4.10.4 Platform Screed Door (PSD)

(1) Present Condition of PSD in Metros

There are no PSD systems in the existing Metro Line 1 and 2, and no PSD development plan for Metro Line 3.

(2) Proposed System

As discussed in the previous chapter which dealt with the basic requirement of railway system for Metro Line 4, the PSD system brings several benefits for the railway operators. These benefits include:

- Prevention of collision with persons on the tracks,
- Fewer delays caused by safety incidents,
- Reduction in the energy costs caused by loss of cooled air at underground stations, and
- Minimal requirement of the number of station staff and train crew.

In order to enjoy these benefits, current railway operators tend to introduce the PSD system. The following table shows the example of full-height PSD system in tropical countries.

Table 4-97 Example of Full-height PSD in Tropical Climate Countries

Country	PSDs Provided
1. Bangkok	Yes
2. Singapore	Yes
3. Hong Kong	Yes
4. Delhi	No
5. Dubai (Under construction)	Yes

Source: JICA Study Team

There are two types of PSDs i.e. 1) Full-height PSD and 2) Half-height systems. The full-height PSD system is generally used at underground stations for the purpose of passenger safety, reduction of the number of station staff and crew and decreasing energy cost for air-conditioning. In contrast, the half-height PSD system is generally introduced at elevated and/or at gated stations.

Half-height PSD in China

Full-height PSD in Bangkok

Under such conditions and situation, the JICA Study Team recommends the following PSD systems to be introduced at Metro Line 4.

- The full-height PSD system will be introduced at underground stations, except the El Remayah station (M4W Sta. No. 12)
- The El Remayah station will be provided with a half-height PSD system due to the architectural design requirement.

(3) System Function and General Specifications

a) System Composition

The PSD system consists of following facilities as minimum requirement:

- Fixed screens and sliding screen doors
- Exit/entrance door for driving cabin with suitable locking system
- Appropriate individual and integrated control and monitoring system for driver and station personnel
- Safety system with sensors, alarms and indicators
- Control cables
- Structural frame, fixing materials

The general system configuration of PSD is shown in Figure 4-308.

b) General Requirement and Specification

- The PSD system should be designed to accommodate an 8-car train;
- The structural design of the PSDs should take into account the effects of train air pressure and crowd loading pressure;
- The PSD system should prevent unauthorized person access from the station platforms to the main line (restricted area);
- Each fully-equipped door set should consist of bi-parting, power-operated sliding screen doors. The sliding screen doors should be synchronously controlled throughout the length of the platform. The sliding screen doors

should provide a clear opening width of not less than 350 mm wider than the clear opening width of the vehicle doors taking into account the train stop accuracy and a clear opening height of not less than 2.0 metres above the finished floor level.

- The time for unlatching and opening should be no longer than 3 seconds. The time for closing and latching should be no longer than 3.5 seconds and should be achieved within a maximum speed of 0.5 metres/second. The opening and closing time should be adjustable from 2.5 seconds to 4.0 seconds. Each door opening or closing speed should not vary by more than +/-10% when compared with the speed of adjacent doors on the same platform.
- The sliding screen doors should include an obstruction detection system, which should be capable of detecting any obstruction causing a gap of more than 20 mm between a pair of sliding screen doors, and between sliding screen and train body. In the event of an obstruction causing a gap of less than 20 mm becoming trapped, the sliding screen doors closing, the compression of the sliding screen door seals should be such as to allow the obstruction to be removed.
- The gap between the PSD and car limited gage should not be less than 200 mm.
- The PSD should be equipped with small windows to operate release lever for train door opening in an emergency. The location of the windows should correspond to the location of the release levers installed on the train.
- The PSD should maintain the required insulation between the PSD and passengers to prevent possible electric shock due to the potential difference between passenger in train and PSD. The required insulation value should not be less than 0.5 M ohm when measured with a test voltage of 500 V DC being applied between the PSD surface and platform structure.

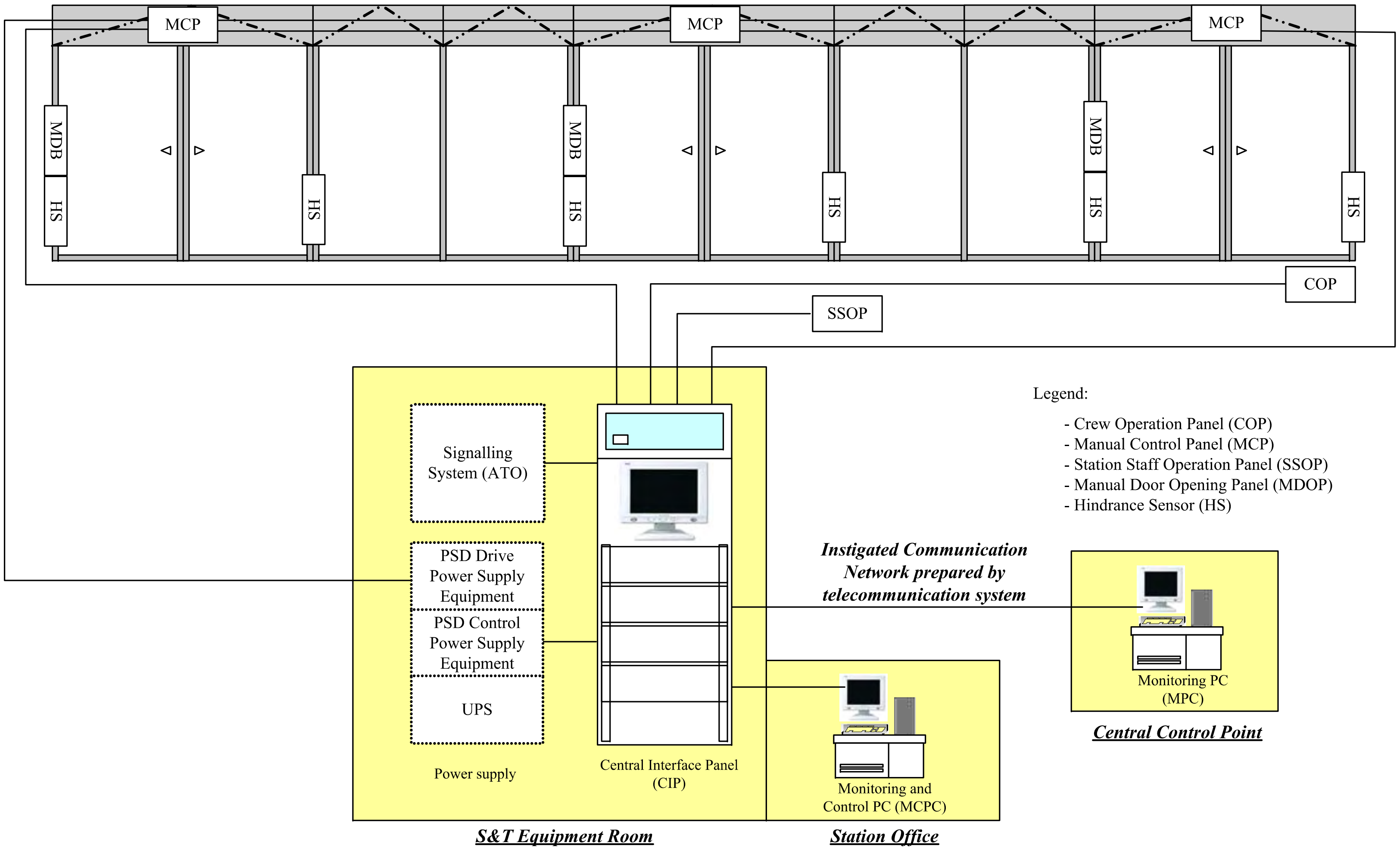


Figure 4-308 General System Configuration for PSD

c) Opening and Closing Operation

When a train is correctly positioned at a platform, the PSD system should receive door command signals, which originate from the train via the signalling system, to either open or close the sliding screen doors. The open and close command signals will correspond with the operation of the train passenger doors, ensuring that the train passenger doors are synchronized with the sliding screen doors.

The opening operation of the sliding screen doors should be synchronized with the train passenger doors following a short delay provided by the train, ensuring that the PSD sliding screens open first. Similarly the closing operation should also be synchronized with the train passenger doors to ensure that the train passenger doors close first, again following a short delay provided by the train. The time difference of both opening and closing of the sliding screen doors, compared with the operation of the train passenger doors, should be identical in every station.

In the event of a trackside signal transmission failure, preventing the train from transmitting door control commands, local means should be provided on the platform or into the PSD, accessible only to authorized staff to manually activate either an open or close command of the sliding screen doors. In the event that a local door command is activated, a corresponding message should be transmitted.

In case of malfunctioning of the PSD system or in an emergency, the PSD sliding screens should be manually opened through the passenger's operation.

d) Monitoring and Control

The PSD system should have appropriate control and monitoring panels, including, but not limited to, the following:

<u>Central Interface Panel (CIP)</u>

This panel will be installed in the equipment room with following functions:

- Control of all functions
- Interface between signalling system and PSD system
- Output of alarm and monitoring signal
- Maintenance status indication
- Interface with other systems (i.e. Facilit-SCADA)

<u>Monitoring and Control PC (MCPC)</u>

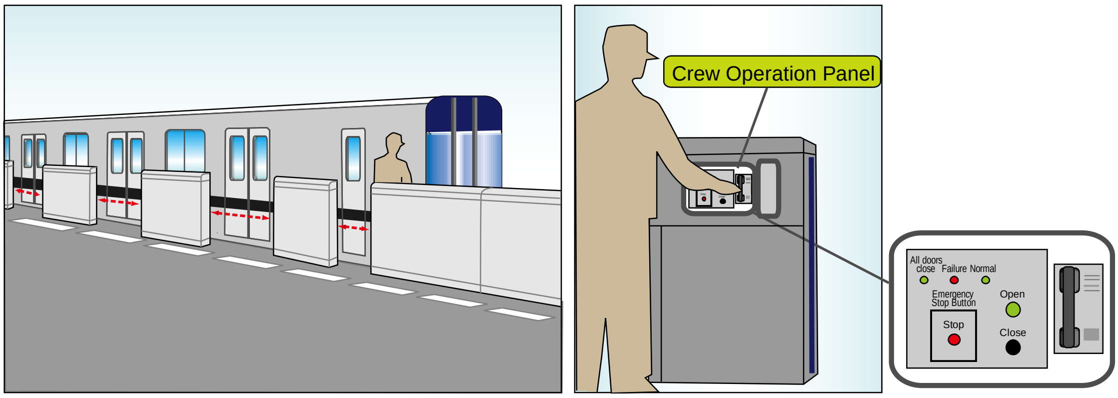
This panel will be installed in the station office with following functions:

- Individual and group control of sliding screen door
- Individual and group monitoring, including alarm

- All closed status
- Manual open/close control status
- Fault conditions, etc.

Crew Operation Panel (COP)

This panel will be installed in the track side of the PSD near the driver's cabin. In case of malfunction in the automatic operation mode, sliding screens can be manually opened and closed by authorized persons after selecting the manual mode.

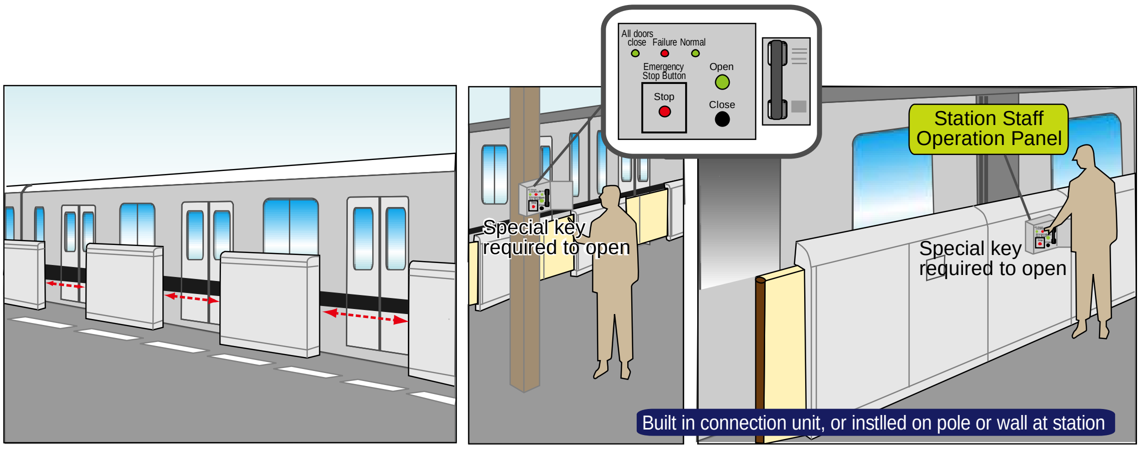


Source: JICA Study Team

Figure 4-309 Image of COP

Station Staff Operation Panel (SSOP)

This panel will be installed in the platform side of the PSD at the appropriate position of platform. In case there is malfunctioning of the automatic mode, authorized station staff will control (open/close) the sliding screen door using this panel.

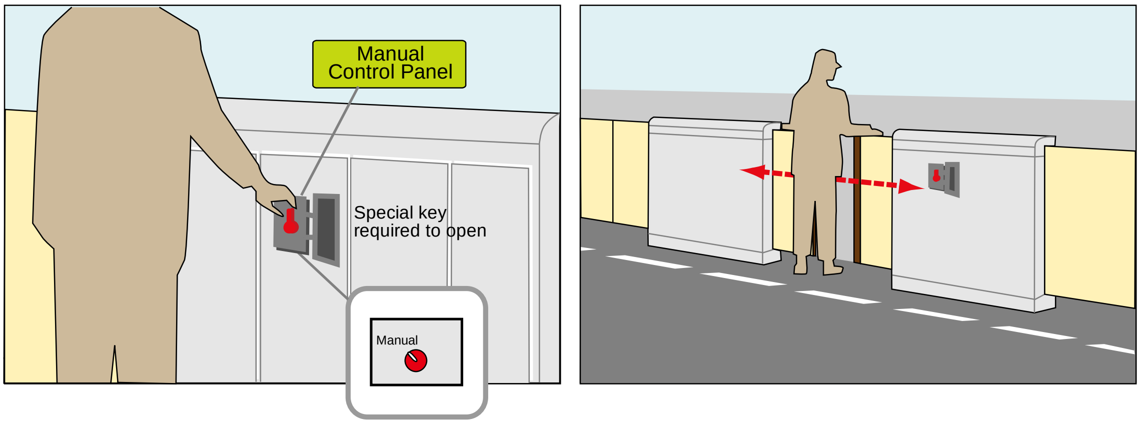


Source: JICA Study Team

Figure 4-310 Image of SSOP

Manual Control Switch (MCS)

In case of trouble of the system such as failure of power supply and automatic operation mode, sliding screens should be manually controlled by the station staff. For this purpose, a manual and automatic changeover switch should be installed in each pair of sliding screens at the platform side.

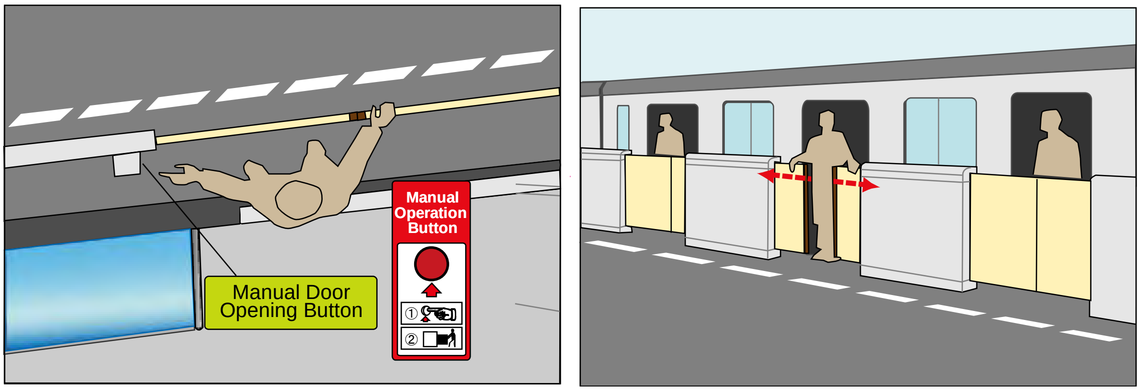


Source: JICA Study Team

Figure 4-311 Image of MCS

Manual Door Opening Button (MDB)

In case of emergency such as evacuation from the train to platform under power failure conditions and no-station staff in the platform, sliding screens should be manually opened by means of the passengers' operation. For this purpose, manual door opening button (MDB) will be installed in each pair of sliding screens at the train side.



Source: JICA Study Team

Figure 4-312 Image of MDB

Hindrance Sensor (HS)

In order to prevent accidents, a pair of hindrance sensors will be installed on each pair of sliding screens.

The hindrance sensor detects obstruction between the pair of sliding screens, and between the sliding screen and train body. When the sensor detects the obstruction during the closing operation, the door automatically stops the closing operation. After the obstruction is removed, the sliding screen starts the closing operation again.

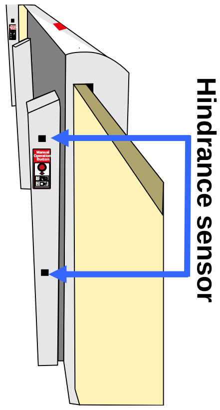


Figure 4-313 HS

e) Indicator and Alarms

Each sliding screen door should include an associated 'door open' indicator light, which should be amber in colour, that should be illuminated when the sliding screen door is open and turned off when the sliding screen door is finally closed and latched. The light should be flashing when the sliding screen door is moving.

The indicator should be placed in a position above the associated sliding screen door and should be clearly visible to the station personnel when standing at the end of platform.

Each sliding screen door should also incorporate an additional red status indicator light to identify either an 'out of service' condition or malfunction on that sliding screen door e.g. failure to open or close when instructed. The 'out of service' indicator light should be located so as not to be confused with the 'door open' indicator.

