor should be allocated so that these vehicles can run safely in the construction area.

(3) Plan for measures to prevent accidents

Specify rules on implementation plans of safety measures (safety equipment, allocation of security staff, etc.) for construction work, a security confirmation document for checking qualifications of security-related staff, security meeting sheets used to get permission from safety inspectors in terms of daily work details, and other work procedures.

(4) Implementation of measures to prevent accidents

Specify rules on staff allocation, wearing protective devices, operation, tools, work attitudes and others in specific implementation of plans for measures to prevent accidents. These rules should include items such as roll calls, a method to issue work instructions, pointing and calling, a ban on use of metallic ladders, trace confirmation of brought-in tools, and so on.

(5) Measures to be taken in adverse weather

When adverse weather happens with strong wind, heavy rainfall, etc., it might be possible that an event that is never observed in normal time happens, including inundation, a flood, rolling motion of equipment. Therefore, specify rules on items to check, a contact system, and other matters needed in times of adverse weather.
(6) Third party disaster and accident prevention

For the AFC equipment, third parties mean in most cases its users. In order to prevent users from coming into the work area, specify rules on arrangement of conductors, use of protective sheets for partition at the work area, display of signs such as “No Entry.”

3.5 First-aid treatment

When an injury accident happens, first-aid treatment would be required after quickly rescuing a sufferer till a medical doctor arrives. Accordingly, rules and procedures should be specified on first-aid treatment. Their specific details need to be decided with reference to emergency medical measures practiced in Vietnam.

3.6 Others

(1) Standards of wearing protective equipment

Specify rules on wearing protective equipment so as not to rely on judgment by individuals.

<table>
<thead>
<tr>
<th>Type</th>
<th>Scope of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hat/Cap</td>
<td></td>
</tr>
<tr>
<td>Helmet</td>
<td>Overall work area</td>
</tr>
<tr>
<td>Cloth cap</td>
<td>Locations where wearing a helmet can be avoided.</td>
</tr>
<tr>
<td>Spectacles</td>
<td></td>
</tr>
<tr>
<td>Protective goggles</td>
<td>Overall work area</td>
</tr>
<tr>
<td>Face guard</td>
<td>Work where dust is generated such as grinding. Work requiring a posture facing upward.</td>
</tr>
<tr>
<td>Light shielding glasses</td>
<td>Welding, etc.</td>
</tr>
<tr>
<td>Earplug</td>
<td>Work accompanied by big noise.</td>
</tr>
<tr>
<td>Mask</td>
<td></td>
</tr>
<tr>
<td>Dust mask</td>
<td>Work where dust is generated such as grinding.</td>
</tr>
<tr>
<td>Gas mask</td>
<td>Work using hazardous chemicals such as organic solvent.</td>
</tr>
<tr>
<td>Glove</td>
<td></td>
</tr>
<tr>
<td>Rubber/vinyl gloves</td>
<td>Cleaning work handling chemical substances</td>
</tr>
<tr>
<td>Rubber insulated gloves</td>
<td>Hot-line jobs (in a state of electric current flowing)</td>
</tr>
<tr>
<td>Cut wound -preventing gloves</td>
<td>Work with cutting tools.</td>
</tr>
<tr>
<td>Cloth/leather gloves</td>
<td>Work to handle heavy loads. Work to fully fasten a union of piping or the like.</td>
</tr>
<tr>
<td>Safety belt</td>
<td>High-place work</td>
</tr>
<tr>
<td>Hood</td>
<td>Welding</td>
</tr>
<tr>
<td>Apron foot cover</td>
<td>Work in the proximity of a track. Work in a narrow place with protrusions</td>
</tr>
<tr>
<td>Leggings</td>
<td></td>
</tr>
<tr>
<td>Shoes</td>
<td>Protective Overall work area</td>
</tr>
</tbody>
</table>
### Safety Colors/Safety Signs

Safety colors/safety signs are measures to indicate the meaning related to danger, caution, fire protection, etc. by use of colors and signs. They are characteristic in that they can be instantly identified visually, so that they are used in various cases. ISO 3864 (Graphical symbols - Safety colors and safety signs) specifies colors and signs to be used, so that it is desirable to conform to this standard.

### Communication Method in Unusual Situations

In order to make a prompt and appropriate response possible in case of an unusual situation, rules should be specified on the following items, and parties concerned should master them through training that should be conducted in normal time.

1) **Setup of an Emergency Contact Network**

   When an accident or any other disaster occurs, information must be quickly distributed to divisions concerned, and action must be taken following appropriate instructions. For this purpose, it is necessary to define contact procedures in case of occurrence of an accident.
   - Contact information
   - Contact rule (who calls whom)

2) **Standardization of Messages to be Communicated**

   Confusion is usually generated in emergency situations, so necessary information might not be distributed properly. For this reason, it is helpful to define minimum required contents of information to be distributed.

### Response on the Outbreak of an Accident

#### 4.1. Features of the AFC Equipment

The AFC equipment needs to function from the start of business in the early morning to the end of business late at night without interruption. Furthermore, the data centers of OU and HMC should complete processing of fare data and other data of the day, so that they must work after the end of business over the midnight. Therefore, there is a need for a system that can promptly respond to a situation and restore equipment if an accident should occur where a failure of equipment causes it to
The AFC equipment is a network system that processes data through connection to a network. Therefore, a trouble might have a significant influence depending on its cause. If a large-scale accident should occur, an ordinary maintenance system cannot cope with the situation. For this reason, there is a need for a scheme to respond to a large-scale accident, including provisions about an emergency contact network, members to be mobilized, procedures of calling them, etc.

AFC machines placed in stations are dispersed through an urban area stretching over tens of kilometers. It means that there is a possibility that maintenance staff cannot promptly arrive at a station where an accident has broken out. Therefore, there is a need to set up a system, including a base for maintenance services in each section.

4.2. Accident response system

In order to build a system where requirements characteristic to the AFC equipment are reflected, it is necessary to define organizations and their roles. Table 6-7-40 presents an example of organizational structure. The on call center, where information is consolidated and response is controlled, plays a key role. It is also important, when a large-scale accident occurs, to provisionally set up countermeasure headquarters where authorities and functions should be concentrated so as to handle the situation promptly.

Now, it is necessary to review how the on call center is positioned. In the urban railway of Hanoi City, HMC is in charge of implementing headquarters functions, and OU performs business operation for each line. From this standpoint, the on call center can be regarded as an organization that belongs to OU. However, with a focus on a necessity to integrally handle accidents in all the lines, it is better to position it as a division that controls all the lines. It seems to be a practical approach to first set up an on call center in each line, and integrate them in the future.

**Table 6-7-40 Organizational structure (Example)**

<table>
<thead>
<tr>
<th>Division</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station (with equipment for station operation installed)</td>
<td>Activate an alarm on accidents or failures.</td>
</tr>
<tr>
<td>OU (with a train line server installed)</td>
<td></td>
</tr>
<tr>
<td>HMC (with a business operator server installed)</td>
<td></td>
</tr>
<tr>
<td>On call center (*)</td>
<td>Monitor and control accident/failure information.</td>
</tr>
<tr>
<td>Division of OU in charge of the AFC equipment</td>
<td>Recover and repair equipment after accidents or failures.</td>
</tr>
<tr>
<td>Equipment maintenance service company</td>
<td></td>
</tr>
<tr>
<td>Division of HMC in charge of the AFC equipment</td>
<td>Supervise accident/failure recovery countermeasures.</td>
</tr>
<tr>
<td>Countermeasures headquarters (a provisional organization)</td>
<td></td>
</tr>
</tbody>
</table>

(*) In Appendix 8-6-7-1 (A)-D, it is expressed as “maintenance control division.”

4.3. Workflow of accident response
It is desirable to take countermeasures according to details and scales of an accident. For this purpose, it is necessary to make clear judgment criteria and persons in charge of judgment. An example is presented below.

- Common accidents (small-scale observed in specific equipment at a specific location, etc.)
- Serious accidents (large-scale, unrecoverable, related to injury or death of human being, etc.)

(1) Common accidents

Common accidents are handled within an ordinary organizational system. As the equipment division of the headquarters office does not directly handle these accidents, their roles are not specified in the accident recovery workflow. However, as part of technical management work, the division needs to give guidance while receiving reports, in the form of weekly, monthly and yearly reports, on maintenance from the OU equipment division. Figure 6-7-26 shows one example, but the flow should be developed taking into account official capacity of OU and HMC.

![Flowchart](image)

Fig. 6-7-26 Accident recovery workflow (Example)

(2) Serious accidents
In serious accidents, information should be quickly distributed to corporate executives, divisions concerned, and other various parties concerned. In this regard, a scheme of emergency contact becomes one of key issues.

In addition, it will be an effective measure to set up a provisionary organization such as countermeasures headquarters where information and command authority are concentrated, in order to lead various parties and divisions concerned and carry out recovery work swiftly while avoiding confusion about information and command.

In serious accidents, the first motion after obtaining accident information is very important. Clear workflow is needed for building organizational structure to achieve swift recovery.

Cause investigation of serious accidents is also very important in order to make causes clear and prevent recurrence of accidents. In addition, recovery work is sometimes carried out around the clock, so that duty management of staff, food services and other related matters should be taken into consideration. Figure 6-7-27 is an example of the structure of countermeasures headquarters.

Fig. 6-7-27 Structure of countermeasures headquarters (Example)
Appendix 8-6-7-5-A(A) Collection of Rules for the Maintenance of the Equipment Used for Line 2A

1. Information obtained from TECHNICAL DESIGN

   Sources: TECHNICAL DESIGN, Package 5 EPC CONTRACT, BOOK 5 Equipment System, Volume 10 Automatic Fare Collection System (AFC)
   No. HNHD-05-10-00-00-TDS-C

   (1) Design guidelines and important technical indicators
   (2) Equipment and devices constituting AFC systems
   (3) Management and operation methods of electronic train tickets
   (4) System structures for AFC processing
   (5) Functions and operational management of AFC systems and equipment
   (6) System for performing maintenance work
   (7) Education and training systems
   (8) Data processing network systems
   (9) Electric power supply and grounding
   (10) Equipment allocation
   (11) Facility spaces
   (12) System interfaces
   (13) Analysis on localization
   (14) Estimation of the number of equipment and devices

   Items (6) and (7) above have some descriptions of maintenance

   (6) System for performing maintenance work

       The concept that the line district center has the central control function of AFC and issues instructions to take measures for abnormality as mentioned below. It is close to that of this chapter.

       1) The line district center of Line 2A takes central control of AFC equipment and systems.

       2) In a similar way, the center takes center control of updating and down loading equipment software

   (7) Education and training systems

       It is described to establish an education and training system in the maintenance center. The organization name listed in the staff allocation table of Line 2A is Electric Signal Communications Maintenance Department. There is a difference.
Key Issues for the Urban Railway in Hanoi

Seminar for the HMC Railway O&M Company

In Hanoi,
1st August, 2013

Prof. Dr. Shigeru MORICHI
Director, Policy Research Center
National Graduate Institute
for Policy Studies (GRIPS)
Adviser, Hanoi Metro Project

Contents

I. Introduction
   - Specialty of Transport in the Asian Megacities -
II. Function of railway operator
III. Performance of railway network
IV. Priority of railway investment
V. Requirement of PPP Scheme
VI. Conclusion
1. Introduction
- Specialty of Transport in the Asian Megacities -

• Asian megacities are different from European and US cities.
  : Size of population and urbanized area
  : Increasing speed of population and motorization
• Railway oriented urban structure is desirable.
• Coordination between urban development and railway, and timing of development are necessary.
• Profitability of railway operator is required.

① Urban Structure and Transport: Mono-centric urban form

Asian Megacities:
• High-density core → Mono-centric
• In 14-16 km radius, 8-10 mil pop

Tokyo core:
Area: 616 sq km
Pop: 8.1 mil

Seoul core:
Area: 606 sq km
Pop: 10.3 mil

Metro Manila (core)
Area: 637 sq km
Pop: 10.1 mil

Bangkok core
Area: 600 sq km
Pop: 4.5 mil

Shanghai core:
Area: 812 sq km
Pop: 10.1 mil

Jabotabek core:
Area: 664 sq km
Pop: 8.7 mil
Population Decentralization: possible spatial patterns

- Car-oriented sprawl
  → Undesirable!

- Public-transport oriented poly-centric form
  → Desirable!

Or Transit corridor with weak centers

Poly-centric decentralization

Car ownership trend (1980-2004)

② Car Ownership and Road Transport

Tokyo-to
Taipei
Seoul
Bangkok
Jakarta
M. Manila
Shanghai
GDP per capita and city-level car ownership rate

- Higher car ownership rate in developing megacities for given GDP per capita level

GRP per capita Vs car ownership rate:
Selected metropolitan areas (2002~04)

- In general, income growth increases car ownership rate

Data source: STREAM Study compilation from various sources
GRP per capita Vs car ownership rate:
Selected metropolitan areas (2002~04)

- US cities
- European cities
- Developed Asian
- Developing Asian

No of cars per 1000 population

Data source: STREAM Study compilation from various sources

Road Space in Selected Cities 2004

<table>
<thead>
<tr>
<th>City</th>
<th>Area (Km²)</th>
<th>Pop. Density Per/ha</th>
<th>Road Area Km²</th>
<th>% (city area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Paris</td>
<td>105</td>
<td>202</td>
<td>27</td>
<td>25.8</td>
</tr>
<tr>
<td>New York City</td>
<td>678</td>
<td>112</td>
<td>210</td>
<td>25.2</td>
</tr>
<tr>
<td>Inner London (12 boroughs)</td>
<td>589</td>
<td>72</td>
<td>96</td>
<td>16.4</td>
</tr>
<tr>
<td>Inner Tokyo (8 wards)</td>
<td>110</td>
<td>121</td>
<td>24</td>
<td>21.7</td>
</tr>
<tr>
<td>Tokyo 23-wards</td>
<td>621</td>
<td>131</td>
<td>114</td>
<td>18.1</td>
</tr>
<tr>
<td>Seoul City</td>
<td>605</td>
<td>168</td>
<td>80</td>
<td>13.3</td>
</tr>
<tr>
<td>Taipei City Inner Core</td>
<td>134</td>
<td>197</td>
<td>20</td>
<td>14.9</td>
</tr>
<tr>
<td>Shanghai City Inner Core</td>
<td>108</td>
<td>378</td>
<td>13</td>
<td>12.0</td>
</tr>
<tr>
<td>Bangkok City Core</td>
<td>225</td>
<td>96</td>
<td>16</td>
<td>7.2</td>
</tr>
<tr>
<td>Jakarta City</td>
<td>656</td>
<td>133</td>
<td>48</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Data source: STREAM Study compilation

Asian Megacities
- In adequate road
- Inefficient road hierarchy
Average Speed of Road Traffic

- New York: 30 km/h
- Paris: 20 km/h
- London: 25 km/h
- Tokyo: 30 km/h
- Mumbai: 25 km/h
- Shanghai: 20 km/h
- Jakarta: 15 km/h
- Manila: 10 km/h
- Bangkok: 10 km/h

Data source: UITP (2001)

Result → severe traffic congestion!

Motorcycle ownership, 2004

- M. Manila: 50 units/1000 population
- Tokyo: 100 units/1000 population
- Shanghai: 150 units/1000 population
- Bangkok: 200 units/1000 population
- Taipei: 250 units/1000 population
- Jakarta: 300 units/1000 population
- HCMC: 350 units/1000 population

Data source: STREAM study, 2006

Rapid growth in motorcycle ownership

Pressure of motorization at early stage
Impact on environment and safety
TATA nano: alternative to “family motorcycle” in Asia

$2,500 car...impact??

Bangkok

Policy Response to Congestion → Build Expressway?

Jakarta

Shanghai
Some cities have developed Toll ways rapidly...

...any better alternative?

Under rapid motorization challenging accident dynamics

- How to avoid the peaking of fatalities?
- Possibility of stabilizing total fatalities earlier?

Source: Bureau of Statistics, Japan
Thailand: following Japanese pattern?

Trend of road traffic accident in Thailand

Notes:
• Motorcycles included in vehicles population
• Vehicle population over-estimate
• Is it possible to achieve Japanese rate of <1 death per 10000 vehicles?