In the event that a sliding screen door is 'out of service', a remote indication of the condition should be transmitted to the station office.

In order to call a passenger's attention, a chime or sound should be automatically activated during the time of opening and closing of the sliding screen doors.

f) Power Failure

In the event of failure of the normal power supply to the PSD system, the PSD system should continue to operate from the UPS provided by the power supply system at each station for a period of not less than 30 minutes. In the event of loss of all power supply, the sliding screen doors should remain in the same status, i.e. if the sliding screen doors were open, they should remain open, and similarly if they were closed, they should remain closed, except by manual operation.

(4) Estimated Cost of PSD

The estimated cost of the PSD for Metro Line 4 is presented in Chapter 7.

4.10.5 Automatic Fare Collection (AFC) System

(1) Present Condition of AFC in Metros

AFC system has an important role to increase railway business activities not only for revenue control but also to assist in the efficient railway operation through the collection of passenger information and enhance passenger convenience. The specific benefits include:

- Revenue control
- Assists efficient and timely railway business through collection of the following passenger information:
  1. Number of passengers at each station
  2. Number of passengers in peak hours and off-peak hours
  3. OD (Origin to Destination) data, etc.
- Enhance passenger convenience by using the contactless IC ticket, and
- Labour savings for staff by the introduction of automation.

In order to obtain such benefits, the Egyptian Company for Metro (ECM), formerly the Cairo Metro Organization (CMO), and NAT are implementing AFC development within Metro Line 1 and 2, and Metro Line 3, respectively.

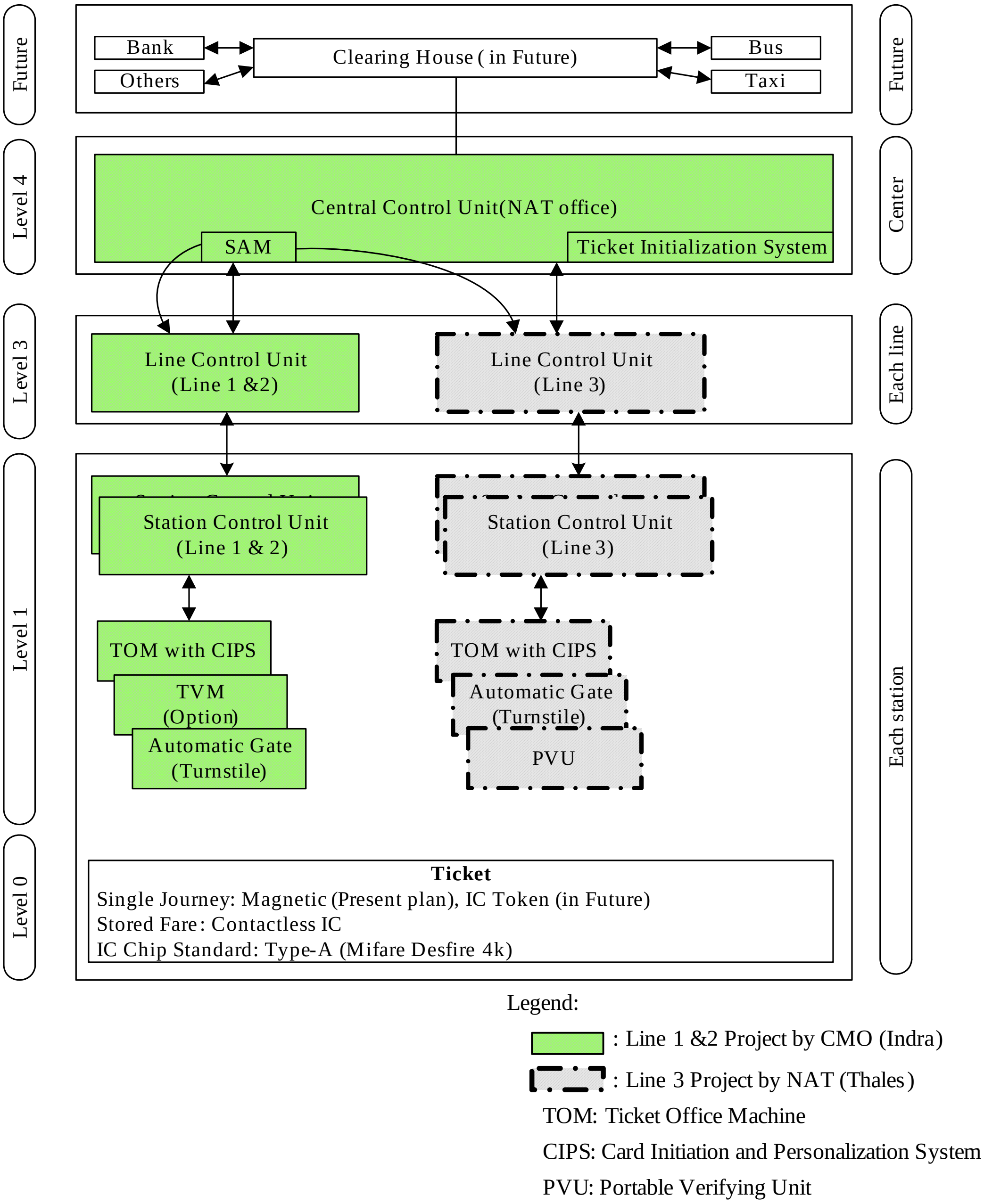
Table 4-98 Current AFC Development in the Metro

Item	Metro Line 1 and 2	Metro Line 3
1. Expected commencement of service	Dec. 2009	Oct. 2011
2. Responsible Organization	CMO	NAT
3. Contractor	Indora	Thales
4. Major Systems		
・ Central Control Unit (CCU) with Ticket Initialization System (TIS)	Equipped	Not equipped
・ Line Control Unit (LCU)	Equipped	Equipped
・ Station Control Unit (SCU)	Equipped	Equipped
・ Automatic Gate	Turnstile	Turnstile
・ Ticket Office Machine	Equipped	Equipped
・ Ticket Vending Machine	Option	Not equipped
・ Ticket media	Single Journey: Magnetic Ticket (MT) Stored Fare Ticket (SF): IC Note: IC token will be utilized in the future	
・ Ticket standard	ISO/IEC1443 (Type-A, Mifare Desfire 4k)	

Source: Information from ECM, JICA Study Team

(2) System Integration

The ECM and NAT have shared vision to establish an integrated AFC system to be applied to the present and future Metro lines that could be managed by different operators. For this purpose, an integrated policy entitled “Unification of the Technical Specifications” has been prepared by CMO in 2006. After the integrated policy has been prepared, series of intensive meetings have been held between ECM and NAT to clarify the integration concept. As a result, the following integration policy and implementation demarcation were agreed by the ECM and NAT in June 2009. The following Figure 4-314 presents the system unification plan that was agreed by the two parties.

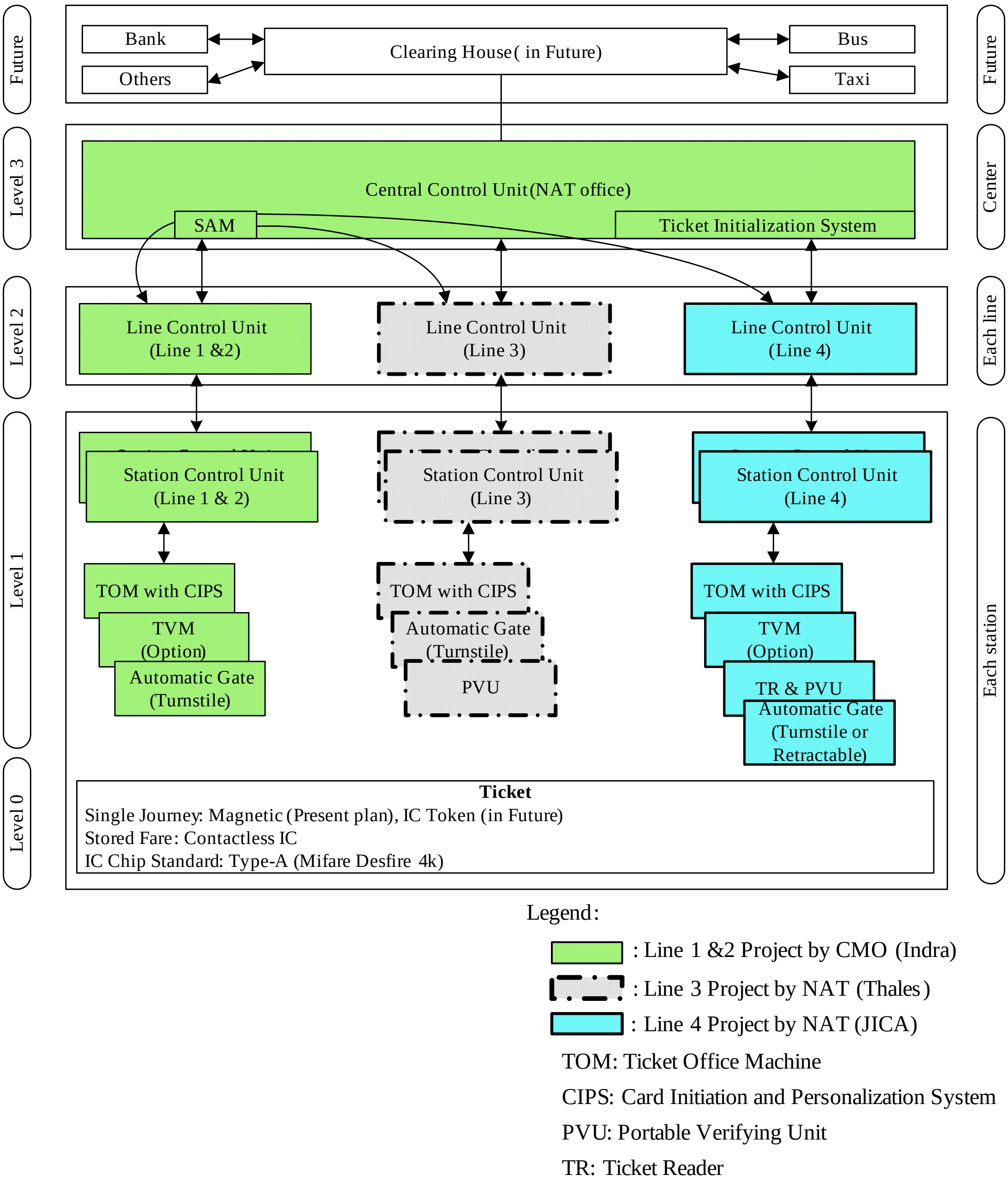


Source: JICA Study Team

Figure 4-314 System Unification Plan for AFC Development in Lines 1 and 2, and Line 3

(3) Proposed System Architecture

For Metro Line 4, it is planned to construct two transfer stations: one will be El Malek El Saleh transfer station for Metro Line 1 and another will be El-Giza transfer station for Metro Line 2. Therefore, the ticketing system among Metro Line 1, 2 and 4 should be integrated in order to establish a unified fare management system and avoid inconvenience of passengers. To achieve this, JICA Study Team proposes an integrated AFC system with foregoing project such as Metro Line1 and 2, and Metro Line 3 under the common ticket concept. The Figure 4-315 shows the proposed conceptual system architecture with system demarcation between other prior projects and the Metro Line 4 system.



Source: JICA Study Team

Figure 4-315 Conceptual System Architecture of Integrated AFC System in Metro

(4) System Concept and Components

In order to integrate the AFC system of Metro Line 4 and other foregoing projects (especially in Metro Lines 1 and 2), the communication procedure, data format and transaction process of the AFC system for Metro Line 4 should follow those of the previous projects.

Based on the above concept, the AFC system for Metro Line 4 can be classified into four levels, i.e., from level 0 to level 3 that includes following components:

- Ticket (Magnetic and IC ticket)
- Ticket Office Machine (TOM) with Card Initialization and Personalization Function (CIPF)
- Ticket Vending Machine (Option; the applicability of TVM will be determined after commencement of service of Metro Line 3 AFC system)
- Ticket Reader (TR)
- Portable Verifying Unit (PVU)
- Automatic Gate (AG)
- Station Control Unit (SCU)
- Line Control Unit (LCU)
- Network facilities including cable, hub, switch, router

Level 0 is the fare media that are used by the passengers to buy their travels according to the fare rules such as “Flat rate”, “Zone rate”, “Distance based rate”, etc. and fare tables which will be decided in the future. It is noted that contactless card have to be pre-personalized with security keys before actual use by the TOM or Ticket Vending Machine. This process will be done by the Ticket Initialization System (TIS) or other means under the Metro Line 1 and 2 project.

Level 1 is the station facilities that include the TOM) with CIPF, Portable Verifying Unit (PVU), and Automatic Gate (AG).

Level 2 is located between level 1 facility called SCU and Level 3 computer system named LCU. The SCU deals with following main functions:

- Download of operational and technical parameters form LCU
- Download of new software of the equipment
- Monitoring and control of station equipment
- Upload sales and transaction data to the LCU
- Upload alarms and events to LCU received form equipment

Level 3 is the Central Control Unit (CCU) which deals with following functions.

- Control and monitoring of level 2 and level 1 facilities in Metro Line 4
- System security management using public keys infrastructure with PKI-SAM

- Monitoring and control of station equipment in Metro Line 4
- Traffic and transaction management in Metro Line 4
- Processing and reporting of both financial and traffic statistics in Metro Line 4
- Communication with CCU

(5) System Function and General Specifications

a) Ticket Media and IC Chip Standards

Ticket media and IC standards should be common among metros. Therefore, the ticket media and IC chip standard of Metro Line 4 follows the previous projects.

Table 4-99 Ticket Media and IC Chip Standards

Item	Specification	
Ticket Media	Single Journey	Magnetic Ticket (MT) Contactless IC Token (Option)
	Stored fare	Contactless IC Card (CICC)
IC Chip standard	ISO/IEC 14443 (Type-A)	
Card size	ISO 7810	
Data transmission protocol between IC and antenna	ISO/IEC 18092 (NFC IP-1)	

Source: JICA Study Team

In the prior projects (Metro Line 1 and 2, Metro Line 3), there is no concrete plan to use the IC token. Therefore, the JICA Study Team recommends that utilization of the IC token in Metro Line 4 will be determined in the future stage.

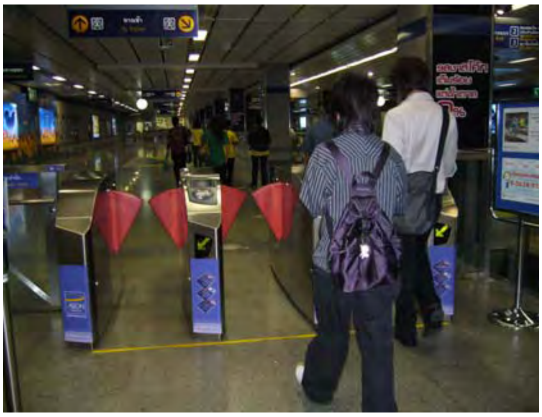
b) Automatic Gate (AG)

The AG has the function to control passenger movement between the paid and unpaid areas by reading the magnetic ticket and contactless IC ticket, checking their validity, and actuating a controlling barrier. The IC ticket reader and writer (R/W) is capable of reading at least Type-A. The AG is also equipped with the insertion slot of magnetic ticket, R/W with mechanical feeding system and ticket collection box.

The following three types of automatic gates are generally applied in other parts of the world. Current railway operators tend to choose the retractable or flap-type gate from the technical and design point of view.

Source: JICA Study Team

Flap-type Gate in Beijing



Source: JICA Study Team

Retractable-type Gate in Bangkok

Retractable automatic gates are used in Singapore, Bangkok, Delhi, Taipei and other countries because these have the advantage of protection performance compared with the flap-type gate. In contrast, the flap-type AGs are used in Japan, Beijing, Korea and other countries from the viewpoint of processing speed and safety advantage.

Table 4-100 Comparison of AG Types

Item	Flap-type	Turnstile	Retractable
Actual Processing speed	60 passengers/minute	30 passengers/minute	40 passengers/minute
Width of machine	200 mm	300 mm	300 mm
MCBF	More than 1,000,000 cycles	More than 1,000,000 cycles	More than 1,000,000 cycles
Passenger's safety	Excellent	Good	Poor *[1]
Protection performance (Against breaking through)	Comparatively weak compared with others	Strong	Strong

Note: *[1], There is a possibility that a passenger gets caught in the retractable door.
Source: JICA Study Team

In view of the advantages cited in the foregoing, JICA Study Team recommends the flap-type AG for Metro Line 4 at this moment. However, the type of AG to be finally used in Metro Line 4 will still be determined based on the preference of the railway operator, taking into consideration actual operation experiences.

c) Ticket Vending Machine (TVM): Option

The TVM should be equipped with a discrimination function protection against false banknotes and coins. Some countries have not introduced the TVM due to the difficulty the discrimination of false banknote. Under such situation, introduction of TVM in Metro Line 1 and 2 is an option, although there is no plan to introduce TVM in Metro Line 3.

Source: Japanese Manufacturer

Therefore, JICA Study Team recommends that introduction of TVM in Metro Line 4 will be determined in the later phase, taking into account the result of the previous projects and/or social condition. The following options can be considered for the introduction:

- Restriction for type of tickets (ex. Handling single journey only)
- Restriction for type of money (ex. Only coins and/or cash card are allowed)
- No change

When TVM will be introduced into Metro Line 4, it should be equipped with the following functions as minimum requirements:

- Issue the ticket (Magnetic or IC ticket)
- Top-up stored fare card
- Issue the receipts on passengers' demand

In addition to the above, the TVM should consider future use of credit cards.

d) Ticket Office Machine (TOM) with Card Initioation and Personalizaion Function (CIPF)

TOM with CIPF provides the following teller services to the passengers.

- Initialization of contactless IC card ticket
- Personalization of contactless IC card ticket
- Sell the tickets
- Single journey ticket (Magnetic, IC token (Option))
- Stored fare ticket (Personalized card, Anonymous card)
- Top-up stored fare card
- Read the stored fared ticket information such as historical information, fare information, personalized information
- Adjust the fare (add, deduct) of passenger's stored fare ticket when necessary
- Display the information to the passenger

The TOM with CIPF is connected to the SCU through the station LAN for the purpose of information sharing. Following shows the basic information that should be transmitted from TOM to SCU:

Source: Japanese Manufacturer

- Identification of the operator on duty
- Faults
- Audit registers
- Transaction data

As for the audit registers, the following information is transmitted from TOM to SCU as a minimum requirement:

- Number of ticket issued for each type
- Value of ticket issued for each type
- Number of ticket issued for each type
- Value of encoded on new contactless IC ticket
- Number of contactless IC ticket topped-up
- Total value added to each contactless IC ticket
- Number of period passes issued by type
- Total value of period passes issued by type
- Number of penalty deductions made
- Total value of penalty deductions made

e) Portable Verifying Unit (PVU)

The PVU is a handheld terminal, which allows metro revenue inspectors to verify the following passenger's contactless IC ticket information, both in the train and at the station.

- Validity of ticket
- Date and time of entry and exit
- Outstanding value of contactless IC ticket

f) Ticket Reader (TR)

The TR is located in both paid and unpaid areas, respectively. Passengers can confirm the following information regarding contactless IC card ticket by passenger's operation.

Source: Japanese Manufacturer

Remaining validity of ticket period

Remaining value and/or remaining number of trips

Accumulated fare value and/or historical journey information (date, boarding station, alighting station)

g) Station Control Unit (SCU)

<u>General Requirements:</u>

The main objective of the SCU is to collect accounting and statistical information, and manage the level 1 facility. SCU is located between the level 1 and level 3 facilities. The SCU consists of server, operation terminals, including docking function with PVU, and printers.

In addition, in order to secure safety, SCU servers should be located in a secure area to which unauthorised persons will be denied access. The following functions are the minimum requirements for the SCU.

At each station, SCU should poll all station AFC equipment in turn for transaction and status information, The SCU should process the transactional data received from the station AFC equipment, respond and store the data accordingly. At fixed intervals, the SCU conducts a traffic audit by requesting traffic data to be sent from the AG.

The SCU should record the accounting and user flow data of the AFC equipment regularly, including contactless IC ticket origin information.

The SCU should record the contactless IC card identities received from the entry and exit AG.

The SCU should automatically record details of all transactions as well as the total value of all ticket sales in the station.

The SCU should be designed to permit the autonomous operation of the various components of the AFC system to ensure that a failure in any component will not disrupt the whole system.

The SCU should also provide fallback facilities in the event of prolonged communication failure with the station level equipment. Station configuration data files on the SCU should be copied onto to a backup media and downloaded to station level equipment, if necessary. Revenue and fare structure data stored in the station level equipment should be copied onto the backup media. Therefore, SCU should be equipped with the writing and reading function for data back-up purposes.

Reporting of Status and Alarms

The SCU should monitor the status of each item of the AFC equipment. Whenever a fault or change in status appears, the SCU should record it permanently on file, give an instantaneous printout if required for use in the station, update the daily activity report, and give a warning on the terminal display.

As a minimum, the following warning messages for equipment change of status should be provided in order to optimize the efficiency of station operations:

For TVM (Option) – “coin cash box nearly full”, “coin cash box full”, “bank note cash box nearly full”, “bank note cash box full”, “Contactless Smart Token container nearly empty”, “Contactless Smart Token container empty”, “change hopper nearly empty”, “change hopper empty”, “coin jam”, “bank note jam”, “Contactless Smart Token jam”, “no change mode”, “machine out of service”, “tamper detection” and fault status;

For entry AG – “machine out of service”, “tamper detection” and fault status;

For exit AG - “Contactless Smart Token and/or Magnetic capture bin nearly full”, “Contactless Smart Token and/or Magnetic capture bin full”, “Contactless Smart Token” and/or “Magnetic ticket jam”, “machine out of service”, tamper detection” and fault status;

For TR – “machine out of service” and fault status; and

For TOM – “machine out of service”, “tamper detection” and fault status.

Loss of communication with any connected AFC device should be immediately and clearly displayed on the status screen of the SCU terminal.

Selected fault alarms should be transmitted to the LCU in real time.

Other Functions:

The SCU should, as a minimum, be capable of carrying out the following other functions:

- Manage the synchronisation of date and time with the station AFC devices;
- Manage the updating of the fare table data resident in the AG and TVM;
- Control the functions of AG, TVM and TOM;
- Provide a printout of daily station ticketing activities and logging of all non-routine events;
- Provide a printout of daily station revenue reports and traffic statistics reports on request by the operator;
- Report alarms to the LCU in real time;
- generation; and
- Manage the download of programme files from the LCU to the equipment downstream.

Anti-Fraud Measures

All Contactless IC tickets should be rejected at the entry AG if their anti-fraud codes are on the blacklist.

Security of Data

A basic philosophy of the AFC system should be that of self-sufficiency. In the event that one SCU fails to be operational, each piece of equipment should be able to operate autonomously without loss of data. When the SCU becomes operational after a failure, it should be automatically updated with data from the LCU devices connected to it.

Security features should be incorporated to prevent casual tampering with the LCU data, systems log and any other information of the SCU.

Software to enable new fare tables should be downloaded from the LCU into the memory of every SCU where they should be stored and activated system-wide on a configurable predetermined date and time, or on a broadcast command from the LCU. Under no circumstances should it be possible for a fare table to be changed locally using the SCU terminal.

h) Line Control Unit (LCU)

General Requirements:

The LCU consists of servers and operation terminals. The LCU should consist of poll each SCU via dedicated network and process the data to provide overall audit, statistical and operational information for the Metro Line 4. Following are minimum requirements for LCUs.

Source: Japanese Manufacturer

In order to ensure safety, LCU should be located in a secure area to which unauthorised persons will be denied access.

The LCU should hold and download necessary data, including fare table information to each SCU from where they should be distributed to the station AFC equipment.

The LCU should automatically collate all ticket data from the SCU to provide accurate audit and traffic statistics for the Metro Line 4.

The LCU should be designed for autonomous operation from the various components of the AFC system to ensure that a failure in any one AFC system component should not disrupt the system as a whole. In the event of a failure of either the LCU or the data transmission network, each SCU should operate independently and record all transaction and alarm data for a duration of not less than ten predetermined periods. All data stored should be transmitted to the LCU once the system is fully operational.

The LCU should also provide fallback facilities, in the event of prolonged communication failure with the SCU. Station configuration data files on the LCU should be copied onto a backup media and hand-carried to the stations for SCU initialization, if necessary. The LCU should be able to read the station data from the backup media. Therefore, SCU should be equipped with the writing and reading function the above backup data.

In addition to the above, the LCU should deal with following tasks as minimum requirement:

- Collect and process the usage and sale transaction data
- Download new equipment operating data, control commands and new software
- Prepare and printout reports related to resource management, traffic, revenues and performance
- Manage the security features in relation with the certification authority (CA) who delivers the equipment certificates and secure access modules (PKI-SAM)
- Data exchange between Metro Line 4 LCU and other LUC's in Metro Line 1 and 2, and Metro Line 3 in accordance with the data exchange procedures and rules which should be prepared by the foregoing project (Metro Line 1 and 2 or Metro Line 3).
- Data exchange between Metro Line 4 LCU and CCU for all metro lines in accordance with the data exchange procedures and rules which should be prepared by the foregoing project (Metro Line 1 and 2 or Metro Line 3).

External Interface:

The LCU should be equipped with following interfaces:

- SCU for data exchange through dedicated network
- Metro Line1 and 2 and Metro Line 3 LCU for data exchange through pre-determined interface, both physical and logical, such as HTTP, FTP, etc. and pre-determined data exchange rules and procedures.
- CCU for data exchange through pre-determined interface both physical and logical interface such as HTTP and FTP, and pre-determined data exchange rules and procedures.

The LCU should obtain the standard date and time, and synchronize its clock automatically from the master clock system which will be provided by the telecommunication system in Metro Line 4 or other master clock systems.

Data Flow:

As a minimum, the following information should be collected from Level 1 facilities:

- Usage data
- Contactless IC card sales and cancellations
- Contactless IC token sales and cancellations
- Product sales, usage and cancellation
- Other required data
- Audit registers
- Sales equipment audit registers
- Validation equipment audit registers
- Other required data
- Audit registers
- Contactless IC card transaction request
- Contactless IC balance request
- Contactless IC unblock request
- Other required data
- Events and alarms

In addition to the above, the following information should be transmitted to Level 1 facilities:

- Equipment operation data
- Equipment software
- Transport network topology (lines, stations, etc.)
- Fare parameters and/or fare table
- Blacklist
- Certificate revocation list, Calypso-SAM blacklist
- Other required data
- Control data
- Control Commands (stop, start, set mode)
- Other required command

i) Backup Power Supply

The SCU and LCU should at least be connected to the main M&E UPS back-up for sufficient time to ensure an orderly closure of the each system and shutdown of computer-based systems in the event of a power supply failure. In addition, SCU and LCU should, as a minimum, ensure that all transactions in progress are completed, all volatile data is recorded to non-volatile storage media, and alternative configurations of station equipment can be established by the station controller in the event of a power supply failure.

j) Required Interface Condition and Facility to be Provided by Prior Projects

In order to provide interface with other AFC systems which are implemented by the Metro Line 1 and 2, and Metro Line 3 projects, at least the following interface information and equipment are required for Metro Line 4:

- Provision of SAM from the preceding projects to Metro Line 4 project
- Provision of electronic fare data (Metro Line 1, 2, 3 and 4) which can be utilized by Metro Line 4 AFC system.
- Data structure, data table and its meaning in terms of electronic fare data
- IC ticket (card and token) and magnetic ticket data structure, data table and its meaning
- Procedure and judgement of IC and magnetic ticket
- Physical network interface specification not only between LCUs, but between LCU and CCU.
- Logical interface condition such as data structure, data format, data table and its meaning for the data communication between Metro Line 4 equipment and AFC equipment in other project (Metro Line1 and 2, and Metro Line 3)
- Procedure and rules for data processing and communication, including security policy
- Other required interface conditions to meet the requirement of integration policy, which should be specified by the previous projects.

4.10.6 Air Conditioning

(1) Basic Design Conditions

The following are the characteristics for the air conditioning in underground stations:

- The platform is connected to the track and tunnel and the concourse is connected to the platform and ground level.
- Except in a terminal station, passengers stay in the station for only a short period and high quality air conditioning is thus not required.

Taking into account the characteristics mentioned above, the basic design condition for the air conditioning is defined for the preliminary study, as follows:

a) Outside Temperature and Humidity

Table 4-101 Design Condition of Outside Temperature and Humidity

	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Dry Bulb Temperature (˚C)	18.9	20.4	23.5	28.3	32.0	33.9	34.7	34.2	32.6	29.2	24.8	20.3
Relative Humidity (%)	55.0											

Source: Weather Channel (http://www2m.biglobe.ne.jp/~ZenTech/English/Climate/Egypt/Cairo.htm)

b) Design Temperature and Humidity

The design temperature is totally related to the electric power consumption of the facilities in station. If the design temperature is too high, the electric power for the station facilities would be consumed more than the actual requirement. In order to determine the appropriate design temperature, a preliminary simulation for comparison of the power consumption is carried out.

Table 4-102 Design Parameter in Station

Design Temperature	˚C	25	26	27	28	29	30
Design Relative Humidity	％	50.0	50.0	50.0	50.0	50.0	50.0
Design Absolute Humidity	kg／kg	0.0099	0.0105	0.0111	0.0118	0.0125	0.0133
Design Enthalpy	kJ／kg	50.3	52.9	55.5	58.3	61.2	64.2

Source: Psychometric Chart

Table 4-103 Simulation of Power Consumption

Simulation of Power Consumption Unit: kW

Design Heat Load	Design Temperature (℃)					
	25	26	27	28	29	30
Platform						
Heat brought from Tunnel by Train Wind	116.2	107.6	99.0	89.7	80.1	70.2
Heat from Outside Air	374.2	346.5	318.8	288.9	258.0	226.0
Concourse						
Heat brought from Tunnel by Train Wind	37.6	34.8	32.0	29.0	25.9	22.7
Heat from Outside Air	436.0	403.7	371.4	336.6	300.6	263.3
Total	964.0	892.6	821.2	744.3	664.7	582.3

Power Consumption	193	179	164	149	133	116
Percentage (%)	118	109	100	91	81	71

Source: JICA Study Team

Taking into account the characteristics of the air conditioning in the station and the comparison of the power consumption, the following design temperature is used for the preliminary design.

Table 4-104 Design Condition of Temperature and Humidity (Inside Station)

	Dry Bulb Temperature DB（℃）	Relative Humidity RH（%）	Absolute Humidity（kg／kg）	Wet Bulb Temperature WB（℃）	Specific Enthalpy（kJ／kg）
Platform	28.0	50.0	0.0118	20.4	58.3
Concourse	28.0	50.0	0.0118	20.4	58.3
Station Office	26.0	50.0	0.0118	20.4	58.3
Substation for Electrical Servises	28.0	-	0.0093	17.1	47.8
Communications Equipment Room	28.0	-	0.0093	17.1	47.8
Signalling Equipment Room	28.0	-	0.0093	17.1	47.8

Source: JICA Study Team

c) Design Air Conditioning Time

The operation time of the air conditioning is assumed as follows for the preliminary design.

Table 4-105 Operation Time of Air Condition

	Operation Time	Starting Time	Stopping Time	Operation Hour per day (h/day)
Platform	All Season	AM 5:00	AM 0:00	19.0
Concourse	All Season	AM 5:00	AM 0:00	19.0
Station Office	All Season	AM 5:00	AM 1:00	20.0
Substation for Electrical Servises	All Season	All Time	All Time	24.0
Communications Equipment Room	All Season	All Time	All Time	24.0
Signalling Equipment Room	All Season	All Time	All Time	24.0

Source: JICA Study Team

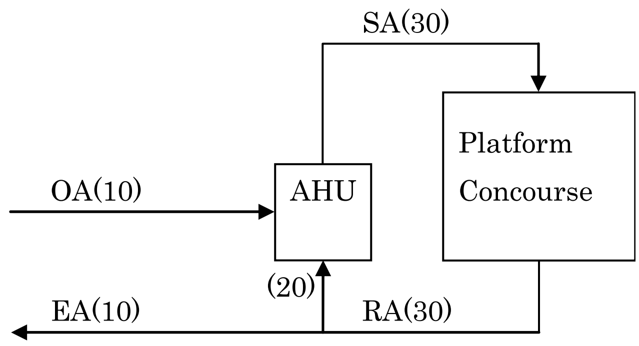
d) Minimum Air Supply Volume

The following minimum air supply volume is applied based on *"The Guideline for Mechanical Facilities of Subway, Japan Railway Construction, Transport and Technology Agency"*. Image of the air flow in the air conditioner is illustrated in Figure 4-316.

Table 4-106 Minimum Air Requirement for Each Location

	Supply Air (SA)	Outside Air (OA)	Returned Air (RA)
Platform	30 (m^3/h)/m^2	10 (m^3/h)/m^2	30 (m^3/h)/m^2
Concourse	30 (m^3/h)/m^2	10 (m^3/h)/m^2	30 (m^3/h)/m^2
Station Office	-	30 (m^3/h)/person	-

Source: The Guideline for Mechanical Facilities of Subway, Japan Railway Construction, Transportation and Technology and Ordinance of Tokyo Metropolitan Gov.



Source: JICA Study Team

Figure 4-316 Image of Air Flow in the Air Conditioner

(2) Outline of Air Conditioning

The purpose of the air conditioning is to provide comfortable space in the station. However, the structure of the station is different from a normal building, thus the method of the air conditioning is also different. The station is an elongated structure in a longitudinal direction. In addition, the platform and concourse are connected to outside through the exit/entrance and the efficiency of the air conditioning are influenced and decreased by these circumstances. The design heat load per unit area is bigger than that of normal buildings. Therefore, the air conditioning system in the station should be a simple component and structure, taking into consideration easy O&M work.

a) Cooling Method

- Central Cooling System

The central cooling system is applied for large space such as the platform, concourse and station offices, etc.

- Stand-Alone Cooling System

The stand-alone cooling system is basically applied for the electric and communication facility rooms (Substation, Signalling Equipment Room, and Communication Equipment Room). These rooms are very important for the train operation and refuge guidance in case of emergency incidents. Thus, the stand-by facilities as spare for emergency cases is considered.

b) Air Conditioning Method

- Unit Duct System

The unit duct system is used for large spaces such as the platform and concourse.

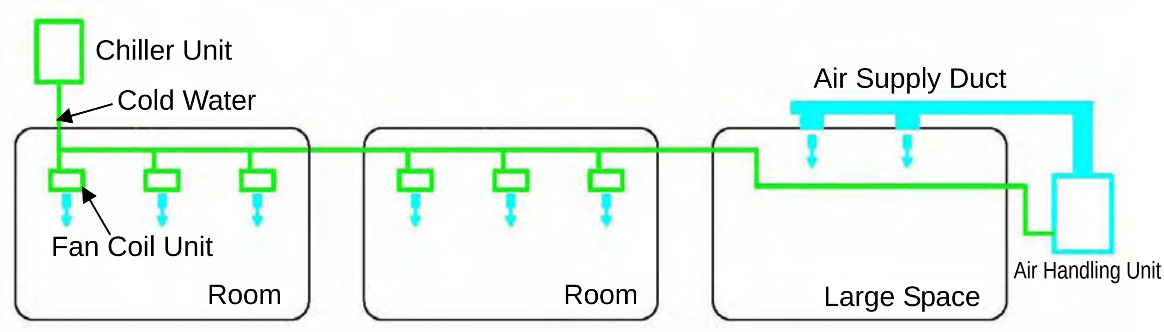
- Fan Coil Unit System

The fan coil unit system uses a central cooling system and is locally controlled. It is applied in the station office and rooms where the station staffs stay.