Data source: National Office of Statistics, Thailand

Directions for the future

Road oriented: Los Angeles
Rail oriented: Tokyo
Public Transport

- Toward better transport service that is...
  - Accessible and Efficient (Economically efficient)
  - Clean and healthy (Environmentally sound)
  - Safe, Affordable, Inclusive (Socially acceptable)

Diverse modes in Asia

Modal split (1998~2004)

Trends of public transport mode share

In general, public transport mode share on declining trend

Asian megacities: breeding ground for Public Transport reform

Examples:
- Tokyo, Osaka, Seoul: Extensive MRT network
- Taipei, Shanghai, Beijing, Bangkok: Rapid expansion of MRT network
- Seoul, Taipei: Innovative bus reform
- Jakarta: introduction of BRT System

BRT for Asian megacities
- Low-cost alternative for MRT??
- Capacity and road space issue
- BRT Vs MRT → BRT + MRT
**Policy experience: Bus reform**

**Bus reform in Seoul and Taipei:**

**Common features**

- Comprehensive reform: modernization, Median bus-lane, IC-ticketing, fare and service integration with MRT, fare-discount for transfer (distance-based fare)
- Improvement in service and ridership.

**Differences:**

<table>
<thead>
<tr>
<th>Taipei</th>
<th>Seoul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reform through gradual process</td>
<td>Reform through major intervention</td>
</tr>
<tr>
<td>Ownership and operation largely by private sector; regulation by public sector</td>
<td>Public-private partnership in management and operation, significant role of public sector</td>
</tr>
<tr>
<td>No direct subsidy (indirect cross-subsidy from MRT for fare discount)</td>
<td>Significant financial burden on public sector (direct subsidy)</td>
</tr>
</tbody>
</table>

**Public Transport Fare for a 10 km one-way trip (2007)**

- Tokyo, Seoul, M. Manila: MRT and Bus fares are harmonized
- Bangkok and Shanghai: Bus fare much less than MRT

**Note:** Bus fare is for Air-conditioned bus; LRT in M. Manila and BRT in Jakarta are considered as MRTs.
Timing of subway opening: Income stage

Opening year of the first subway and income per capita

![Graph showing the timing of subway opening and income per capita.](image)

Data source: OECD (2003); http://osamuabe.ld.infoseek.co.jp

Timing of subway opening: City population

City population and opening year of the first subway

![Graph showing the timing of subway opening and city population.](image)
Timing of MRT development: to maintain the high share of public transport mode

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Right timing when….</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>high enough for charging reasonable fare</td>
</tr>
<tr>
<td>Car ownership</td>
<td>not too high to ensure good patronage</td>
</tr>
<tr>
<td>Population</td>
<td>high enough for threshold demand volume</td>
</tr>
<tr>
<td>Urban density</td>
<td>Not too low for required passenger density</td>
</tr>
</tbody>
</table>

Timing should be decided considering the state of all indicators!

Timing of transit investment and ridership trend

Taipei: Investment not too late
→ Ridership regained

US cities

US: Late investment
→ only marginal gain in ridership
④ Recommended issues for urban railway in Asia

Modal share is still high in Asian Megacities, however it is going down under the growing economy and motorization. What are recommended issues?

1. Without Railway, with BRT and with LRT, it is impossible to manage the transport in Asian Megacities.
2. Hierarchy railway network is required in future for megacities as same as road network.
3. Profitability of railway operators is required for the Innovation of service and technology.
4. The fare of Bus and para-transit have to be compatible to railway. Bangkok case is remarkable for successful higher fare.
5. The timing of investment for urban railway is important, however the master plan should be prepared at early stage. The master plan of urban railway network in Tokyo in early 1960's.
Transport Development in Asian Megacities

A New Perspective

The rapid growth of the Asian urban population concentrates on a few large cities, turning them into giant megacities. Despite new theoretical insights into the benefits of megacities, the emerging Asia is facing a daunting challenge concerning the management of infrastructure and services in their megacities. The deteriorating urban mobility is the most difficult challenge with respect to the sharp increase in vehicle numbers and to inadequate and poorly managed road infrastructure. Public transport, a sustainable mode of mobility, is subjected to a vicious cycle of poor service, decreasing ridership and lower investment. Despite various policy initiatives, the situation has not improved. The scale and growth pattern of Asian megacities have distinctive features which generate a unique set of challenges and opportunities. New perspectives are needed to effectively address these transportation problems making the best use of available opportunities. This book, which is a result of an international collaborative project,

5 Trend of the Transport Policy in Japan

~1950 Development of Extensive Urban Railway Network

1950’s
- Expansion of Transportation Network, Institutions for Development
1960’s
- Improvement of Terminal (Rail, Bus), Law for Car Parking Space
- Horizontal Division of Rail and Road
- Direct Operation between Subway and Suburban Rail etc.

1970’s
- New Transportation Systems
- Transportation System Management
- Rail – Bus Transfer Terminal, etc.

1980’s
- Transportation Demand Management
- Privatization of Japan National Railway

1990’s
- Public – Private – Partnership
- Incentive Scheme for Private Railway

2000’s
- Coordination Scheme for Transport Industries
New Policies for Better Connectivity and Service

• 2005: The Law for Urban Railway Improvement
• : The Law of Passenger Information for Foreign Travelers
• 2006: The Law of Universal Design
  ① Accessible and Usable Building Law
  ② Barrier Free Transport Law
  ③ Transfer Service Improvement
• 2007: The Law for improvement of Regional Public Transport
• : The Law for Regional Infrastructure Improvement
• 2008: The Law for Regional Railway
• 2009: The Law for Safety of Taxi
  ( Improvement of Deregulation Policy )
• 2009: The Basic Law for Transportation (not approved)
• 2010: The Law against Tsunami Disaster

Today’s Additional Topics

1. Self-controlled organization.
   Company have to be able to decide management, investment, service and fare.

2. Performance of network is important.
   Transfer service between railway lines and between rail and road transport.

3. Priority of urban and railway development.
   Master-plan and coordination of development.

4. Advantage and constraints of PPP scheme
1. Self-controlled organization: Railway operator

Railway Company has to be able to decide the strategy such as management, investment, service and fare. But regulations for safety and report of information are essential.

Failure Case: JNR bankrupt through the following reasons.

* Lack of freedom of management
  - Control of fare by congress
  - Regulation of businesses except railway related one.

* Lack of incentive for the efforts to improve the efficiency
  - Weakness of management
  - Strong labor union supported by some political party
  - Investment for unprofitable projects by political pressure
  - Low service level for customers

Successful Case: Privatization of JNR... better service & efficiency

Many countries follow the privatization of National Railway.

Balanced policy for regulations and incentives

Major policy issues in US and EU:

- Benchmark regulation to improve the efficiency of railway operators
- Expansion of network through public investment
- Better service and fare through government efforts

Major policy in Japan:

- Incentives for railway operators
- Private railway operators and operators by Local governments make efforts for better service under the competition
- Only profitable operators can innovate the railway system
  - R&D, Expansion of network, Improvement of System, etc

To keep the future profitability

- Organization, Management, Efficient technology, Subsidy,
- Suitable fare level, Consistency between rail and urban development, etc
Profitability of Urban Railway

• Subsidy for Subway
  Japan: 50% of Subway Construction Cost
           (25% Government, 25% Local Government)
  No subsidy for operation cost
  US & EU: 100% of Construction Cost
           20-80% of Operation Cost

• Profitability
  Except Japan, Only Taipei: profitable for operation cost
  Railway operators in Tokyo enjoy the profitability
     (At the first stage not profitable )

• Only the profitable railway companies
  innovate the system, technology and service.
  Unprofitable company cannot take the risk to change the system.

• All railway operators in Tokyo enjoy the profitability.