- Packaged Air Conditioning System

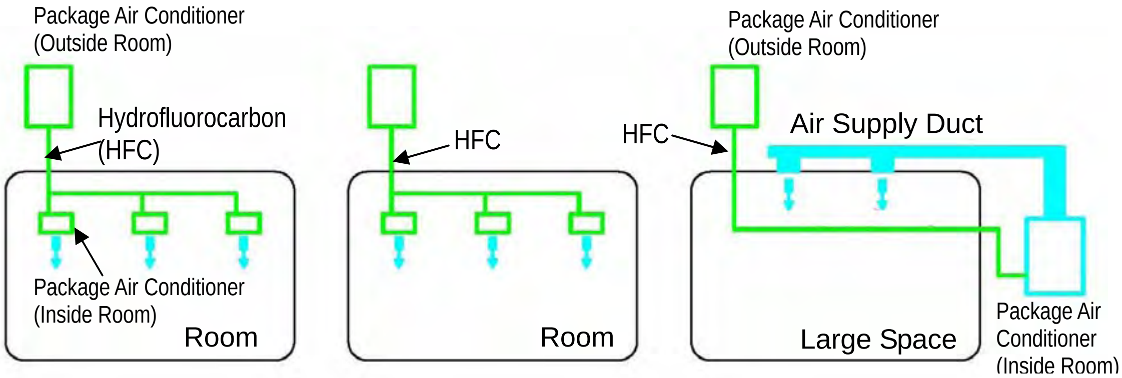
The packaged air conditioning system is a stand-alone system. Therefore, it could be used separately, apart from the central cooling system which is stopped when the train does not operate. It is applied for electric facility rooms (Substation, Signalling Equipment Room and Communication Equipment Room).

Image of the fan coil unit system and packaged air conditioning system are illustrated in Figure 4-317 and Figure 4-318.



Source: JICA Study Team

Figure 4-317 Image of Fan Coil Unit System



Source: JICA Study Team

Figure 4-318 Image of Packaged Air Conditioning System

(3) Design Heat Load of Air Conditioning

a) Design Heat Load

The heat from the rolling stock, its attached facilities and electrical equipment existing in the station and tunnel must be considered for the design of air conditioning. In addition, the heat from passengers and lighting are also not negligible. The design heat loads which are used for each place are listed below.

Table 4-107 Design Heat Load in Each Place

Heat Load \ Place	Platform	Concourse	Station Office, etc.	Electric Facility Room
Passengers	○	○	○	
Lighting	○	○	○	
Equipments			○	○
Rolling Stock	○	○		
Electric Advertisement	○	○		
Heat Load by Train Wind (from Tunnel)	○	○		
Outside Air	○	○	○	○

Source: JICA Study Team

b) Heat Load from Passengers

The heat load from each passenger and station staff is tabulated in Table 4-108. Design heat load at the platform is calculated as follows.

$$q_s = V_{ED} \times t_S / 3600 \times H_s$$

$$q_L = V_{ED} \times t_S / 3600 \times H_L$$

q_S: Sensible heat (kcal/h)

q_L: Latent heat (kcal/h)

V_{ED}: Volume of entrainment and detrainment passengers (persons/h.)

ts: Staying time of entrainment and detrainment passengers at station (sec.)

Herein, ts=0.5 x headway of train operation (sec.)

H_S: Sensible heat per passenger (kcal/h)

H_L: Latent heat per passenger (kcal/h)

Table 4-108 Design Heat Load from each Passenger and Station Staff

Unit: kW

Place	Sensible Heat (Hs)	Latent Heat (Hl)	Total Heat (W/person)
Platform	58.1	93.0	151.1
Concourse	58.1	81.4	139.5
Station Office	63.9	69.8	133.7

Source: Plan and Design Guideline for Logistics and Transportation Facility (The society of heating, air conditioning and sanitary engineers of Japan)

c) Heat Load from Light

The heat load from the lights is as follows:

Table 4-109 Design Heat Load from Light

Place	Heat Load (W／m2)
Platform	30.0
Concourse	40.0
Station Office	18.0

Source: Plan and Design Guideline for Logistics and Transportation Facility (The society of heating, air conditioning and sanitary engineers of Japan)

d) Heat Load from Braking of the Train

When the train brakes before reaching the station, brake heat is generated and brought to the platform by the train. The following formula shows the brake heat load to the platform.

$$q_B = 1/427 \times \{(W + w\eta_T) \cdot V_B^2 /(2g) + W \cdot (h_B - h_s)\} \times (1-\beta) \times (1+\alpha_A) \times (1+\alpha_s) \times N \times \alpha_0$$

q_B: Heat from rolling stock (kcal/h)

W: Gross weight of rolling stocks (including weight of passengers, 1 set of train) (kg)

w: Net weight of rolling stocks (1 set of train) (kg)

η_T: Inertia ratio, 0.08

V_B: Train velocity when braking starts (m/s)

h_B: Altitude of point where braking starts (m)

h_S: Altitude of point where trains stops (m)

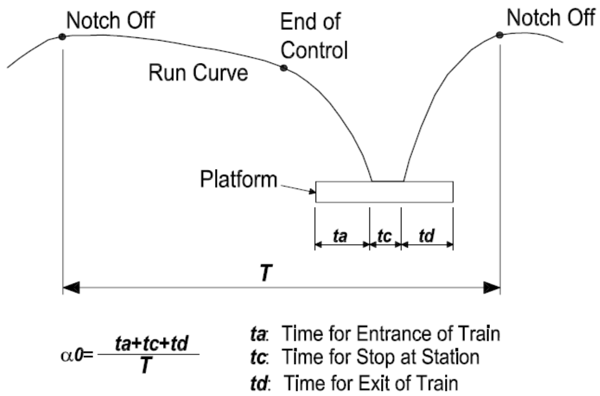
β: Regenerating factor, 0.2 to 0.4 if the regenerative brake is applied.

α_A: Coefficient for acceleration heat (0.25)

α_S: Coefficient for auxiliary facilities (0.05)

N: Number of trains per hour (number/h)

α_0: Ratio of heat load of platform



Source: Plan and Design Guideline for Logistics and Transportation Facility (The society of heating, air conditioning and sanitary engineers of Japan)

Figure 4-319 Ratio of the Braking Heat Load to the Platform

e) Heat Load from Air Conditioner on Rolling Stock

When the train stops in the platform, heat is released from the air conditioner on the rolling stock. The heat load to the platform is calculated by the following formula according to the stopping time of the train at platform. In case that the track ventilation is installed, 40% of its heat load is treated as the heat load to the platform.

$$q_c = q_D + M \times 860(kcal / kWh)$$

q_c: Heat from air conditioner on rolling stock (kcal/h)

q_D: Rated power of air conditioner (kcal/h)

M: Motor input for air conditioner (kWh)

In order to obtain the heat at the platform, time at the platform is defined as follows:

$$t = T_C + 0.5 \times (T_A + T_D)$$

t: Total time at platform (sec.)

T_C: Stop time at platform (sec.)

T_A: Time from arrival to stop at platform (sec.)

T_D: Time from departure to exit (sec.)

f) Heat Load Brought by Train Wind

The heat in tunnel, which is generated by the rolling stock, is basically treated by the tunnel ventilation. However, some of the heat in the tunnel is brought to the platform by the train wind, which is calculated by the following formula.

According to the travel of trains, the heat induced from the tunnel to the platform is as follows:

$$Q_S = V \times (t_{TR} - t_p) \times 0.29 \times N$$
$$Q_L = V \times (x_{TR} - x_p) \times 715 \times N$$

Q_S: Sensible heat brought by train (kcal/(set of trains)·h)

Q_L: Latent heat brought by train (kcal/(set of trains)·h)

V: Air volume brought by train (m^3/(set of trains))

t_{TR}: Dry bulb temperature of train wind (˚C)

tp: Dry bulb temperature at platform (˚C)

x_{TR}: Absolute humidity of train wind (kg/kg)

xp: Absolute humidity at platform (kg/kg)

Usually, the air volume which is generated by the piston effect of the train is in the range from 5,000 m^3 to 20,000 m^3. However, most of air volume is diverted or released through a ventilation system/draft relief shaft to minimize the influence of the train wind at platform. Therefore, the following design air volume based on experience in Japan is used for the preliminary design:

Table 4-110 Design Air Volume Brought by the Train

Unit: m^3/train

	Rush Hour	Off Time
Single Track	2000	2500
Double Track	1000	1500

Source: Plan and Design Guideline for Logistics and Transportation Facility (The society of heating, air conditioning and sanitary engineers of Japan)

g) Heat Load from Outside Air

When the ventilation system takes the fresh air from outside, heat is also taken from outside. The heat load from outside air is calculated as follows:

$$Q_S = V \times (t_r - t_p) \times 0.29$$
$$Q_L = V \times (x_r - x_p) \times 715$$

Q_S: Sensible heat of outside air (kcal/h)

Q_L: Latent heat of outside air (kcal/h)

V: Air volume taken from outside (m^3/h)

t_r: Dry bulb temperature of outside air (˚C)

t_p: Dry bulb temperature of outside air (˚C)

x_r: Absolute humidity of outside air (kg/kg)

x_p: Absolute humidity of outside air (kg/kg)

(4) Preliminary Study of Cooling Facilities

a) Accumulated Design Heat Load for Cooling Facilities

The heat loads calculated based on the described formula are tabulated as follows:

Table 4-111 Accumulated Design Heat Loads for Cooling

■Heat Load on Platform

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Area	3,400 m2	1,700 m2	3,400 m2	3,400 m2	2,040 m2	2,040 m2	2,380 m2	3,400 m2
Length	170 m	170 m	170 m	170 m	170 m	170 m	170 m	170 m
Width	10 m	10 m	10 m	10 m	12 m	12 m	14 m	10 m
Number of Platform	2	1	2	2	1	1	1	2
Passenger	63.8 kW	31.9 kW	63.8 kW	63.8 kW	38.3 kW	38.3 kW	44.6 kW	63.8 kW
Lighting	127.5 kW	63.8 kW	127.5 kW	127.5 kW	76.5 kW	76.5 kW	89.3 kW	127.5 kW
Rollingstock	160.0 kW	160.0 kW	160.0 kW	160.0 kW	160.0 kW	160.0 kW	480.0 kW	160.0 kW
Advtisement, etc.	101.0 kW	50.5 kW	101.0 kW	101.0 kW	60.6 kW	60.6 kW	70.7 kW	101.0 kW
Heat Load brought by Train Wind	99.0 kW	99.0 kW	99.0 kW	99.0 kW	99.0 kW	99.0 kW	298.0 kW	99.0 kW
Heat Load by Outside Air	318.8 kW	159.4 kW	318.8 kW	318.8 kW	191.3 kW	191.3 kW	223.1 kW	318.8 kW
Subtotal	870.1 kW	564.6 kW	870.1 kW	870.1 kW	625.7 kW	625.7 kW	1,205.7 kW	870.1 kW

■Heat Load on Concourse

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Area	4,000 m2	8,400 m2	2,520 m2	2,100 m2	3,740 m2	3,080 m2	3,520 m2	5,520 m2
Length	160 m	60 m	140 m	150 m	170 m	140 m	160 m	80 m
Width	25 m	40 m	18 m	14 m	22 m	22 m	22 m	24 m
Number of Concourse	1	2	1	1	1	1	1	1
Length	0 m	180 m	0 m	0 m	0 m	0 m	0 m	100 m
Width	0 m	20 m	0 m	0 m	0 m	0 m	0 m	36 m
Number of Concourse	0	1	0	0	0	0	0	1
Passenger	154.8 kW	325.1 kW	97.5 kW	81.3 kW	144.7 kW	119.2 kW	136.2 kW	213.6 kW
Lighting	212.4 kW	446.0 kW	133.8 kW	111.5 kW	198.6 kW	163.5 kW	186.9 kW	293.1 kW
Others	123.4 kW	11.6 kW	52.1 kW	186.4 kW	32.7 kW	67.9 kW	24.5 kW	32.3 kW
Heat Load brought by Train Wind	32.0 kW	32.0 kW	32.0 kW	32.0 kW	32.0 kW	32.0 kW	96.0 kW	32.0 kW
Heat Load by Outside Air	371.4 kW	779.9 kW	234.0 kW	195.0 kW	347.3 kW	286.0 kW	326.8 kW	512.5 kW
Subtotal	894.0 kW	1,594.6 kW	549.4 kW	606.2 kW	755.3 kW	668.6 kW	770.4 kW	1,083.5 kW

■Total Heat Load

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Platform	870.1 kW	564.6 kW	870.1 kW	870.1 kW	625.7 kW	625.7 kW	1,205.7 kW	870.1 kW
Concourse	894.0 kW	1,594.6 kW	549.4 kW	606.2 kW	755.3 kW	668.6 kW	770.4 kW	1,083.5 kW
Safety Factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	2,117 kW	2,591 kW	1,703 kW	1,772 kW	1,657 kW	1,553 kW	2,371 kW	2,344 kW
Load of Chiller (USRT)	602 RT	737 RT	484 RT	504 RT	471 RT	442 RT	674 RT	667 RT

Source: JICA Study Team

b) Selection of Cooling Facilities

The capacity of the cooling facilities is calculated according to the required cooling load. The performance of the selected cooling facilities is as follows:

Table 4-112 Selected Cooling Facilities

■Selection of Chiller

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Load of Chiller (USRT)	602 RT	737 RT	484 RT	504 RT	471 RT	442 RT	674 RT	667 RT
Safety Factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Required Power of Chiller (USRT)	722.4 RT	884.4 RT	580.8 RT	604.8 RT	565.2 RT	530.4 RT	808.8 RT	800.4 RT
Number of Chiller	2	2	2	2	2	2	2	2
Required Power per Chiller (USRT)	362 RT	443 RT	291 RT	303 RT	283 RT	266 RT	405 RT	401 RT
Selected Power per Chiller (USRT)	370 RT	450 RT	300 RT	300 RT	300 RT	300 RT	400 RT	400 RT

■Selection of Pump for Cold Water

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Power per Chiller (USRT)	370 RT	450 RT	300 RT	300 RT	300 RT	300 RT	400 RT	400 RT
Temperature Diffenrece of Circulation	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃
Required Cold Water (L/min)	3,730 L/min	4,536 L/min	3,024 L/min	3,024 L/min	3,024 L/min	3,024 L/min	4,032 L/min	4,032 L/min
Number of Pump	1	1	1	1	1	1	1	1
Cold Water per Pump	3,730 L/min	4,536 L/min	3,024 L/min	3,024 L/min	3,024 L/min	3,024 L/min	4,032 L/min	4,032 L/min

■Selection of Cooling Tower

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Power per Cooling Tower (USRT)	370.0 RT	450.0 RT	300.0 RT	300.0 RT	300.0 RT	300.0 RT	400.0 RT	400.0 RT
Refrigerator Coefficient	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Required Power per Cooing Tower (USRT)	481 RT	585 RT	390 RT	390 RT	390 RT	390 RT	520 RT	520 RT
Number of Cooling Tower	1	1	1	1	1	1	1	1
Required Power (USRT)	481 RT	585 RT	390 RT	390 RT	390 RT	390 RT	520 RT	520 RT

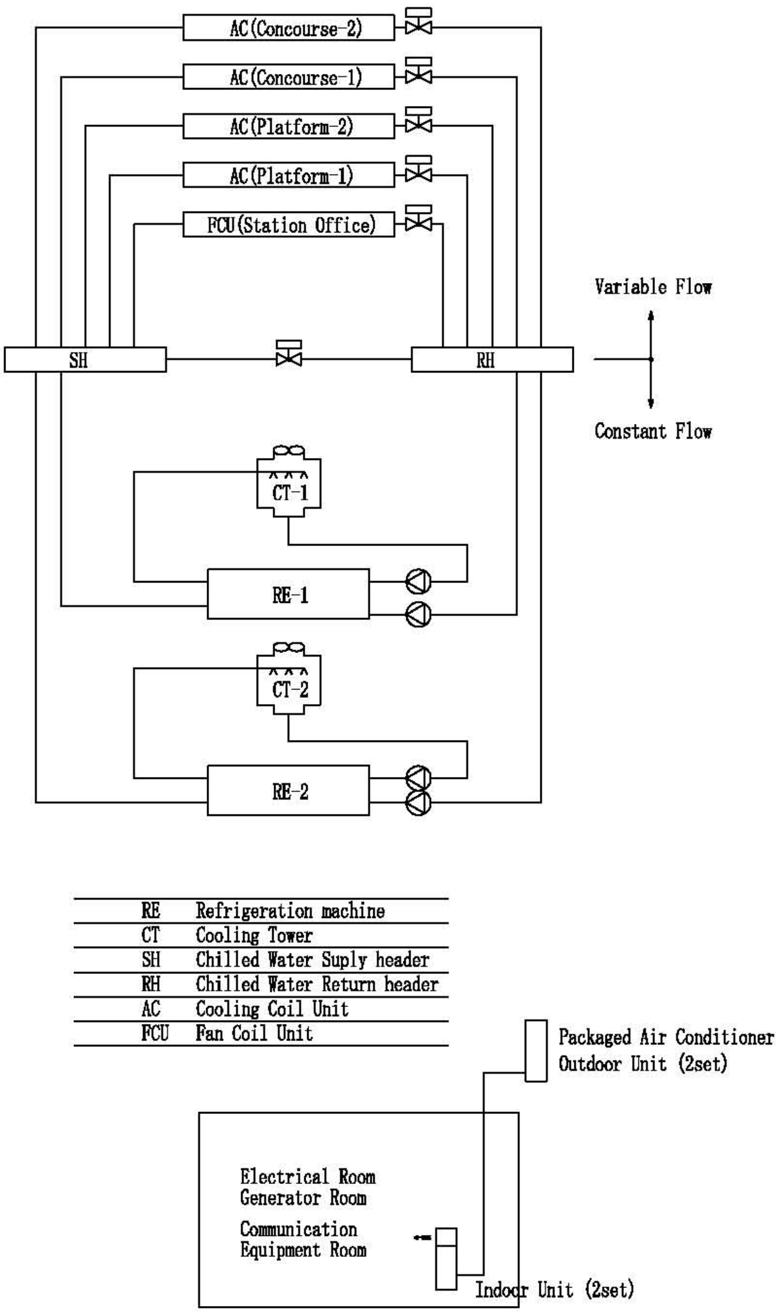
■Selection of Pump for Cooling Water

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Required Power for Cooling (USRT)	481 RT	585 RT	390 RT	390 RT	390 RT	390 RT	520 RT	520 RT
Temperature Diffenrece of Circulation	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃	5.0 ℃
Required Cooling Water (L/min)	4,848 L/min	5,897 L/min	3,931 L/min	3,931 L/min	3,931 L/min	3,931 L/min	5,242 L/min	5,242 L/min
Number of Pump	1	1	1	1	1	1	1	1
Cooling Water per Pump (L/min)	4,848 L/min	5,897 L/min	3,931 L/min	3,931 L/min	3,931 L/min	3,931 L/min	5,242 L/min	5,242 L/min

Source: JICA Study Team

(5) Diagram of Cooling Facilities Flow

The fan coil units in the station are divided into two systems. Each system has two refrigerators as a fail-safe system. Taking into consideration the maintenance condition in Egypt, it will be studied to supply multiple refrigerators (more than three) in the fan coil unit. The diagram of the cooling facilities flow is shown as follows.