Operational characteristics of selected subway systems

(2005)

<table>
<thead>
<tr>
<th></th>
<th>Tokyo</th>
<th>Seoul¹</th>
<th>Taipei</th>
<th>London</th>
<th>New York²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route (km)</td>
<td>183</td>
<td>109</td>
<td>135</td>
<td>52</td>
<td>408</td>
</tr>
<tr>
<td>Passengers</td>
<td>2,110</td>
<td>761</td>
<td>1,440</td>
<td>819</td>
<td>361</td>
</tr>
<tr>
<td>(mil/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass/km/day</td>
<td>32</td>
<td>19</td>
<td>29</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>(1000 persons)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue/cost</td>
<td>1.29</td>
<td>1.07</td>
<td>0.74</td>
<td>0.55</td>
<td>1.07</td>
</tr>
<tr>
<td>Fare (US$)</td>
<td>1.3 ~ 2.5</td>
<td>1.4 ~ 3.5</td>
<td>0.8 ~ 1.1</td>
<td>0.6 ~ 1.9</td>
<td>3.0 ~ 8.0</td>
</tr>
</tbody>
</table>

1. data year 2003, 2. revenue/cost includes also of bus
2. Data source: Seoul (Sung 2007), rest from homepage of respective agencies

Only Tokyo and Taipei operators are profitable.
Financial Resources for Public Transport

① Fare  ⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅⋅::
- Regulation or Deregulation
- Operators’ Initiative
- Regulators’ Role
- Public Sector’s Decision

① Fare for Profitability

- Balance between Bus and Railway Competition under the Different Costs
- Regional Disparity between Prior and Inferior Regions
- Transport Behavior by Income Segmentations and the Time Series Change

Philippines’ Example:
- LRT3 Fare and Deregulation for Air-conditioning Bus

Thailand’s Example:
- High Fare for New Urban Railway: High Income Passengers

② Cross Subsidy between Routes

- Profitable and Efficient Organization
- Profitability of Urban Railway Operator
  - Tokyo Metro and Hanoi Metro
- Rationale for Cross-subsidy
- Independent PFI Projects

③ Subsidy

- Disincentive for efficiency
- Incentive for Operators
- Neutral for Transport Modes
- Difference between EU, US and Japan
- Role of Government for PFI Projects

④ Value Capture
4 Value Capture

- Transit Oriented Development
- Multi-core Urban Structure for Mega Cities

Urban railway development by private sector in Tokyo (Tokyu Denentoshi Line)

From Japanese experience:
- Urban railway can be profitable.
- Main Revenue of railway company
  1\textsuperscript{st} step (Population is limited) : housing, real estate
  2\textsuperscript{nd} step (population increased) : high land price, all business increased railway passengers
  3\textsuperscript{rd} step (almost land was sold out) :
    railway, urban renewal, etc
- Profitability is essential for innovation of system.
- Railway Company is key factor of attractiveness of area
  (Attractiveness decides the land price)
2. Performance of not only lines but also network

* Direct operation between different lines, different operators
  - Subway and suburban railway: Tokyo case
  - Intercity trains start from subway station (Odakyu & Tokyo Metro)

* Transfer service between railway and other modes
  - Station plaza: for Bus, Taxi, and Cars.
  - Universal design of the routes for pedestrians inside station and from station to surrounding facilities
  - Connection of urban railway to inter-city transport terminals such as HSR station, airport and bus terminal.

* Hierarchical urban railway network in mega-city

* IC Cards Based Common Ticketing System

* Information system and reservation system

---

**Hierarchy of Urban Railway Network (Tokyo)**

<table>
<thead>
<tr>
<th>Railway Type</th>
<th>St. Spacing</th>
<th>Operating Speed *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shinkansen Railway (Bullet Train)</td>
<td>30 – 50 km</td>
<td>120 -130 km / hr</td>
</tr>
<tr>
<td>Inter-city Train (Japan Railways)</td>
<td>5 – 6 km</td>
<td>50 - 60 km / hr</td>
</tr>
<tr>
<td>Express Train (Private Railways)</td>
<td></td>
<td>40 - 45 km / hr</td>
</tr>
<tr>
<td>Ordinary Train (Private Railways)</td>
<td>1 – 2 km</td>
<td></td>
</tr>
<tr>
<td>Subway</td>
<td>0.5 – 1 km</td>
<td>30 - 35 km / hr</td>
</tr>
<tr>
<td>Monorail / AGT (BRT?)</td>
<td>0.5 – 1 km</td>
<td>20 - 30 km / hr</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Distances</th>
<th>Capacity</th>
<th>Number of Passengers</th>
<th>Far end of urban rail line</th>
<th>Metropolitan Area</th>
<th>Downtown Area</th>
<th>Inter-city Train</th>
<th>Express Train</th>
<th>Shinkansen Railway</th>
<th>Ordinary Train</th>
<th>Monorail / AGT</th>
<th>Total 2,308 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Capacity</td>
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<td>Number of Passengers</td>
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</tr>
</tbody>
</table>
IC Cards Based Common Ticketing System

**JR**
- JR East
- Tokyo Monorail
- Tokyo Rinkai

**Private Rail, Subway, Bus**
- Passnet (magnetic card)
- Bus Card (30 Co) (magnetic card)
- Railway Co: 26
- Standardization 2007

**Common Ticketing 2007**

**Collaboration with other regions and fields**
- 2009: Common ticketing with JR Hokkaido
- 2010: Common ticketing with JR Kyusyu and urban railway in Fukuoka
- 2011~: Common use with many shops and restaurants
- 2013: Common ticketing and use all over the Japan

**Requested higher performance of IC card Ticketing System**
- Capacity of ticket gate
- Failure rate of passage
- Possibility for future performance
- Possibility common use in wider region
- Higher reliability for usage in many fields
Master plan for urban railway in metropolitan areas

Major factors discussed in the planning

* Demand: Trip generation, Distribution, Modal Split, Route assignment
  (Economical growth, Population, Car ownership, Urban Development)
* Social Needs
  : Transportation problems: Congestion, Service level, Environment, Universal design, etc.
  : Cost and Benefit Analysis
* Coordination between railway network and related plans:
  Plans of other transport modes, Regional & Urban Plan, Environmental plan, etc.
* Feasibility of each line: Profitability, Financial viability, Agreement of stakeholders
* Long term strategy is very much important: Early stage planning

Tokyo Case

* 12 lines in existing 13 lines have been approved in MP in 1960’s
* Urban Railway Policy Council proposed the master plan in every 10-15 years
* Government issues the license of the construction in this term only for proposed lines
  (If necessary, the Master Plan will be revised)
  (Local governments and railway operators have to prepare carefully)
* The Council Members: Professors, central government, municipalities, railway operators, mass communications, etc.
* Proposed lines in last Master Plan
  A1 Lines: which should be operate in the term (e.g. 15 years)
  A2 Lines which should be start the construction in the term
  B Lines which should be evaluate in the term
3. Priority of urban and railway development

Railway project is different from road project

- Large demand risk, High initial cost, Limited subsidy
- Planed length of route have to be opened in targeting term
  (Delay of project means its bankrupt)
- Planed land-use along the route is important for the profitability
  (Lack of demand in initial term means its bankrupt)
- Urban development requires the simultaneous investments of
  various infrastructures and agreement of many organizations

* Coordination between Master-plans of Urban Plan, Transportation Plan and Railway plan.
* Coordination of related development projects

Coordination between transport and urban planning

1) Legal level coordination
   ex. • Urban Planning law
       Urban planning procedure for transport facility
       • Environment assessment law
       • Special law for the railway between Tokyo and Tsukuba
         (Housing area and railway development law)

2) Institution level: Budget and system for coordination
   ex. • Subsidy for new town railway
       • Subsidy for continuous vertical division of railroad crossing

3) Planning level coordination
   ex. • Coordination by Local Government
       • Planning Committee:
         Professors, related agencies and stakeholders
Vertical Separation of Railway Systems

Concept: Ownership of infrastructure and operation of services by different entities

Railway operator and passenger bear the costs for all or a part of construction

Public sector develop infrastructure and lease to railway operator under the agreed terms

Multimodal Policy

Rail to Rail
- Improvement of Transfer Facilities in Terminals
- Direct Operation between Subway and Sub-urban Railway

Rail to Road
- Grade Separation between Rail and Road Crossings
- Station Plaza
- Rail – Bus Transfer Terminal

Station to Surrounding Area
- Under Ground Shopping Area
- Skyway
- Commercial Station Building

Software Improvement
- Information System
- Fare Discount for Transferring
- IC Based Common Ticket
Subsidy for Grade Separation of Rail and Road Crossings

- Ensuring smooth traffic flow and promoting local interaction
- Distributing financial burden between road and rail sides

<table>
<thead>
<tr>
<th>Construction Cost</th>
<th>Financial Burden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation of Existing Infrastructure</td>
<td>Road 86–95%</td>
</tr>
<tr>
<td></td>
<td>Rail 14–5%</td>
</tr>
<tr>
<td>Elevation of Expanded Infrastructure</td>
<td>Road 0%</td>
</tr>
<tr>
<td></td>
<td>Rail 100%</td>
</tr>
</tbody>
</table>