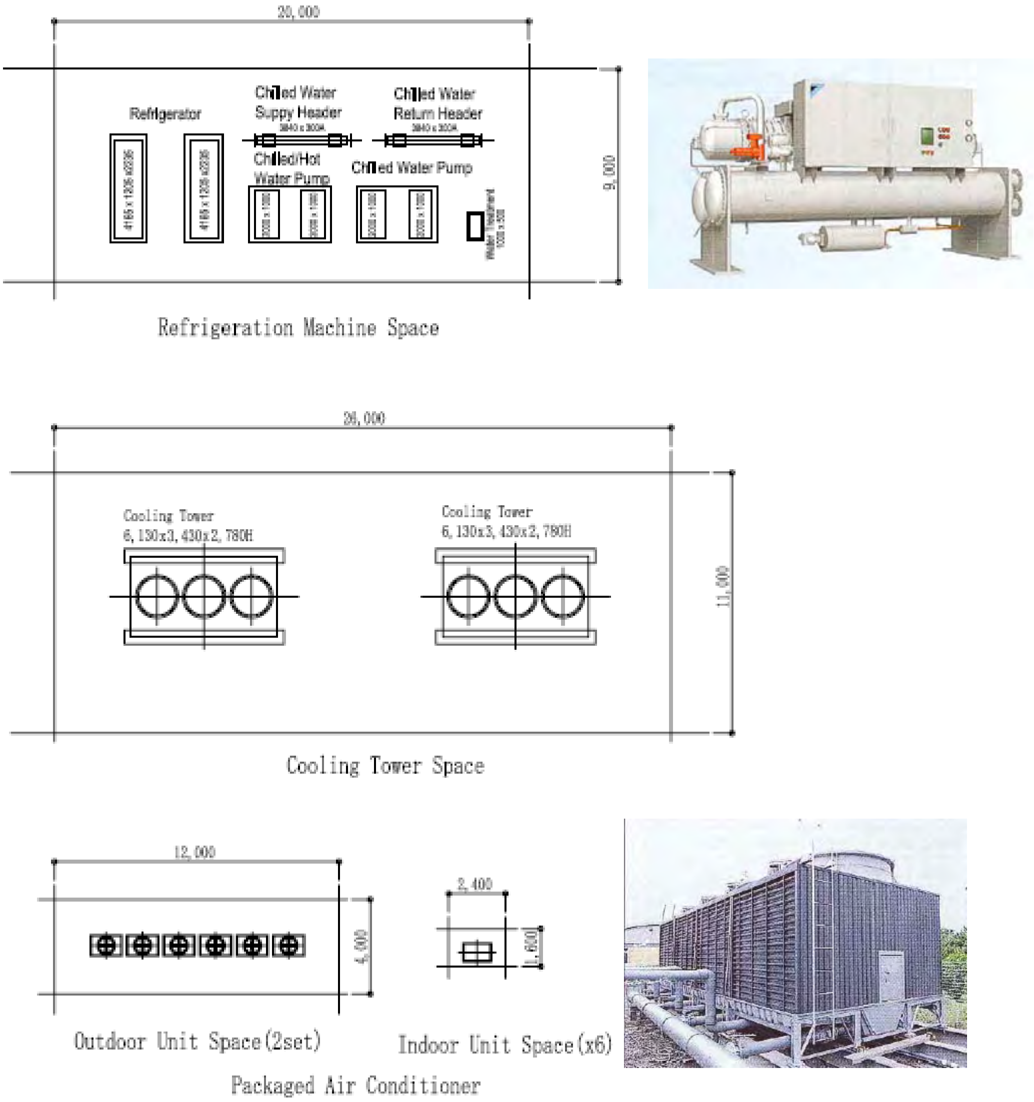


Source: JICA Study Team

Figure 4-320 Diagram of Cooling Facilities

(6) Required Space for the Cooling Facilities

The outline of the cooling facilities and their required spaces are shown as follows.



Source: JICA Study Team

Figure 4-321 Refrigeration Machine and their Required Spaces

(7) Method of the Air Conditioning

The air conditioning system for each place is indicated in the following table.

Table 4-113 Air Conditioning Method

	Unit Duct Method	Fan Coil Unit Method	Packeage Air Condionning Method
Platform	○		
Concourse	○	○*	
Station Office		○	
Substation for Electrical Servises			○**
Communications Equipment Room			○**
Signalling Equipment Room			○**

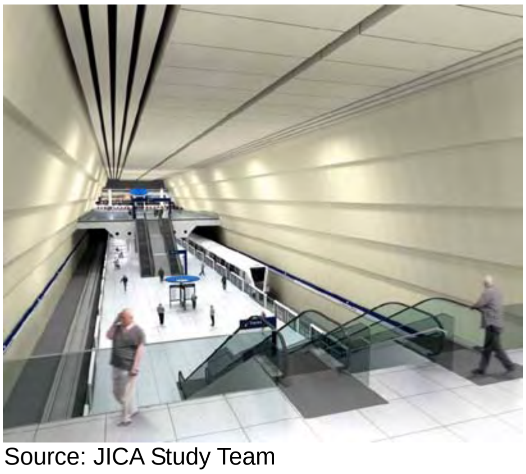
Note
* It is possible to use in some part of concourse according to structure type.
** 24 hour operation and Stand-Alone system
Stand by system is prepared for Electric and Signaling System
Source: JICA Study Team

a) Substation, Signalling and Communication Equipment Room

These rooms are very important for the train operation, public address to the passengers and refuge guidance, in case of emergency incidents. Thus, the stand-by facilities as spare for emergency cases is applied. Moreover, the stand-by air conditioner is provided in case of failure.

b) Platform and Concourse

The platform and concourse are large spaces and the necessity of air conditioning is widely spread and not concentrated in any specific space. Therefore, the unit duct method is suitable for the platform and concourse. El Remayah Station is planned to have large spaces with high ceiling (see Figure 4-322).



Source: JICA Study Team

Figure 4-322 Image of El Remayah Station

The location of the air conditioning facilities and the air duct for these stations must be studied carefully, taking into consideration air environment in the station and management of emergency incidents. The location of the air conditioning machine room is planned to be near the air conditioned area, hence the length of the air duct is shortened as much as possible. In the basic design stage, the location of the outlet of the air conditioning will be studied and determined taking the air flow distribution and the effective range into account.

c) Station Office and Other Rooms

The station office and other rooms where the station staffs stay longer are separately controlled from other places. Therefore, the air conditioning for these rooms is provided by the fan coil unit method.

(8) Preliminary Study of Air Conditioning Facilities

In order to cool down and control the design temperature, chilled air, which is 10˚C lower than the design temperature, is used. If the difference between the temperature of blown air and design temperature is large, the efficiency of the air conditioning will be enhanced but will make the passengers uncomfortable. According to past practices and experiences, a 10˚C difference is applied. The required capacity of the air conditioner is calculated as follows.

Table 4-114 Required Capacity for Air Conditioning Facilities

■Required Air Volume on Platform

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Temperature Difference of Air Supply	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃
Passenger	31.9 kW	15.9 kW	31.9 kW	31.9 kW	19.1 kW	19.1 kW	22.3 kW	31.9 kW
Lighting	127.5 kW	63.8 kW	127.5 kW	127.5 kW	76.5 kW	76.5 kW	89.3 kW	127.5 kW
Rolling Stock	160.0 kW	160.0 kW	160.0 kW	160.0 kW	160.0 kW	160.0 kW	480.0 kW	160.0 kW
Advtisement, etc.	101.0 kW	50.5 kW	101.0 kW	101.0 kW	60.6 kW	60.6 kW	70.7 kW	101.0 kW
Heat Load brought by Train Wind	20.0 kW	20.0 kW	20.0 kW	20.0 kW	20.0 kW	20.0 kW	298.0 kW	20.0 kW
Subtotal	440.4 kW	310.2 kW	440.4 kW	440.4 kW	336.2 kW	336.2 kW	960.3 kW	440.4 kW
Design Air Supply Volume(m3/h)	132,000 CMH	93,000 CMH	132,000 CMH	132,000 CMH	100,000 CMH	100,000 CMH	287,000 CMH	132,000 CMH
Required Outside Air Volume(m3/h/m2)	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2
Required Outside Air Volume(m3/h)	34,000 CMH	17,000 CMH	34,000 CMH	34,000 CMH	20,400 CMH	20,400 CMH	23,800 CMH	34,000 CMH
Maximum Air Speed in Duct (m/s)	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s
Required OA Shaft Area (m2)	1.9 m2	0.9 m2	1.9 m2	1.9 m2	1.1 m2	1.1 m2	1.3 m2	1.9 m2
Required Exhaust Air Shaft Area(m2)	7.3 m2	5.2 m2	7.3 m2	7.3 m2	5.6 m2	5.6 m2	15.9 m2	7.3 m2

■Required Air Volume on Councourse

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Temperature Difference of Air Supply	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃	10 ℃
Passenger	77.4 kW	162.5 kW	48.8 kW	40.6 kW	72.4 kW	59.6 kW	68.1 kW	106.8 kW
Lighting	212.4 kW	446.0 kW	133.8 kW	111.5 kW	198.6 kW	163.5 kW	186.9 kW	293.1 kW
Others	123.4 kW	11.6 kW	52.1 kW	186.4 kW	32.7 kW	67.9 kW	24.5 kW	32.3 kW
Heat Load brought by Train Wind	6.0 kW	6.0 kW	6.0 kW	6.0 kW	6.0 kW	6.0 kW	32.0 kW	6.0 kW
Subtotal	419.2 kW	626.1 kW	240.7 kW	344.5 kW	309.7 kW	297.0 kW	311.5 kW	438.2 kW
Design Air Supply Volume(m3/h)	125,000 CMH	187,000 CMH	72,000 CMH	103,000 CMH	92,000 CMH	89,000 CMH	93,000 CMH	131,000 CMH
Required Outside Air Volume(m3/h/m2)	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2	10 m3/h/m2
Required Outside Air Volume(m3/h)	40,000 CMH	84,000 CMH	25,200 CMH	21,000 CMH	37,400 CMH	30,800 CMH	35,200 CMH	55,200 CMH
Maximum Air Speed in Duct (m/s)	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s
Required OA Shaft Area (m2)	2.2 m2	4.7 m2	1.4 m2	1.2 m2	2.1 m2	1.7 m2	2.0 m2	3.1 m2
Required Exhaust Air Shaft Area(m2)	6.9 m2	10.4 m2	4.0 m2	5.7 m2	5.1 m2	4.9 m2	5.2 m2	7.3 m2

■Outside Air (OA) Supply Shaft Area (Total)

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Platform	1.9 m2	0.9 m2	1.9 m2	1.9 m2	1.1 m2	1.1 m2	1.3 m2	1.9 m2
Concourse	2.2 m2	4.7 m2	1.4 m2	1.2 m2	2.1 m2	1.7 m2	2.0 m2	3.1 m2
Safety Factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	4.9 m2	6.7 m2	4.0 m2	3.7 m2	3.8 m2	3.4 m2	4.0 m2	6.0 m2

■Exhaust Air (EA) Shaft Area (Total)

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Platform	7.3 m2	5.2 m2	7.3 m2	7.3 m2	5.6 m2	5.6 m2	15.9 m2	7.3 m2
Concourse	6.9 m2	10.4 m2	4.0 m2	5.7 m2	5.1 m2	4.9 m2	5.2 m2	7.3 m2
Safety Factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	17.0 m2	18.7 m2	13.6 m2	15.6 m2	12.8 m2	12.6 m2	25.3 m2	17.5 m2

Source: JICA Study Team

The selected air conditioning facilities are tabulated as follows.

Table 4-115 Capacity of the Selected Air Conditioning Facilities

■Selection of Air Conditionning Facilities for Platform

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Required Supplied Air(SA) Volume (m3/h)	132,000 CMH	93,000 CMH	132,000 CMH	132,000 CMH	100,000 CMH	100,000 CMH	287,000 CMH	132,000 CMH
Required Outside Air(OA) Volume (m3/h)	34,000 CMH	17,000 CMH	34,000 CMH	34,000 CMH	20,400 CMH	20,400 CMH	23,800 CMH	34,000 CMH
Power of Cold Water Coil (kW)	440.4 kW	310.2 kW	440.4 kW	440.4 kW	336.2 kW	336.2 kW	960.3 kW	440.4 kW
Number of Facilities	2	2	2	2	2	2	2	2
Required SA Volume per Facility (m3/h)	66,000 CMH	46,500 CMH	66,000 CMH	66,000 CMH	50,000 CMH	50,000 CMH	143,500 CMH	66,000 CMH
Required OA Volume per Facility (m3/h)	17,000 CMH	8,500 CMH	17,000 CMH	17,000 CMH	10,200 CMH	10,200 CMH	11,900 CMH	17,000 CMH
Power of Cold Water Coil/Facility (kW)	220 kW	160 kW	220 kW	220 kW	170 kW	170 kW	480 kW	220 kW

■Selection of Air Conditionning Facilities for Concourse

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Required Supplied Air(SA) Volume (m3/h)	125,000 CMH	187,000 CMH	72,000 CMH	103,000 CMH	92,000 CMH	89,000 CMH	93,000 CMH	131,000 CMH
Required Outside Air(OA) Volume (m3/h)	40,000 CMH	84,000 CMH	25,200 CMH	21,000 CMH	37,400 CMH	30,800 CMH	35,200 CMH	55,200 CMH
Power of Cold Water Coil (kW)	419.2 kW	626.1 kW	240.7 kW	344.5 kW	309.7 kW	297.0 kW	311.5 kW	438.2 kW
Number of Facilities	2	2	2	2	2	2	2	2
Required SA Volume per Facility (m3/h)	62,500 CMH	93,500 CMH	36,000 CMH	51,500 CMH	46,000 CMH	44,500 CMH	46,500 CMH	65,500 CMH
Required OA Volume per Facility (m3/h)	20,000 CMH	42,000 CMH	12,600 CMH	10,500 CMH	18,700 CMH	15,400 CMH	17,600 CMH	27,600 CMH
Power of Cold Water Coil/Facility (kW)	210 kW	310 kW	120 kW	170 kW	150 kW	150 kW	160 kW	220 kW

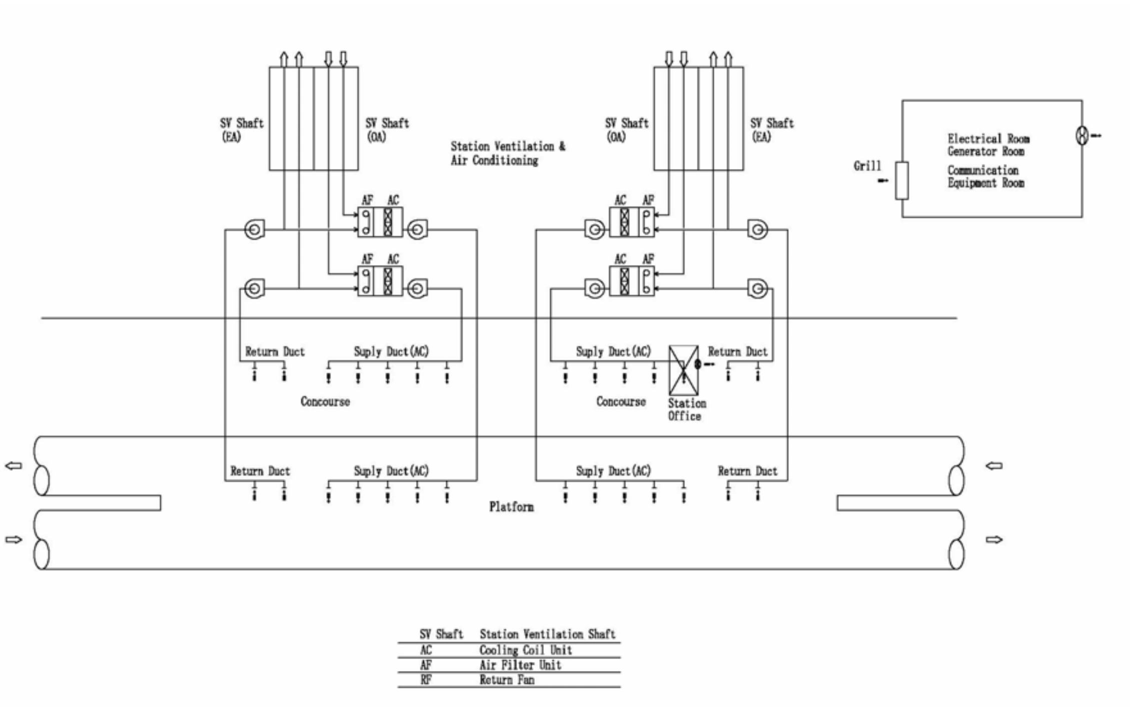
Source: JICA Study Team

(9) Diagram of Air Conditioning Facilities Flow

The diagram of the air conditioning facilities flow is shown in Figure 4-323. The station is an elongated structure in the longitudinal direction and the following characteristics are noted for the design of air conditioning facilities and the required space in the station.