**e.g. Network Expansion and Better Accessibility**

① Tokyo: New Subway line (Fukutoshin Line)
- Connect major sub-centers
- Direct operation: 3 lines
- Design of stations
- Local and express trains in subway

Opened in June 2008
② Osaka: Nakanoshima-line (along the river)

Opened in Oct. 2008

Stations along riverside
- Attracted new investment for development around river-side stations
- Contributed to urban renewal in the city core areas

Terminal Renovation : Shinjuku Station
4. Advantage and constraints of PPP scheme

- Limited successful projects
- Failure of public and private sectors
- Competitiveness of the country and the project in the world-wide market
  
  Country risk and project risk
- Difference the optimizations between public and private sector
- Lack of cross subsidy
- PFI project for urban railway with public subsidy
VI. Conclusion

1. Transit oriented system
   Car oriented system brings:
   Low density land-use and sprawl in suburban area
   Difficulty of railway development forever

2. Timing of Urban Railway Development
   To avoid the difficulty of recovery

3. Transport mode selection
   For future demand...Low capacity modes for only feeder route
   To keep the possibility of capacity expansion
   MRT; Elevated or Subway
   LRT; Surface or Elevated
   Monorail / AGT; mainly elevated
   BRT; only for feeder route in mega-city

4. Master Plan in early stage
   Future hierarchical railway system is requested
   Coordination between urban development and railway

5. Profitability of urban railway
   Efficiency and high quality of transport system
   However subsidy and related policies are essential.
   High construction cost and low fare level means lack of feasibility.
   Especially at first stage, financial support is necessary.
Thank you for your kind attention!
Securing the Safety of Railway Transportation
—System and Practical Business in Japan—

November 2013
Atsushi Kawai, Advisor

1. Organizations related to Railway Safety

Railway operators
- Provide transportation services to the nation's citizens under license of the national government.
- In addition to privately-financed companies, also include rail systems operated by local governments and companies financed by the national government/local governments.
- Some operators (Type III Railway Business Operator) own infrastructure and lease those facilities to an operating company.

Competent authorities (Railway Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT))
- Performs policy-making for railway operation as a whole.
- Grants business licenses to railway companies, and provides guidance and support for safe operation and sound management.
- Provides the necessary funding and information to the following organizations.

Japan Transport Safety Board (established in MLIT)
- Investigates the causes of railway accidents and incidents, and makes proposals and recommendations for prevention of recurrence.
- Provides appropriate information to the victims of accidents and their surviving families.

Japan Railway Construction, Transport and Technology Agency (Independent Administrative Agency; an agency of the national government)
- Performs construction of railways at the request of the national government and railway operators and loan of the constructed railway facilities.
- Implements government assistance for railway operators.

Railway Technical Research Institute (Public Interest Incorporated Foundation; a foundation operated with funding by the JR Group, etc.)
- Performs technical development and research related to railways.
- Provides results to railway operators, and performs technical assessments and technical support.
Proposes technical standards to the Railway Bureau, and provides technical support for the Transport Safety Board.

- Manufacturers, construction companies, etc. (private-sector companies)
  - Provide safe, high quality products and services to railway operators, etc.

## 2. History of Business System related to Railways

- 1869: Decision to construct railways by the government
  1872: Start of operation of railway between Tokyo and Yokohama (30km; nationally-owned)
  *Until the 1890s, technology was introduced from England.
- 1883: Start of operation of first private railway
  *Subsequently, a large number of main lines were constructed with private capital.
- 1906: Nationalization of main rail lines
  *Following this nationalization, private capital was responsible for construction of local and regional railways in urban areas, etc.
  *The main rail line network was substantially complete in the 1920s.
- 1927: Start of operation of first subway (2.1km)
- 1941: Establishment of the Teito Rapid Transit Authority (now Tokyo Metro Co., Ltd., funded by the national government and city of Tokyo)
- 1949: National railways were transferred to a public corporation (Japanese National Railways; JNR)—Separation of business and governmental control
- 1964: Start of operation of Tokaido Shinkansen (515km)
- 1987: Privatization of JNR and separation into 7 companies—Establishment of the present business system
- 2001: Establishment of the Aircraft and Railways Accidents Investigation Commission (now Transport Safety Board)—Creation of an independent accident investigation organization
- 2004: Establishment of Tokyo Metro Co., Ltd. (privatization)
  *Rail networks in metropolitan areas are substantially complete.

## 3. Present Legal System for Railways

- Railway Operation Act
  - Law prescribing the basic rights/obligations of railway operators, users, etc.
An old law enacted in 1900; special measures act of the civil code and penal code.

Forms the basis law for technical standards and other basic regulations (ministerial ordinances) which should be observed by railway operators.

Railway Business Act

- Law regulating the railway business in a unified manner.
- Defines the authority of competent authorities in licensing of newly-constructed routes, approval of fares and freight charges, completion inspections, on-site inspections, etc. and the obligations, procedures, etc. which should be performed by railway operators.

Tramway Act

- Law regulating railways laid on roads (tramways, new transportation systems, etc.)
- In addition to the content of the Railway Business Act, also provides matters related to management of roads.

* These laws regulate all operators nationwide in a uniform manner; the actual situation of each company and each route is decided on the responsibility of the operator.

4. Securing the Safety of Railway Transportation (1) Duties of the Railway Bureau

Establishment of ministerial ordinances

- Criteria for securing safety
- Technical standards — Necessary technical matters are provided by performance requirements (Performance-based Regulation)
  * Operational details are covered by non-binding notifications (Model Code, etc.)
- Inspection methods for facilities and rolling stock
- Accident reports
- Other matters prescribed by law

Publication of safety information

Practical business based on laws and ordinances

- Licenses for construction and facility modifications
- Completion inspections of facilities, checks of rolling stock
• Qualification tests for train drivers — In case of large operators, practical business is entrusted to each company, and the contents of education, testing, etc. are checked.
• On-site inspections (safety audits, audits of driver training facilities, etc.)
• Instructions for business improvement (recommendations, business improvement orders, etc.)
Etc.

○ Work related to policy implementation
  • Study of measures to prevent recurrence of accidents
  • Technical development for safety improvement
  • Support for investment in safety by railway operators

* The Railway Bureau also prepares award systems such as commendations for accident-free operation, etc.

5. Securing the Safety of Railway Transportation (2) Responsibilities of Railway Operators

○ Establishment and maintenance of internal regulations based on ministerial ordinances
○ Establishment of safety management system
  • Establishment of Safety Management Regulations
  • Appointment of responsible persons, beginning with Chief Safety Management Officer
  • Sharing of safety-related information from front-line work site to top management
  • Establishment of check function in order to execute work in a reasonable manner
Etc.
○ Publication of accident reports and safety information
○ Observance of matters specified in laws and ordinances and internal regulations
  ⇒ Secure everyday safety by implementing periodic inspections and maintenance of facilities and rolling stock and education/testing to improve the qualifications of personnel
○ Implementation of education and training assuming conditions during accidents and disasters
  ⇒ Establishment of a system that enables calm response under abnormal conditions
6. Key Points for Securing Safety in Railway Operators

○ Fundamentals of accident prevention
  ☆ In many cases, serious accidents occur as a result of multiple mistakes by personnel when minor trouble occurs.
  ⇒ Do not ignore minor trouble; take proper action.
    ―― Thoroughgoing implementation of routine inspections and maintenance.
  ⇒ Create an environment where personnel can respond calmly during abnormalities.
    ―― Correct education and training, release from stress.
  ☆ It is important to establish rules that can be executed under both normal and abnormal conditions.

○ Fate of organizations that hinder safety
  • Management: Cost reduction, improved service, increased income and profit …
    ―― Unable to listen to what the site is saying item by item ⇒ Ignore site
  • Personnel at site: Severe work environment, irregular sleeping time, fear of accidents …
    ―― Damage if person reports trouble to superior and is reprimanded
    ⇒ Hide trouble
  ☆ Important to create an environment where it is easy to report trouble, and cultivate management people who can correctly grasp/analyze the condition at the site.

7. Key Points of Safety Audits

○ Purpose of audits
  The purpose of audits is not to expose violations, but to secure safety and prevent recurrence of accidents.