- The pressure loss for the air conditioning and ventilation becomes very high due to long ducts.
- The air volume is quite large.
- There is the restriction for the size of the air duct.

Hence, the air conditioning facility rooms (fan room and air handling unit room) should be divided into at least two places along the longitudinal direction.

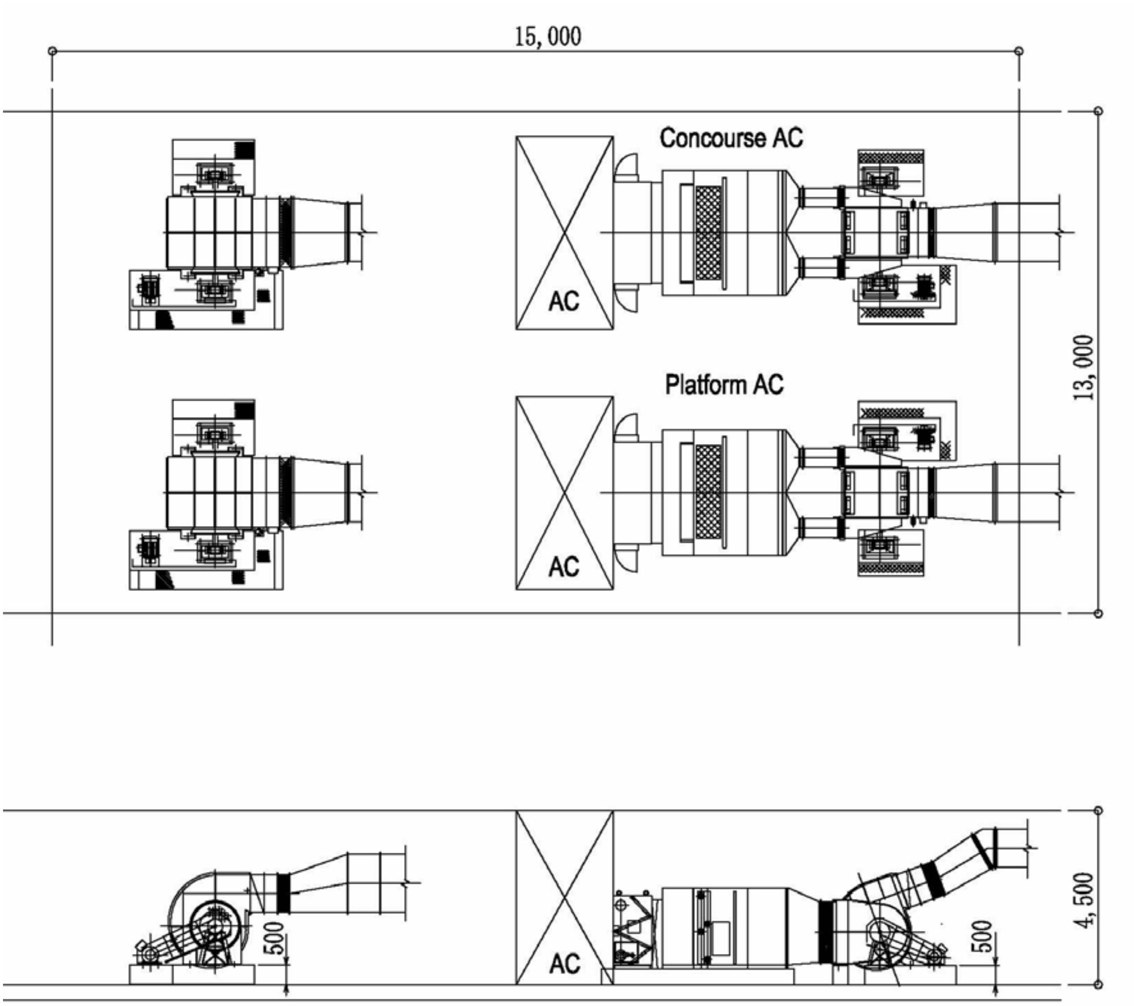


Source: JICA Study Team

Figure 4-323 Diagram of Air Conditioning Facilities Flow in the Station

(10) Required Space for the Air Conditioning Facilities

The outline of the cooling coil unit, the return fan and their required spaces in station are shown in Figure 4-324.



Source: JICA Study Team

Figure 4-324 Outline of Air Conditioning Facilities and their Required Spaces

4.10.7 Ventilation System

(1) Outline of Ventilation System

The purpose of ventilation is to provide comfortable and hygienic space in the station by the intake of outside fresh air and exhaust of polluted air in station and to control the temperature in station which is raised by the heat from the passenger, train and other facilities. Mechanical ventilation is used for the project. In the stations where the full height PSD are applied, the ventilation system of the platform is segregated from that of the tunnel. Therefore, these ventilation systems are designed as separated and segregated systems from each other.

(2) Requirement of the Ventilation System

The requirement of the ventilation system is applied based on *"The Guideline for Mechanical Facilities of Subway, Japan Railway Construction, Transport and Technology Agency",* as follows:

Table 4-116 Minimum Air Volume for Each Place

	Supply Air (SA)	Outside Air (OA)	Returned Air (RA)
Platform	30 $(m^3/h)/m^2$	10 $(m^3/h)/m^2$	30 $(m^3/h)/m^2$
Concourse	30 $(m^3/h)/m^2$	10 $(m^3/h)/m^2$	30 $(m^3/h)/m^2$
Station Office	-	30 (m^3/h)/person	-

Source: The Guideline for Mechanical Facilities of Subway, Japan Railway Construction, Transport and Technology Agency and Ordinance of Tokyo Metropolitan Government

Table 4-117 Minimum Air Volume for Rooms

	Required Air Volume (times/hour)*	Required Air Volume (m3/h)/person
Station Office	-	30.0
Toilet	10.0	-
Chiller Plant/Fan Room	5.0	-
Substation for Electrical Servises	2.0	-
Communications Equipment Room	2.0	-
Signalling Equipment Room	2.0	-

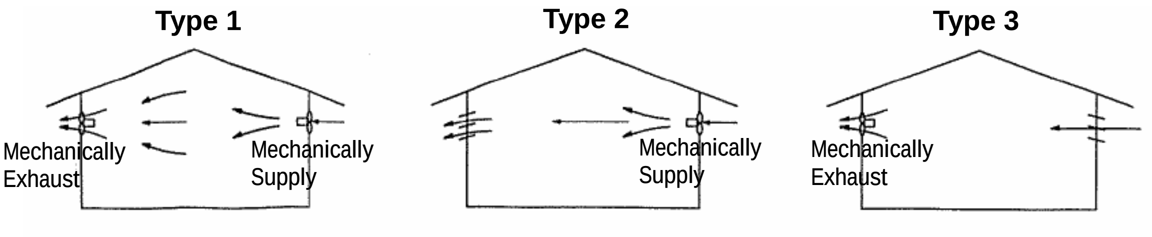
* One time is equivalent to the volume of room.

Source: Design Standard for Building Facilities, Ministry of Infrastructure, Land, Transportation and Tourism (MLIT) and Public Buildings Association, Ltd.

(3) Ventilation Method of Station

a) Type of Ventilation

The ventilation methods for rooms and closed spaces are basically classified into the following three types.



Source: JICA Study Team

Figure 4-325 Ventilation Method for Rooms and Closed Spaces

- Type 1: Mechanically, air is supplied and exhausted.
- Type 2: Mechanically, air is supplied and naturally, air is exhausted.
- Type 3: Naturally, air is supplied and mechanically, air is exhausted.

b) Ventilation Method for Platforms

The purpose of the ventilation of the platform is to provide outside fresh air and comfortable and hygienic conditions for passengers and to exhaust the heat in platform. According to the structure of the station and requirement of huge volume of the fresh air, the Type 1 ventilation system is applied and doubles as the air conditioning system.

c) Ventilation Method of Concourse

The system for the ventilation of the concourse is the same as that of the platform.

d) Ventilation Method of Station Office and Other Rooms

The ventilation of the station office and other rooms where the station staffs stay longer are planned to meet the requirement in Table 4-116 and Table 4-117.

(4) Ventilation Method for Tunnel

a) Natural Ventilation and Mechanical Ventilation

The ventilation methods for the tunnel are classified into the following two types.

- Natural Ventilation: The air in the tunnel is pushed and pulled by the piston effect of the train running and ventilated through the intermediate ventilation shaft between stations. However, it is necessary to locate the vertical shaft at an interval of 100 m or less between stations for natural ventilation. Therefore, it is difficult to apply this method in a congested city area.
- Mechanical Ventilation: The air is supplied and exhausted mechanically by fans.

From the above discussion, the tunnel ventilation for Metro Line 4 is therefore, planned as the mechanical ventilation.

b) Mechanical Tunnel Ventilation Method

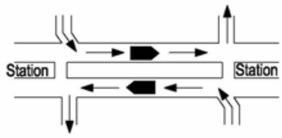
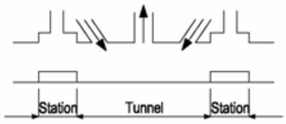
Various tunnel ventilation methods have been used for the metro in Japan and the most popular methods are the longitudinal ventilation method and the concentrated exhaust method in the middle of a tunnel.

In case that the single double track tunnel is used, the train operation is unidirectional traffic and the piston effect by the train running is effective. Thus, longitudinal ventilation method is suitable. Due to the piston effect of the train operation, the ventilation load is decreased and the supply and exhaust fans are installed only at the end of stations. The intermediate ventilation shaft is not basically required. Consequently, this method is economical both in terms of construction and operation.

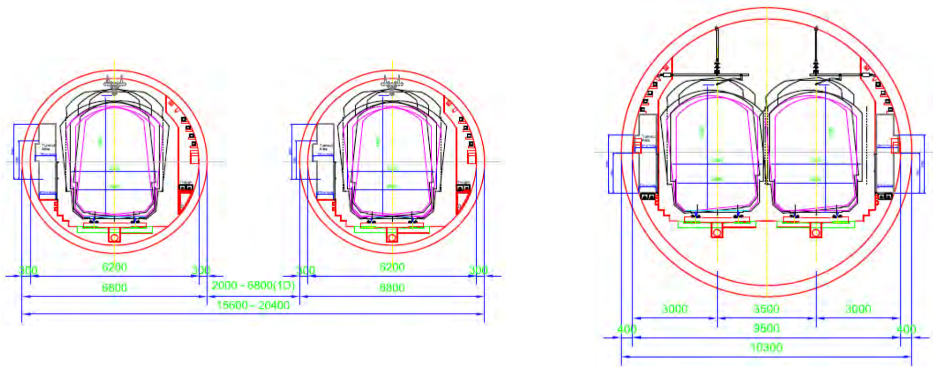
If the double track single tunnel is applied, the train operation becomes bi-directional traffic in one tunnel. The wind by the piston effect of the train running is counterbalanced and this wind also becomes the obstacle against the air flow generated by the fans. The efficiency of the ventilation is quite low and it is necessary to install intermediate ventilation shafts between stations. The longitudinal ventilation system could not be applied, thus the concentrated exhaust method in the middle of tunnel is suitable. Therefore, not only the construction cost for the intermediate ventilation shaft but also the ventilation cost, including power consumption, becomes expensive.

The comparison of the tunnel ventilation systems is shown in Table 4-118 and the cross sections of the single track double tunnel and the double track single tunnel are shown in Figure 4-326.

Table 4-118 Comparison of Tunnel Ventilation Method

Ventilation System	Schematic Layout	Characteristics
Longitudinal Ventilation		- Suitable for Single Track Double Tunnel because of the piston effect of train. - Intermediate ventilation shaft is not baisically required.
Concentrated Exhaust in the middle of Tunnel		- Suitable for Double Track Single Tunnel. - Intermediate ventilation shaft is required.

Source: JICA Study Team



Source: JICA Study Team

Figure 4-326 Single Track Double Tunnel (left) and Double Track Single Tunnel (right)

c) Fan of Tunnel Ventilation Method

The speciality of the metro tunnel ventilation is high pressure loss due to the long and bended duct in the station. Moreover, the noise from the fan should be minimized because it is located in the station. Based on these characteristics, the single inlet centrifugal fan is applied. The air is blown in one direction through the saccardo nozzle. As indicated in the next section, the tunnel ventilation fan is used for smoke exhaust in case of fire, when the requirement of air volume is usually larger than that of normal operation. Therefore, the fans are planned to generate the air flow in the tunnel faster than 1 m/s, which is the speed value required for smoke exhaust.

Source: Tokyo Metropolitan Gov. Transportation Bureau

Figure 4-327 Centrifugal Fan for Tunnel Ventilation (left) and Saccardo Nozzle (right)

(5) Preliminary Study of Ventilation Facilities

The required capacity of the ventilation facilities are calculated as follows:

Table 4-119 Required Capacity of Ventilation Facilities

■Track Exhaust Volume (One side)

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Temperature Difference of Supplied Air	5 ℃	5 ℃	5 ℃	5 ℃	5 ℃	5 ℃	℃	5 ℃
Heat Load of Rolling Stock (kW)	320.0 kW	320.0 kW	320.0 kW	320.0 kW	320.0 kW	320.0 kW	kW	320.0 kW
Required Exhausted Air Volume (m3/h)	191,000 CMH	191,000 CMH	191,000 CMH	191,000 CMH	191,000 CMH	191,000 CMH	CMH	191,000 CMH
Maximum Air Speed in Duct (m/s)	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	m/s	5 m/s
Required Total Duct Area (m2)	10.6 m2	10.6 m2	10.6 m2	10.6 m2	10.6 m2	10.6 m2	m2	10.6 m2
Over Track Exahust Area (one side) (m2)	3.6 m2	3.6 m2	3.6 m2	3.6 m2	3.6 m2	3.6 m2	m2	3.6 m2
Under Track Exahust Area (one side)(m2)	1.8 m2	1.8 m2	1.8 m2	1.8 m2	1.8 m2	1.8 m2	m2	1.8 m2
Supplied Air Shaft Area (one side) (m2)	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	0.0 m2	5.3 m2
Exhaust Air Shaft Area (one side) (m2)	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	0.0 m2	5.3 m2

■Tunnel Ventilation Volume (One side)

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Effective Cross Sectional Area of Tunnel (m2)	29 m2	29 m2	29 m2	29 m2	29 m2	29 m2	29 m2	29 m2
Hydraulic Diameter (mm)	6,050 mm	6,050 mm	6,050 mm	6,050 mm	6,050 mm	6,050 mm	6,050 mm	6,050 mm
Required Aiir Speed in Tunnel(m/s)	1.0 m/s	1.0 m/s	1.0 m/s	1.0 m/s	1.0 m/s	1.0 m/s	1.0 m/s	1.0 m/s
Required Air Volume in Tunnel (m3/h)	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH
Maximum Air Speed in Duct (m/s)	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s	5 m/s
Supplied Air Shaft Area (one side) (m2)	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2
Exhaust Air Shaft Area (one side) (m2)	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2

■Tunnel Ventilation Shaft (Supply, one side)

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
TEF	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	0.0 m2	5.3 m2
TVF	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2
Safety Factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	13.3 m2	13.3 m2	13.3 m2	13.3 m2	13.3 m2	13.3 m2	7.0 m2	13.3 m2

■Tunnel Ventilation Shaft (Exhaust, one side)

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
TEF	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	5.3 m2	0.0 m2	5.3 m2
TVF	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2	5.8 m2
Safety Factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	13.3 m2	13.3 m2	13.3 m2	13.3 m2	13.3 m2	13.3 m2	7.0 m2	13.3 m2

Source: JICA Study Team

The selected ventilation facilities are tabulated as follows:

Table 4-120 Capacity of the Selected Ventilation Facilities

■Track Exhaust Fan

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Required Exhaust Air Volume (m3/h)	191,000 CMH	191,000 CMH	191,000 CMH	191,000 CMH	191,000 CMH	191,000 CMH	0 CMH	191,000 CMH
Number of Fan	2	2	2	2	2	2		2
Required Exhaust Air Volume (m3/h)	95,500 CMH	95,500 CMH	95,500 CMH	95,500 CMH	95,500 CMH	95,500 CMH	CMH	95,500 CMH

■Tunnel Supply Fan

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Required Exhaust Air Volume (m3/h)	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH
Number of Fan	1	1	1	1	1	1	1	1
Required Exhaust Air Volume (m3/h)	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH

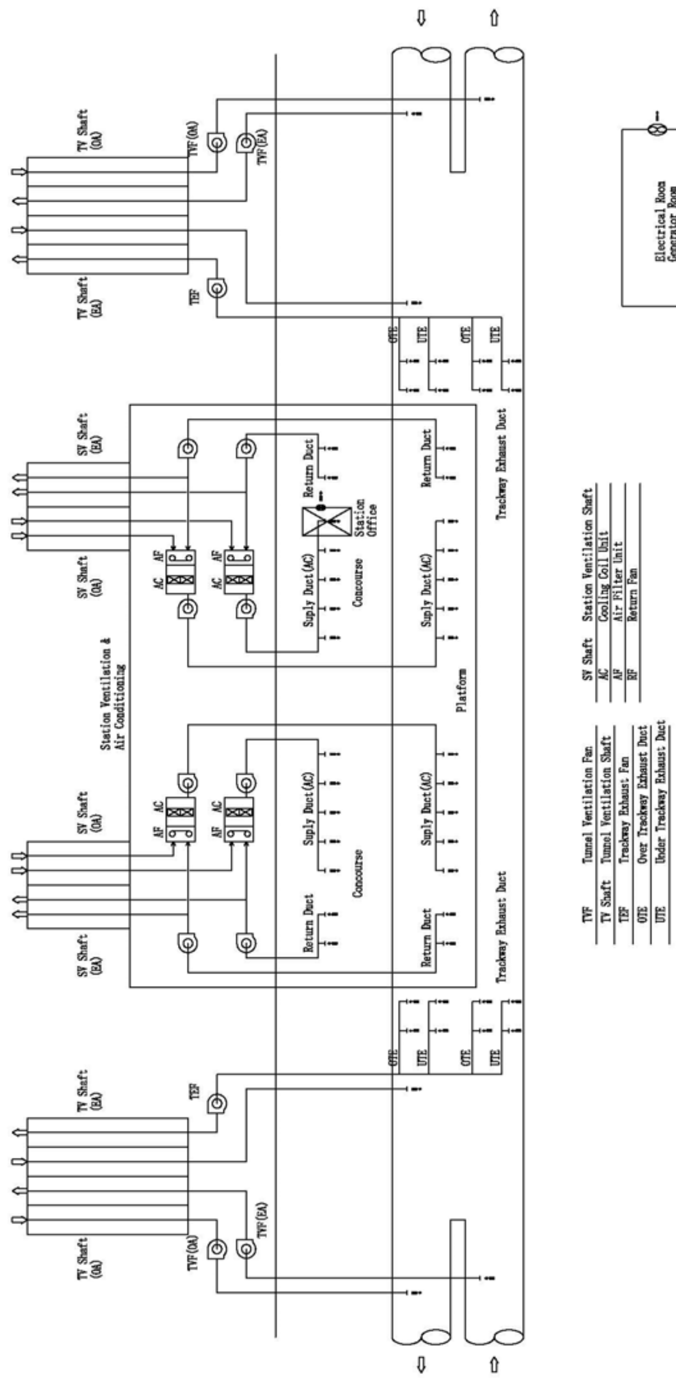
■Tunnel Exhaust Fan

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Required Exhaust Air Volume (m3/h)	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH
Number of Fan	1	1	1	1	1	1	1	1
Required Exhaust Air Volume (m3/h)	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH	104,400 CMH

Source: JICA Study Team

(6) Diagram of Ventilation Facilities Flow

The diagram of the ventilation facilities is shown as follows: The full height PSD is planned to be installed on the platform. In order to release the train wind, the draft relief shaft (shaft without fan) is provided. If the full height PSD is not installed on the platform, the draft relief shaft will be eliminated.

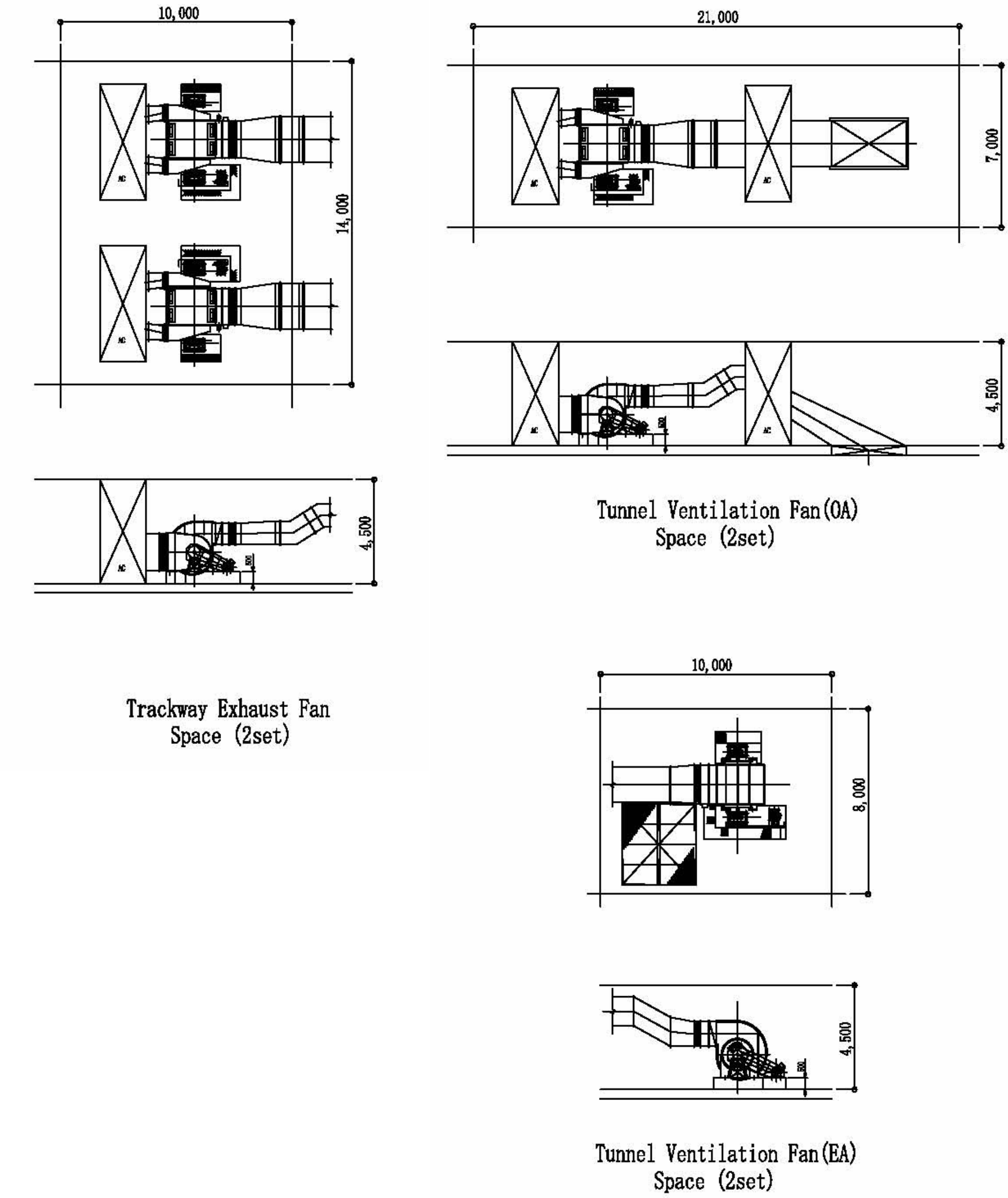


Source: JICA Study Team

Figure 4-328 Diagram of Tunnel and Track Ventilation Facilities Flow

(7) Outline of the Ventilation Fans and the Required Spaces

The outline of the tunnel and track ventilation fans and their required space in the station is shown as follows:



Source: JICA Study Team

Figure 4-329 Outline of Tunnel and Track Ventilation Fans and their Required Spaces

(8) Required Space for the Ventilation Shaft

The cross sectional area of the duct for the ventilation system is determined by the air volume and air speed in the duct. If faster air speed is applied, the cross sectional area can be reduced. However, the high speed air in the duct will generate high pressure loss and noise. In order to avoid production of noise and operate properly, it is recommended to apply the air speed of 5 m/s in the duct, as practiced in Japan (Plan and Design Guideline for Logistics and Transportation Facility, The society of heating, air conditioning and sanitary engineers of Japan).

According to this recommendation, the required area of the shaft and its opening is calculated as follows. The opening area of the ventilation shaft is usually covered by the louver or cage. The ratio of the opening area is determined by the outside air or other conditions. It will be determined in the design stage.

Table 4-121 Required Area in Ventilation Shaft and its Opening Area

Required Area in Shaft and Openning Area of Shaft

	Sta.1 EL_MALIK	Sta.2 EL_RODA	Sta.3 and Sta.13 EL_NILE	Sta.4 EL_GIZA	Sta.5 and 9 STANDARD (B2TYPE)	Sta.6-8, 10, 11, 14 STANDARD (B3TYPE)	Sta.12 AL_REMAYAH	Sta.15
Outside Air Supply (OA)								
Required Area in Shaft (one side)	19.0 m2	20.0 m2	18.4 m2	18.2 m2	18.3 m2	18.0 m2	10.7 m2	19.6 m2
Openning for Supply, one side								
Openning Ratio 100%	31.6 m2	33.4 m2	30.6 m2	30.3 m2	30.5 m2	30.1 m2	17.9 m2	32.6 m2
Openning Ratio 80%	39.5 m2	41.7 m2	38.3 m2	37.9 m2	38.1 m2	37.6 m2	22.3 m2	40.8 m2
Openning Ratio 50%	63.2 m2	66.8 m2	61.2 m2	60.6 m2	61.0 m2	60.1 m2	35.7 m2	65.2 m2
Exhaust of Air (EA)								
Required Area in Shaft (one side)	26.3 m2	27.2 m2	24.2 m2	25.4 m2	23.7 m2	23.6 m2	23.6 m2	26.5 m2
Openning for Exhaust, one side								
Openning Ratio 100%	43.8 m2	45.3 m2	40.3 m2	42.3 m2	39.5 m2	39.3 m2	39.3 m2	44.2 m2
Openning Ratio 80%	54.7 m2	56.7 m2	50.3 m2	52.9 m2	49.3 m2	49.1 m2	49.1 m2	55.2 m2
Openning Ratio 50%	87.6 m2	90.6 m2	80.5 m2	84.6 m2	78.9 m2	78.5 m2	78.5 m2	88.4 m2

Source: JICA Study Team

4.10.8 Smoke Exhaust System

In the event of fire accident in the station and tunnel, the smoke exhaust is one of the essential factors for passenger evacuation and for fire fighting. The smoke exhaust is usually done by the ventilation systems. The measure of each place is indicated as follows:

(1) Smoke Exhaust for the Platform

The volume of the smoke exhaust is large and it is not economical to install the air duct only for the purpose of smoke exhaust. In addition, the space above the platform level is limited. Therefore, it is reasonable and economical to use the ventilation system for the smoke exhaust in case of a fire accident. The basic policy of the smoke exhaust is as follows.

- Type 1 (see Figure 4-325) ventilation
  Type 1 ventilation (mechanically supplied and exhausted) is applied for the

ventilation of the platform. Therefore, the exhaust duct for the ventilation is used for the exhaust of smoke in case of fire.

- Residential area
  If the mouth of the exhaust shaft is located in a residential area, the air supplied duct will be used for smoke exhaust after the duct is switched and the direction of air flow is reversed.

(2) Smoke Exhaust Method for the Concourse

The principle of the smoke exhaust is the same as the platform. The capacity of the fan is studied to meet the requirement which is described in Section 4.3, in order to secure enough space for the evacuation of the passengers.

(3) Smoke Exhaust Method for the Station Office and Other Rooms

Dedicated exhaust duct and fans are provided for these rooms, where the station staffs or the passengers stay longer. Based on the Japanese standard (the Standard of Fire Safety Management for Subway Station, etc, Ministerial Ordinance of the Ministry of Land, Infrastructure, Transportation and Tourism, Japan), the minimum capacity of the fan is 1 m^3/min per m^2 of floor area. In case that an exhaust fan is used for two rooms/sections or more that are separated by a fire compartment or wall, the minimum capacity of the exhaust fan is 2 m^3/min per m^2 of floor area.

(4) Smoke Exhaust Method of the Tunnel

In case of a fire accident in the tunnel, the ventilation fans are used for the exhaust of smoke. The air speed for the smoke exhaust has to be smooth to secure the safety of the passengers and to help in the fire fighting. If the air speed in the tunnel is too fast, too much air is supplied, thus enlarging the fire scale due to excessive provision of oxygen. The exhaust fans have enough power to generate 1-2 m/s air speed in the tunnel. The suitable air speed in the tunnel for fire accidents is described in Section 4.3.

4.10.9 Water Supply, Sewage/Drain and Fire Fighting System

(1) Water Supply System

In order to determine the amount of water supply in the station, the passengers in the station, number of station staff and requirement of the air conditioner is determined. The water requirement is assumed to be 0.4 litres per passenger and 160 litres per station staff (Source: Plan and Design Guideline for Logistics and Transportation Facility, The Society of Heating, Air Conditioning and Sanitary Engineers of Japan).

There are mainly three types of water supply systems:

a) Direct connection to public water supply pipe

The water pressure is influenced by the fluctuation of the water pressure of public water supply pipe and it is necessary to connect by large diameter pipe to secure the large demand of water at peak time. Moreover, this system does not have local storage water tank at the station and there is the possibility that water supply is stopped due to the stoppage of the public water supply. Therefore, this system is not suitable for the water supply of the station.

b) Domestic water supply with gravity tank

It is difficult to secure enough space at ground level for the installation of the gravity tank. Therefore, this system is not suitable for the water supply of the station.

c) Domestic water supply with pressurized tank

This system is suitable for stable water supply and could be installed in the station. Water supply for the station is planned based on this system.

(2) Sewage/Drain System

The metro station is located underground. Thus, drained water is collected in the storage tank and pumped up to the ground level. The drained water is classified into two systems as follows:.

a) Wastewater

Wastewater is collected from many places in the station and the length of the drain pipe tends to be longer. In order to secure appropriate hydraulic gradient, the station will be divided into several zones and a storage tank will be assigned in the appropriate position.

b) Rainfall and Ground water

Rainfall water and ground water from the tunnel is collected at the end of the platform, where the storage tank is also installed.

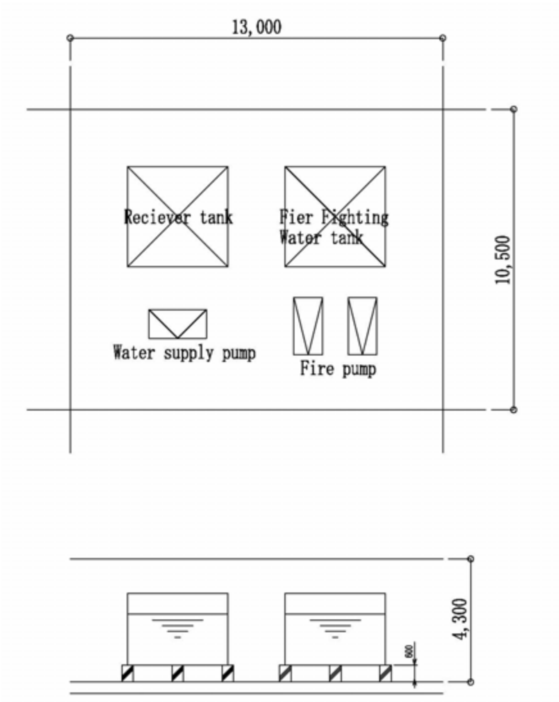
(3) Fire Fighting System

In order to prevent and minimize fire accidents, the following fire fighting system will be installed:

- Hydrant for platform, concourse and other areas
- Automatic sprinkler for station staff room, etc. and storage room
- Water supply pipe and hydrant in tunnel

(4) Outline of Water Tank, Pump and its Required Space

Outline of the water tank and pump and their required spaces are indicated as follows.



Water Tank
Source: Morimatsu Industry Co., Ltd.

Source: JICA Study Team

Figure 4-330 Outline of Water Tank, Pump and their Required Spaces in the Station

4.11 Workshop and Depot Plan

4.11.1 Introduction

As part of the construction of the future Metro Line 4, new modern rolling stock will be procured. This significant asset of the Egyptian nation must be maintained and preserved. It is essential therefore to have adequate facilities, equipment and resources in order to meet this important objective.

In order to facilitate maintenance operations and to limit vehicle downtimes, maintenance must be particularly adapted to suit the new rolling stock. In order to ensure the required reliability, availability and safety, it is also crucial that these installations (installations, equipment, tools and personnel) be particularly adapted to the new rolling stock.

It should be noted that the new EMUs to be procured will have modern technology and will call upon relatively complex maintenance techniques, which are likely to be different from those for the currently operating vehicles on the other Cairo Metro lines. This will be particularly true for the electric and electronic units and components. The reliability, availability and durability of the new rolling stock will depend not only on its inherent quality but also and mainly on the means of maintenance which will be put in place in which the competence, qualification and training of the maintenance personnel will form an integral part.

4.11.2 Maintenance Policy

The reliability, availability, maintainability and safety (RAMS) requirements and targets will be set in the technical specifications for the rolling stock to be procured. Once in service and after the defects liability period has expired, these goals will only continue to be achieved through on-going effective maintenance and repair operations. In order to facilitate the achievement of the above-mentioned objectives, an effective maintenance policy needs to be established.

Maintenance operations are classified into five technical levels following the volume and nature of work to be undertaken. They originate as recommendations from the rolling stock manufacturer who will propose a maintenance regime in which maintenance tasks and operations will be classified depending mainly upon the complexity of the task, level of qualification of the staff, expected time required to perform the task, tools and facilities required for the task, etc. The abovementioned five technical levels of maintenance operations are briefly described as follows:

Level 1 maintenance: the related tasks comprise those involving driver checks and preparatory tests prior to departure, in the course of running, when changing ends, etc. Modern rolling stock also includes a range of automated tests and condition monitoring, which also forms part of level 1 maintenance, through the use of on-board monitoring and diagnostic devices and event recorders as well as certain ground-based equipment such as hot axle box detectors, etc.

Level 2 maintenance: the tasks at this level comprise the tests, rapid component exchange of Line Replaceable Units (LRUs) and other interventions of a limited duration which can be performed at agreed intervals, such as during turn around at terminal stations, so as not to disturb the normal operation of trains.

Level 3 maintenance: relates to activities which must be carried out at a maintenance depot, with the EMU, or individual vehicles being withdrawn from commercial service. It comprises, in particular, of Planned Preventive Maintenance (PPM) and the exchange of major units or sub-assemblies according to pre-determined criteria, mileage, wear limits, number of cycles in operation, etc. This level also corresponds to corrective maintenance involving the replacement of defective components or complex adjustment and calibration of sub-assemblies as well as such tasks as wheel re-profiling.

Level 4 maintenance: involves major maintenance and overhaul of equipment as part of PPM as well as heavy repairs following collisions, derailments, etc. generally requiring the use of special machinery and equipment such as synchronised jacking systems, cranes and other mechanical handling equipment, etc. Also included in level 4 maintenance activities are the repair and reconditioning of defective major components and assemblies (removed from vehicles) which are to be returned to stock for future use, such as air conditioning units, bogies, electric motors, brake control units, etc.