○ General procedure (normally, approximately 3-5 days)
  • Listen to the general condition of business, measures for securing safety, etc. from management
  • Document investigation of facilities, rolling stock, operation, etc. by field: Condition of maintenance of regulations, existence/condition of use of records of inspection/maintenance, etc., condition of sharing of accident information,
etc.

- Site investigation
  - (Work under normal conditions) Condition of observance of regulations, condition of management of facilities, rolling stock, etc., condition of work of personnel (degree of overtime work, taking holidays, etc.), condition of education and training, etc.
  - (Response during abnormalities) Contact system, passenger evacuation guidance methods, condition of emergency equipment such as fire extinguishers, guide lights, emergency exits, evacuation ladders, etc., condition of training in response during abnormalities, etc.
- Evaluation of condition of efforts to secure safety, analysis of problems

- Response after audit
  - If no problems, praise.
  - In case small, seemingly-frequent problems are discovered, give gentle guidance.
  - If serious problems such as violations of law, etc. are discovered, give strict guidance in writing, for example, "Recommendations," "Work improvement order," etc.

8. Summary

- Since a railway system is materialized from many elements, such as rolling stock, signals, and tracks, the safety of the total system cannot be secured simply by performing proper inspection/maintenance of the individual equipment.

- It is important to conduct training of personnel assuming a variety of cases, prepare equipment for response during abnormalities, etc. so that a proper response is possible, particularly during abnormalities.

- The first point is how to enhance the safety consciousness and skills of the site personnel who operate, inspect, and maintain the individual pieces of hardware.

- The second, and even more important point is the existence of a management team that takes an overview of the system as a whole and works to improve safety at all times.
Tokyo Metro’s Experience

Best practices and Learning from mistakes

December 13, 2013
Tokyo Metro Co., Ltd.

Group Ideals

Keeping Tokyo on the Move

At Tokyo Metro Group, with the railway business at the core of our business development, we support the capital city Tokyo’s urban functions and make Tokyo even more attractive and vibrant. Through outstanding technology and creativity we provide safe and comfortable transportation daily, contributing to the active lives of all people who gather in Tokyo.
1. Tokyo Metro Outline - Company outline

Capital: 58.1 billion JPY (618 million USD)

Stockholders: Government (53.4%), Tokyo Metropolitan Government (46.6%)

Business contents:
1. Operation and management of subway business in and around the heart of Tokyo
2. Managing other affiliated businesses (Real estate leasing business, commercial tenant business, advertising business and others)

Net sales:
- Unconsolidated: 343.6 billion JPY (3.7 billion USD)
- Consolidated: 382.2 billion JPY (4.1 billion USD)

Income from fares: 298.6 billion JPY (3.2 billion USD)

Number of employees: 8,692 employees (As of 31 March 2013)

Group companies:
- Commissioned railway services
- Real estate business
- Commercial tenant business with a total of 11 companies

*1 USD = 94 JPY

Operating lines:
- 9 Lines
  - Ginza: 14.3 km
  - Marunouchi: 27.4 km
  - Hibiya: 20.3 km
  - Tozai: 30.8 km
  - Chiyoda: 24.0 km
  - Yurakucho: 28.3 km
  - Hanzomon: 16.8 km
  - Namboku: 21.3 km
  - Fukutoshin: 11.9 km

Route length: Total 195.1 km

No. of stations: 179 stations

No. of cars: 2,719 cars (As of March 31, 2013)

Average number per day: 6.44 million (FY2012)

Minimum headway: 1 min 50 sec (Marunouchi Line)

* Toei Subway operates four other subway lines.
1. Tokyo Metro Outline
- Railway business (Comparison with Hanoi’s plan)

(1) Change in number route length and number of passengers carried

(2) Change in ratio of transport volume on different modes of transport (in Tokyo 23 wards)

* Tokyo Metro’s ratio is an estimate
1. Tokyo Metro Outline
- Related business (Ratio of total operating revenue from related business)

Other businesses

85%
Railway business

15%

Total revenue of Tokyo Metro Group

4.1 billion USD

* 1USD=94JPY

1. Tokyo Metro Outline
- Outline of related business (Retail business)

- Commercial buildings
- Echika Malls
- Metropia Shops
- Kiosks
- ATMs/baggage lockers

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1. Tokyo Metro Outline
- Outline of related business (Echika Ikebukuro- before development)

Diagram of station before renovation

1. Tokyo Metro Outline
- Outline of related business (Echika Ikebukuro- after development)

Diagram of station after renovation
1. Tokyo Metro Outline
   - Outline of related business (Real estate)

   - Office building
   - Hotel
   - Driving Range
   - Storage Room
   - Multi-purpose Complex

2. Tokyo Metro Outline
   - Outline of related business (Advertising business)

   ▶ Advertising media on trains
   - Poster
   - Hanging Poster
   - Poster above door
   - Poster above window
   - Twin sticker (above door)
   - Hand strap Ad
   - Posters on both sides of door Twin☆Star
   - Other – Reserving all advertising space on a train (U liner)
   - Reserving all hanging space inside a train (SU liner)
   - Car wrapping

   ▶ Advertising media in stations
   - Poster
   - Metro Premium Set
   - Metro Super Premium Set
   - Fare Gate Ad
   - Event Space Portable Board
   - U Board
   - Column wrapping Ad
   - Mirror Ad
   - Platform door Ad
   - Large Board
   - Ad on station name sign
   - SP Development
   - Twin sticker (above door)
   - Hand strap Ad
   - Other

   ▶ Digital signage
   - On trains
     - Tokyo Metro Vision
   - In stations
     - Marunouchi line “Station Vision”

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2. Tokyo Metro’s Experience - Best practices and Learning from mistakes
-Best practice (1) Through-service operation

Succeeded in bringing passengers into the city center from the suburbs by creating a seamless ride (transfer not necessary)

- Eliminating the transfer from other transport modes, and improving conveniences such as direct connections with buildings above, have been the key points in attracting more passengers to the subway

- IC card system (PASMO)
  - One IC card is interoperable with railways throughout Japan
  - It also can conveniently be used for shopping
2. Tokyo Metro’s Experience - Best practice and Learning from mistakes
-Best practice (3) Ingenuity in company operation

-Operation using fare revenue (fare system approved by government)
  ➢ Succeeded in self-reliant efforts such as improvement of passenger service, reducing construction and operation cost

-The railway business is comparatively loosely regulated (Ex. business plans do not require approval from the central government, but must be reported)
  ➢ Autonomy of management was born, leading to ingenious efforts toward safe and stable operation, improvement of passenger service, creating comfortable underground (station) space etc.

Utilizing awareness and proactivity as a private entity

2. Tokyo Metro’s Experience - Best practice and Learning from mistakes
-Learning from mistakes (1) Railway business facilities

-It is extremely difficult to expand space and install new facilities in the subway (due to the immense cost, lengthy construction period while still continuing train operations)
  ➢ Construction incorporating future demand (town development) and changes in social environment
  ➢ Facilities should be installed with as much leeway as possible, keeping in mind handling emergencies, inspection for maintenance, and facility upgrade

Renovation at Kiba sta. on the Tozai line

Change in number of passengers using Kiba sta.

Increase in number of passengers exceeded the estimates at the time operation began, due to development of the area along the line
⇒ Congestion on platform and concourse

Expansion of platform and concourse, as well as improvements in safety and convenience, such as installation of elevators and escalators

Decision to renovate the station

Twice as many users as when began

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2. Tokyo Metro’s Experience - Best practice and Learning from mistakes
- Learning from mistakes  (1) Railway business facilities

There are not enough barrier-free facilities on the older lines
Station space is limited and it is difficult to obtain the necessary land above ground due to urbanization of Tokyo

Despite these severe constraints, we have made various creative adjustments in order to secure space for at least one barrier-free route from the platform to ground level

2. Tokyo Metro’s Experience - Best practice and Learning from mistakes
- Learning from mistakes  (2) Proactive development of related businesses

Due to strict regulation of related business up until the mid 1980’s ...

- Space purchased during construction was the minimal absolute necessary
- Station facilities installed not supposing future development of related business

- It is important to make use of station concourse and station space to expand related businesses in order to improve the convenience of railway users and entice more people to use the subway
- Also, related business development contributes to the variance on risk management
  ➢ Promote development of stations that can have related businesses expanded in them from the very beginning
  ➢ Enterprise to have assets where related businesses can be expanded freely in the future (land close to entrances/exits and land that was once used for material storage during construction)
2. Tokyo Metro’s Experience - Best practice and Learning from mistakes

-Learning from mistakes (2) Proactive development of related businesses

- Metro Stage (Rental condominium)
  Effective use of land that had once been used for storing materials during construction

- Belle Vie Akasaka
  Effective use of available land above a station

- Echika
  Space in stations made available through large-scale renovation and reorganizing facilities

- AOYAMA M’s TOWER
  Effective use of space by moving substation underground

Thank you for your attention.
Two-wheeler Cities

In some Asian cities, two wheeler is the largest modal share. ⇒ It is defined as “two-wheeler cities”
Characteristic of Two-wheeler Cities

Urban and transport indices of two wheeler cities are examined in the comparative perspective with the findings about 100 global cities.

Metro Operation Relative to GDP per capita and Urban Population Size

by Koizumi, Nishimiya & Kaneko (2013)
1. Necessity of Regulation/Incentive at Monopoly Market

- Monopoly occurs when one firm can supply the entire market at a lower price than two or more firms can.
- Railway firms, Electricity firms, Gas firms... They need huge initial cost, so there are serious “Entry barriers”.
- The barriers derives Monopoly market.
Case of “Perfect Market”, price is determined through the competition among many firms. → Firms is “Price Taker”

\[ \pi(Q) = PQ - cQ \quad \text{Profit function} \]

\[ \frac{\partial \pi(Q)}{\partial Q} = P - \frac{\partial cQ}{\partial Q} = 0 \]

Case of “Monopoly Market”, price is determined by monopoly firm. → Firms is “Price Maker”

\[ \pi(Q) = (a - bQ)Q - cQ = R(Q) - C(Q) \]

\[ \frac{\partial \pi(Q)}{\partial Q} = \frac{\partial R(Q)}{\partial Q} - \frac{\partial C(Q)}{\partial Q} = MR - MC = 0 \]

\[ P_M > P_P \quad Q_M < Q_P \]
How to avoid the “Monopoly Price/Quantity”

- Regulations by public sectors
  → Public sectors control the appropriate price
  → However, they don’t have enough information: such as demand/supply curve
- Monopoly firms should decide price with keeping the “Incentive for efficient management”

Representative Incentive Policies

1) Price Cap
A price-cap regulation is a price ceiling—a rule that specifies the highest price the firm is permitted to set. Price cap regulation gives managers an incentive to minimize cost because there is no limit on the rate of return they are permitted to earn.

Price Cap Method

<table>
<thead>
<tr>
<th>Price Increase Rate</th>
<th>Inflation Rate</th>
<th>Cost down by innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 10$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2) Yardstick regulation

In the yardstick regulation the performance of a regulated utility is compared against of a group of comparable utilities: for example, the mean of the costs of a peer group of firms can serve as performance.

→ Public sector should collect the cost information of peer firms, and open the statistics.

→ The lowest cost is selected as the yardstick and prices (fares) lower than the yardstick is approved.

2. “Yardstick regulation” for Japanese Railway

- The current system started in 1997.
- Process:
Calibration of “Standard Cost” [case of metro]

1) Rail Track Cost [cost/km]
   \[ y_1 = a_1(\ln[\text{car density}]) + c_1 \]
2) Cable Run Cost [cost/cable km]
   \[ y_2 = a_2(\text{car density}) + b_2(\text{ratio of cable run}) + c_2 \]
3) Car Cost [cost/car] → “maintenance cost”
   \[ y_3 = a_3(\# \text{ of passengers/car}) + c_3 \]
4) Car Operation Cost [cost/operating km]
   \[ y_4 = a_4(\text{ratio of “one-man” operation}) + \]
   \[ b_4(\ln[\text{car density}]) + c_4 \]
5) Station Service Cost [cost/station]
   \[ y_5 = a_5(\ln[\# \text{ of passengers/station}]) + c_5 \]

a) “Standard Cost” calibrated by three groups
   1) “JR companies” [6]
   2) “Major Private companies” [15]
   3) “Metros” [10]

b) Parameters (a., b., c.) are updated every year by using the latest 3 years data reported by each company.

c) MLIT (Ministry of Land, Infrastructure and Transport) has conducted all procedures and made public the results every summer.
### Basic Stat of Japanese Major Railway Companies

<table>
<thead>
<tr>
<th></th>
<th># of Cars</th>
<th>Operation km</th>
<th># of Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1.Hokkaido</td>
<td>1,095</td>
<td>2,500</td>
<td>465</td>
</tr>
<tr>
<td>J2.East</td>
<td>13,469</td>
<td>7,513</td>
<td>1,688</td>
</tr>
<tr>
<td>J3.Central</td>
<td>3,465</td>
<td>1,971</td>
<td>409</td>
</tr>
<tr>
<td>J4.West</td>
<td>6,534</td>
<td>4,992</td>
<td>1,222</td>
</tr>
<tr>
<td>J5.Shikoku</td>
<td>427</td>
<td>855</td>
<td>259</td>
</tr>
<tr>
<td>J6.Kyusyu</td>
<td>1,704</td>
<td>2,273</td>
<td>566</td>
</tr>
<tr>
<td>P01.Tobu</td>
<td>1,960</td>
<td>463</td>
<td>203</td>
</tr>
<tr>
<td>P02.Seibu</td>
<td>1,274</td>
<td>174</td>
<td>91</td>
</tr>
<tr>
<td>P03.Keisei</td>
<td>594</td>
<td>152</td>
<td>69</td>
</tr>
<tr>
<td>P04.Keio</td>
<td>843</td>
<td>85</td>
<td>69</td>
</tr>
<tr>
<td>P05.Odakyu</td>
<td>1,061</td>
<td>121</td>
<td>70</td>
</tr>
<tr>
<td>P06.Tokyo</td>
<td>1,252</td>
<td>105</td>
<td>97</td>
</tr>
<tr>
<td>P07.Keikyu</td>
<td>790</td>
<td>87</td>
<td>73</td>
</tr>
<tr>
<td>P08.Sotetsu</td>
<td>408</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>P09.Nagoya</td>
<td>1,060</td>
<td>444</td>
<td>275</td>
</tr>
<tr>
<td>P10.Kinki</td>
<td>1,934</td>
<td>505</td>
<td>288</td>
</tr>
<tr>
<td>P11.Nankai</td>
<td>702</td>
<td>154</td>
<td>99</td>
</tr>
<tr>
<td>P12.Keihan</td>
<td>716</td>
<td>91</td>
<td>87</td>
</tr>
<tr>
<td>P13.Hankyu</td>
<td>1,319</td>
<td>144</td>
<td>89</td>
</tr>
<tr>
<td>P14.Hansin</td>
<td>358</td>
<td>49</td>
<td>51</td>
</tr>
<tr>
<td>P15.Nishitetsu</td>
<td>329</td>
<td>106</td>
<td>72</td>
</tr>
<tr>
<td>M01.Tokyo-M</td>
<td>2,719</td>
<td>195</td>
<td>179</td>
</tr>
<tr>
<td>M02.Sappro</td>
<td>368</td>
<td>48</td>
<td>49</td>
</tr>
<tr>
<td>M03.Sendai</td>
<td>84</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>M04.Tokyo</td>
<td>1,110</td>
<td>109</td>
<td>106</td>
</tr>
<tr>
<td>M05.Yokohama</td>
<td>282</td>
<td>53</td>
<td>42</td>
</tr>
<tr>
<td>M06.Nagoya</td>
<td>788</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>M07.Kyoto</td>
<td>222</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>M08.Osaka</td>
<td>1,280</td>
<td>130</td>
<td>123</td>
</tr>
<tr>
<td>M09.Kobe</td>
<td>208</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>M10.Fukuoka</td>
<td>212</td>
<td>30</td>
<td>36</td>
</tr>
</tbody>
</table>

Calibrated 5 cost factors by each company [2012 stat.]
Calibrated 5 cost factors by each company [2012 stat.]

- Average “Cost by Yardstick” are as follows:
  a) JR: 42%, b) Major Private: 52%, c) Metro: 51%
- “Fair Cost” is derived from the difference between “Standard Cost” and “Actual Cost” (reported by companies)
Case of “inefficient” company
Actual > Standard = Fair Cost

Portion for Fare raise is small!

Case of “efficient” company
Standard > Actual
Fair = (Standard + Actual)/2

Portion for Fare raise is large!
3. Remarks on Fare Structure of Hanoi Metro

- Hanoi Metro should be profitable firm
  → Financially Independent
- Low Fare (High Social Benefit) vs. High Fare (Generating Profit)
- How to balance between other modes

<table>
<thead>
<tr>
<th>Income level</th>
<th>Competitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Private Car</td>
</tr>
<tr>
<td>Middle</td>
<td>Motorcycle</td>
</tr>
<tr>
<td>Low</td>
<td>Bus</td>
</tr>
</tbody>
</table>

- Majority in Hanoi is **Motorcycle!**
  → very difficult to switch from Motorcycle to Metro (regarding travel time, travel cost & free to move)
- However, price competition with other modes should be avoided (especially with Bus!)
  → Principle of “**Financially Independent**”

---

### Cost/ Revenue/ Subsidy of Bus Service in Hanoi

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>million vnd</td>
<td>308,679</td>
<td>329,232</td>
<td>372,629</td>
<td>383,949</td>
<td>395,936</td>
</tr>
<tr>
<td>Subsidy</td>
<td>million vnd</td>
<td>203,183</td>
<td>236,955</td>
<td>440,425</td>
<td>424,807</td>
<td>620,867</td>
</tr>
<tr>
<td>Expense</td>
<td>million vnd</td>
<td>506,749</td>
<td>566,521</td>
<td>813,054</td>
<td>808,756</td>
<td>1,016,804</td>
</tr>
<tr>
<td>Revenue/Expense</td>
<td>%</td>
<td>60.9</td>
<td>58.1</td>
<td>45.8</td>
<td>47.5</td>
<td>38.9</td>
</tr>
<tr>
<td>Subsidy/ Expense</td>
<td>%</td>
<td>40.1</td>
<td>41.8</td>
<td>54.2</td>
<td>52.5</td>
<td>61.1</td>
</tr>
</tbody>
</table>

Source: TRAMOC

Buses can be sustainable without subsidy, provided the fare is 2.5 times of the present, that is, by raising from vnd 5,000/ride to vnd 15,000/ride.
Fare Ratio of Rail/Bus/Taxi

Fare Level by Distance
4. Legal System for Transportation/Land-Use Development (Case in Japan)

How to produce spaces for transportation facilities or public spaces

Comparison of Urban Development Projects Systems in Japan

<table>
<thead>
<tr>
<th>Name of Systems</th>
<th>Land Readjustment Project</th>
<th>Urban Redevelopment Project</th>
<th>New Residential Area Development Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
<td>Replotting¹ (Exchanging Rights from One Land to Another)</td>
<td>Right Conversion² (Exchanging Rights from a Land to a Building Floor)</td>
<td>Whole Purchase Including the Right of Compulsory Expropriation</td>
</tr>
<tr>
<td>Objective</td>
<td>Development of Public Facilities Increase of Use in Building Lots</td>
<td>Development of Fire-resistant Building Development of Public Facilities Rational and Sound High Utilization of Land</td>
<td>Planned development of new built-up area by single implementing body.</td>
</tr>
<tr>
<td>Target Areas</td>
<td>Applied Broadly from Urbanized Area to New Town</td>
<td>Urbanized Area</td>
<td>New Town</td>
</tr>
<tr>
<td>Project Size</td>
<td>Usually more than a few ha</td>
<td>Several ha (Mainly 1-3 ha)</td>
<td>More than 100ha</td>
</tr>
<tr>
<td>Implementing Bodies</td>
<td>Individuals, Cooperatives, Local governments, Public Corporations³⁶</td>
<td>Individuals, Cooperatives, Local governments, Public Corporations⁶⁷</td>
<td>Local Governments, Public Corporations</td>
</tr>
<tr>
<td>Achievement⁵⁸</td>
<td>395,206 ha</td>
<td>1,193 ha</td>
<td>17,943 ha</td>
</tr>
</tbody>
</table>

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**Figure 8-2** Framework of Land Readjustment Project

- To adjust snaky roads
- To make public spaces
- To increase asset value

- A, A': Area
- H, H²: Land price

- Mr. A's lot (replot) after readjustment

- The contributed portion of the lot

- Lot area decreases due to contribution
- Land price increases due to the improvement of urban facilities

- Reserve land
- Contribution to reserve land
- Capital from disposition of reserve land covers project cost.
Japanese experience for coordinated development of "railway & residential area", "railway company & local government"

**Case of TSUKUBA EXPRESS**

- Length: 60 km, 20 stations
- Max speed: 130 Km/h
- Average speed: 77 Km/h (45 min. for 60 Km)
- Frequency: 16 trains during peak hour
- Total construction cost: 8.2 Billion US$
- Term of Construction:
  - 1994 to 2005 (Operating from August 2005)
New law, “The Special Measures Law for Coordinated Development of Residential Areas and Railways in Metropolitan Areas” was approved and enforced in 1989 for the construction of “Tsukuba express”

Purpose of the law:
- for facilities simultaneous construction of railways and development of residential land for large housing projects
- to promote railway development hand-in-hand with development of land near the proposed right-of-way
- to promote simultaneous development of railway land, roads, parks, residential lands and other urban facilities
- The railway construction company and its partners in the public sector buy up land lots during the preliminary stage and these lots are finally assembled and/or substituted for other lots to create a contiguous stretch of land purchased by the railway operator

Kazunobu YAMADA (2005): “Tsukuba Express”, Japan Railway & Transport Review 42

Concept of Implementation of “New Law”

1st STEP (Before construction)
- Station area was decided
- Local government, railway company buy up lands near station to produce station/rail space

2nd STEP (Replotting into station)
- The lands bought up are replotted into station/rail lots

3rd STEP (Station/area development)
- Completion of station, rail, roads, parks and other public facilities for better QOL!
- Coordination for better space with station & residential area
- Coordination by railway company, local government and private sectors
- Coordination through efficient/equitable money flow
Railway-Oriented Land Use Pattern in Tokyo Metropolitan Region

BUSINESS OPERATED BY PRIVATE RAIL COMPANY

<table>
<thead>
<tr>
<th>BUSINESS</th>
<th>RANGE OF ACTIVITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>Railway operations; bus services; taxi services; car rentals; trucking; aviation; shipping; freight forwarding; package delivery; manufacturing of rolling stock</td>
</tr>
<tr>
<td>Real Estate</td>
<td>Construction, sale, and leasing of housing, office space, hotels; architectural and engineering services; landscaping</td>
</tr>
<tr>
<td>Retailing</td>
<td>Construction and operation of department stores; supermarket chains, station kiosks, catering services, and specialty stores</td>
</tr>
<tr>
<td>Leisure and Recreation</td>
<td>Construction and operation of resorts and spas, amusement parks, baseball stadia, multiplex movie theatres, fitness club, golf courses; operation of travel agencies</td>
</tr>
</tbody>
</table>
THE TOKYU CORPORATION

The largest rail-based conglomerate in Japan
Operates 7 main lines and one street car; in 1993, it served more than 961 million passengers which is larger than any other company
In all, it owns 389 subsidiary business; in 1992 earned revenues exceeding $35 billion; capital assets worth more than $4 billion

ECONOMICS OF PRIVATE RAILWAY INITIATIVES
Rail operations have hardly been the most profitable ventures of private rail companies
Despite the government’s fare regulation, all private rail companies made a profit; in 1993, all companies earned at least 30 percent return on real estate
Other than rail services, Bus, Real Estate Development are among the major source of profits
“Tama Hills” in Southwest Tokyo

• Before 1945, the Tama Hills, southwest of Tokyo were largely forested and occupied by small villages along an old trunk road.
• After World War II, many farmers migrated to the area.

“Tama Garden City Plan” by Tokyu Railway Company

In 1953, Mr. Keita GOTO unveiled a "new town" planning scheme called the South-Western Area Development Plan.

DESIGN OF TAMA DEN-EN TOSHI

Designed with two town centers and housing estates around the 19 stations along Tokyu’s Denin Toshi rail line

To jump start the construction, Tokyu sold land to public housing corporations

Tokyu also builds pools, tennis courts, museum, and sports facilities to attract potential residents and sell housing at premium prices

To attract big institutions, land were donated or sold below market value in return to generate development and ridership
Advertising examples of real estates in Tama Den-en Toshi...