Level 5 maintenance: is reserved for vehicle modernisation or other types of major re-manufacturing of the rolling stock. Such activities will not be considered in the development of the facilities for the Metro Line 4 depot.

(1) Maintenance Hierarchy

Maintenance is a combination of activities destined to maintain or restore a material to a given state or condition of safety of operation and/or to achieve a necessary function, etc. These activities cover a range of technical, administrative and management actions.

Maintenance can be preventive or corrective. The categories of maintenance operations are as follows:

- Planned Preventive Maintenance (PPM),
- Corrective Maintenance.

a) PPM

The main objective of PPM is to reduce, as much as possible, the probability of in-service failures or the degradation of vehicle performance during commercial operations. In order for this to be achieved, however, it is essential that the rolling stock is procured against well defined RAMS criteria and can thereby be properly and easily maintained.

PPM can be sub-divided into three classes of activity, namely:

- Servicing,
- Planned (Systematic) Maintenance, and
- Conditional Maintenance.

<table>
<tr><th>Servicing</th><th>Planned Maintenance</th><th>Conditional Maintenance</th></tr>
<tr>
<td>Servicing principally consists of daily or weekly preventive maintenance tasks which contribute to the trouble-free operation of the rolling stock as well as the good image of the operator and typically includes:

• Manual or machine washing of the vehicle exteriors;
• Interior cleaning;
• Replenishment of various reservoirs, windscreen wash fluid, etc;
• Correction of minor defects, as reported;
• Visual verification of the condition of current collection devices.

These operations are generally carried out at the servicing point within the depot or in the stabling yard.</td>
<td>Planned Maintenance consists of vehicles entering the depot, according to a pre-established programme as a function of elapsed time or mileage run, in order to perform the different assigned tasks of cleaning, diagnostics, calibrations and component exchange, particularly:

• Verification of the correct operation of vehicle systems and equipment;
• Verification of the correct operation of safety devices and interlocks;
• Equipment cleaning to avoid abnormal heating and the risks of short circuit or arcing;
• Calibrations and adjustments to ensure the optimal functioning of the rolling stock.</td>
<td>Conditional Maintenance consists of undertaking various operations according to the state of the equipment, revealed by reaching a certain threshold.
The determination that the limiting condition has been reached may be made through a number of different means, namely:

• Visual examinations;
• Individual measurements;
• Wear indicators;
• Go / No-Go gauges;
• Level indicators;
• Limiting condition, elapsed time or distance run;
• Diagnostic Systems (tests).</td>
</tr>
</table>

b) Corrective Maintenance

Corrective or curative maintenance comprises those actions taken, following the failure of a vehicle system or the degradation of its performance, in order to allow it to continue its service or to be able to reach an appropriate maintenance facility for further attention. Corrective or curative maintenance activities generally includes the localisation of faults and their diagnosis, correction of the fault (component exchange, repair, etc.) and the verification of correct operation following the repair.

Corrective maintenance can be sub-divided into two classes of activity, namely:

- Running repairs, and
- Corrective maintenance or repair.

Running repairs	Corrective maintenance or repair
Running repairs can be definitive, as in the case of replacing a defective control jumper between vehicles, and once completed, no further attention will be required. More generally, however, running repairs are palliative corrective actions, undertaken on a provisional basis by maintenance staff or, in some cases, by the driver. Such provisional repairs allow the vehicle to recover from a failure while in service in order to minimise the time during which normal operations may be disrupted, provided always that operational safety rules and regulations can be respected. The rolling stock can therefore depart, with or without passengers according to running orders corresponding to the vehicle condition (one trip only to depot, end of day to depot, made safe for being hauled empty to depot, etc.). The rolling stock will subsequently be subject to more detailed corrective maintenance or repair once it reaches the maintenance depot.	A corrective maintenance task is a definitive action taken by a member of the maintenance staff and performed on the defective vehicle, sub-assembly or component. Following this repair, the rolling stock must be fully restored to its original functional characteristics. Whatever its origin, a corrective maintenance operation generally incorporates the following actions: • The diagnosis of the failed component (fault finding); • Repair or component exchange; • Verification of the correct operation of the component; and • Verification of the correct operation of the rolling stock.

(2) Maintenance Periodicity

Maintenance periodicities have to be established in coordination with the rolling stock manufacturer and must be based on his recommendations, in order for vehicle and component warranties and guarantees to be honoured.

Whatever the source of the rolling stock, the underlying maintenance hierarchy (as described in the previous section) will be observed.

At present, there are two different types of maintenance scheduling in use, respectively, by the existing Metro Line 1 and Metro Line 2 depots. The Metro Line 1 depot follows the classical French maintenance regime, shown as an example in section a) below, whilst the Metro Line 2 depot follows the classical Japanese maintenance regime, shown as an example in section b).

a) French PPM System, Similar to that used for Metro Line 1

Level 0	**Periodicity**	**Duration**	**Work Involved**
Check Oil and Grease levels	Each entry to depot	15 min	Oil and grease topping up.
Windscreen wash liquid	Each entry to depot	15 min	Topping up of windscreen wash liquid.
Level 1	**Periodicity**	**duration**	**Work Involved**
VAR Visual inspection by driver		15 min	External visual examination; Visual examination of roof-mounted electric equipment.
Level 2	**Periodicity**	**duration**	**Work Involved**
EAI-CB Interior inspection	Each entry to depot 18 days maximum	1 hour	Visual examination of vehicle interior (seats, lighting, partitions, bays, etc.); Reporting of the defects from drivers' logbook.
ECF Examination, Comfort	18 days (maximum: 37 days)	2 hours	Comfort examination (sound system, lighting); Passenger access doors (operation); Air-conditioning (operation).
ES Service exam, Mechanical	18 days	1 hour	Examination while in service (by walking along the train, disabled parts, audible leaks, etc.).
EMN Mechanical Examination	37 days	4 hours	Bogie assemblies check; Mechanical examination (wheelsets, bearings and pantographs); Underframe checks (without rotation of axles); Suspension and shock absorbers checks; Brake blocks and pads, oil levels, flange lubricators and battery checks; Drivers cab and passenger compartment; Air-conditioning checks.
ATS1 (mechanical, brakes and electrical exam)	104 days	8 hours	EMN + with rotation of axles and wheel gauging and compressor oil checks; Electrical machine filters check, switchgear checks; Vehicle couplers (cleaning, lubrication + buffers and coupling + brake and compressed air system checks+ air-conditioning (filters exchange) + testing before release to service).
Level 3	**Periodicity**	**Duration**	**Work Involved**
VL	80.000 km	2 days	Limited exam, including 1 day of testing.
VG	160.000 km	3 days	General exam, including 1 day of testing.
GVG	320.000 km	5 days	General major exam, including 1 day of testing.
TS12 Vehicle safety tests	12 months	2 days	Safety tests: brake, electrical; Air-conditioning circuits leakage tests.
TS36 Vehicle safety tests	36 months	5 days	Safety tests: brake, electrical, as for TS12 + air reservoirs; Complete brake system examination.

b) Japanese PPM System, Similar to that used for Metro Line 2

Level 1	Periodicity	duration	Work Involved
Daily Inspection	Every 2 to 6 days	1 hour	Oil and grease topping up; Topping up of windscreen wash liquid; External visual examination; Visual examination and functional verification of roof-mounted electric equipment, drivers controls, brakes and doors.
Level 2	**Periodicity**	**duration**	**Work Involved**
Functional Maintenance	Every 90 days or 30,000 km	1 day	Ultrasonic axle inspection; Gauging of wheel wear and profile; Inspection of pantographs, traction circuit, driving unit, brakes and doors; Inspection of body condition; Inspection of action, function and insulation of electrical components.
Level 3	**Periodicity**	**duration**	**Work Involved**
Major Equipment Maintenance	Every 4 years or 600 000 km	10 days	Removal, disassembly and detailed inspection of traction motors, power transmission units, driving units and braking units; Bogie replacement.
Level 4	**Periodicity**	**duration**	**Work Involved**
General Inspection	Every 8 years or 1,200,000 km	1 month	Removal, disassembly and detailed inspection of traction motors, power transmission units, driving units and braking units; Replacement of certain major components, depending on condition; Bogie replacement; Interior passenger accommodation overhaul; Car body repair and re-painting as required.

As is the case with any form of PPM, both of these scheduling arrangements are designed to ensure the required levels of reliability, availability and safety of the corresponding rolling stock. For the new Metro Line 4 rolling stock, provided that adequate RAMS requirements are placed upon the supplier, adequate scheduling arrangements for PPM will be developed in close cooperation with him. These are likely to be similar to one of the two examples above, but are not bound to be identical to either of these.

4.11.3 Existing facilities

The JICA Study Team visited the existing Metro Line 1 and 2 depots in order to make a preliminary investigation as to the nature of these facilities, the physical equipment installed, and the likely future capacity to perform outsourcing services for the new Metro Line 4 depot.

(1) Metro Line 1 Maintenance Depot and Workshops

The existing Metro Line 1 maintenance depot and workshops date from the 1960s, prior to the commencement of underground metro services in Cairo and were formerly part of the

Egyptian National Railway (ENR). The facility is located immediately behind Tora Metro Station.

These depot and workshops handle all the servicing, maintenance, repair and overhaul of the Metro Line 1 fleet which comprises of 52 EMUs manufactured by Alstom (phase 1 fleet), 47 EMUs also manufactured by Alstom (phase 2 fleet) and 53 EMUs manufactured by Kinkisharyo/Toshiba of Japan (phase 3 fleet). The total allocation of EMUs is therefore 152, each of which consists of 3 cars, making a total vehicle allocation of 456 cars. The depot is staffed on a three shift system basis and employs approximately 500 staffs, around 400 of which are technicians.

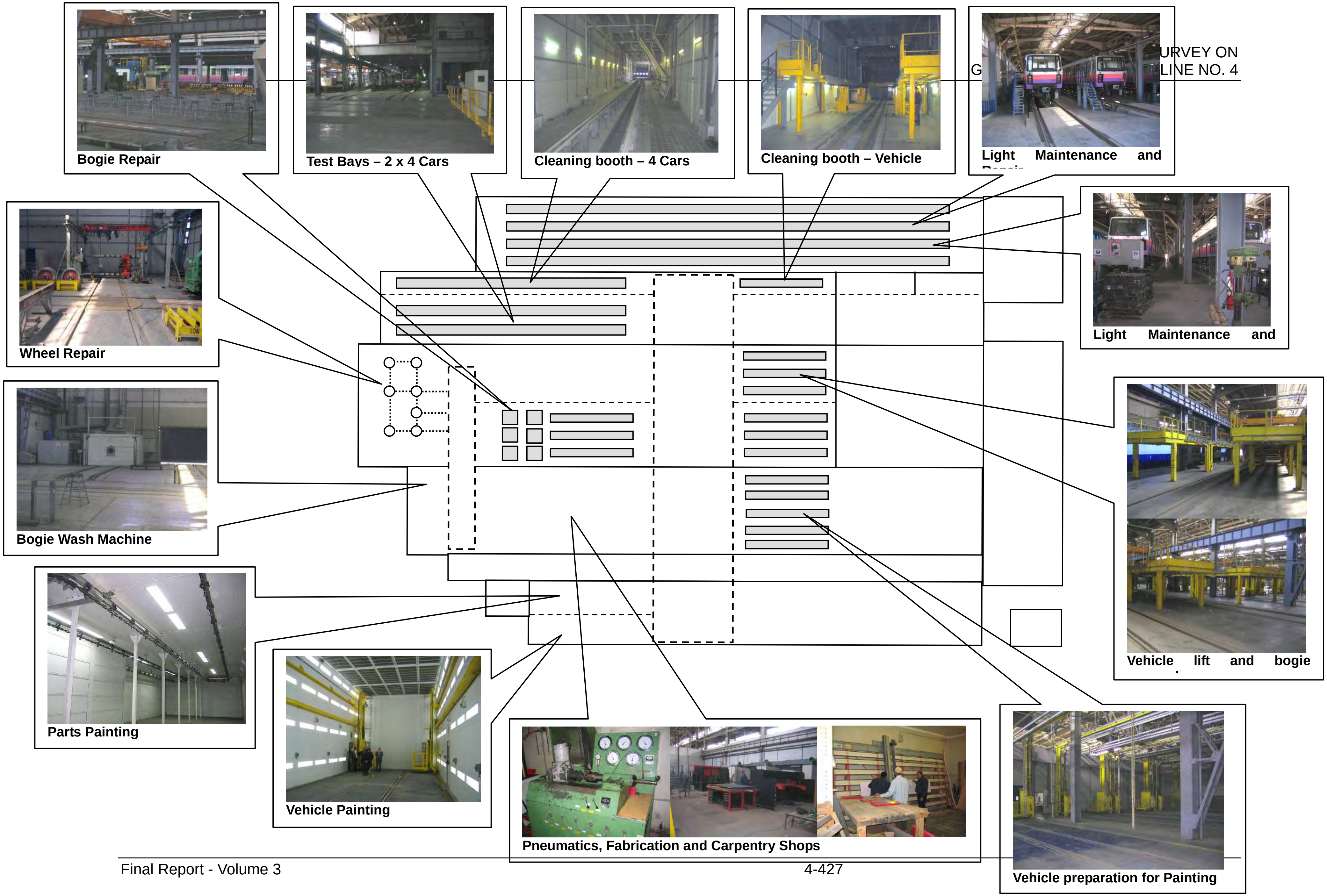
Since the original fleet was supplied by the French manufacturer Alstom, the systematic maintenance programming follows the classic French system as described in section 4.11.2(2)b) above.

(2) Metro Line 2 Maintenance Depot and Workshops

The existing Metro Line 2 maintenance depot and workshops are modern and extensively equipped. The depot has covered stabling over eight tracks with each track capable of berthing two trains. Four tracks are served by platforms and four are open. Total current berthing capacity under cover is therefore eight trains at platforms and eight more trains on tracks with no platforms, making a total of 16 full trains under covered stabling. The existing covered stabling facility will shortly be extended by the addition of two further tracks which will represent a future total capacity for covered stabling of 20 full trains.

The light maintenance and repair bays have four tracks and are annexed to the side of the main workshops. They have the capacity to hold four full trains, one on each of the four tracks. All four bays are served by full length access platforms and the floor area is depressed throughout the workshop facilitating free access to all bogie and underframe-mounted components. A 750 volt DC shore supply is available along the full length of the trains by the use of jumper cables from a conductor rail installed at cant rail level.

Immediately adjacent to the light maintenance and repair shop is the Overhaul Workshop Complex. This shop is split in half by a traverse, which runs across the full width of the workshops. The principal facilities of which are shown in the following figure:


Bogie Repair
Test Bays – 2 x 4 Cars
Cleaning booth – 4 Cars
Cleaning booth – Vehicle
Light Maintenance and
Wheel Repair
Light Maintenance and
Bogie Wash Machine
Vehicle lift and bogie
Parts Painting
Vehicle Painting
Pneumatics, Fabrication and Carpentry Shops
Vehicle preparation for Painting

(3) Outsourcing of Component Repair to Existing Depots

The JICA Study Team will investigate to what extent it will be feasible, effective and convenient to outsource some of the repair of the major components from the new Metro Line 4 rolling stock, to the existing Metro Line 1 and 2 depots. Candidate components and assemblies for such potential outsourcing of repair work may include such items as bogies, traction motors, air conditioning units, etc.

The feasibility of such an arrangement will depend substantially on the technical similarity of the rolling stock selected for Metro Line 4 to the existing Metro Line 1 and 2 vehicles. Equally important in the evaluation of this possibility will be the capacity of the maintenance equipment installed at the Metro Line 1 and 2 facilities and the extent to which these are currently occupied.

The outsourcing process itself involves additional cost. These costs are associated with the logistics involved, namely: process management, transportation and additional spare parts holding of any components selected for such an arrangement, and are due to the time required for the transportation of components for repair back and forth between the two depots, giving rise to an increased repair cycle downtime. It will also be necessary, therefore, to give careful consideration to the outsourcing process cost prior to arriving at a fully evaluated conclusion.

As mentioned in Section 4.11.3 above, the JICA Study Team carried out a summary inspection of the existing maintenance facilities at the existing Metro Line 1 and 2 depots. The Metro Line 1 depot facilities are quite old and both these and the staff capabilities are suitable for maintenance of older series, classic DC traction-equipped vehicles only. Notwithstanding this fact, the depot does not appear to have any substantial spare capacity as would be necessary for accommodating outsourced work. It is therefore not considered practicable to have any outsourcing arrangement with the existing line 1 depot for the maintenance of the new Metro Line 4 rolling stock.

However, the Metro Line 2 depot is comparatively recent. It is extensively equipped and is capable of the maintenance and repair of modern technology vehicles. Furthermore, it appears that there is a reasonable margin of spare capacity capable of supporting an outsourcing arrangement for vehicles coming from another line.

It is understood by the JICA Study Team that the following philosophy has been adopted for the maintenance, overhaul and repair of the new rolling stock for Metro Line 3:

- The Metro Line 3 maintenance facilities to be constructed in Phase 1 will be for light maintenance and repairs only.
- Additional Metro Line 3 maintenance facilities will be constructed as part of Phase 3, in order to handle heavy maintenance, repairs and overhaul of Metro Line 3 rolling stock.
- Any heavy maintenance, repairs and overhaul of Metro Line 3 rolling stock, in

the initial phases, will be outsourced to the existing Metro Line 2 workshops.

It is essential that the above situation is formally clarified through NAT and that any existing studies and reports relative to the maintenance of the Metro Line 3 rolling stock are made available to the JICA Study Team. Without comprehensive data relative to the effect of Metro Line 3 maintenance policy and strategy and its impact on the existing Metro Line 2 workshops, it will be impossible for the JICA Study Team to make an effective analysis of any outsourcing potential relative to the Metro Line 4 rolling stock.

Despite the fact that the information necessary for an effective analysis, to be conducted by the JICA Study Team, has not been made available, there are a number of logical assumptions that can be made in the interim, namely:

- Currently, there is indeed sufficient spare capacity available within the existing Metro Line 2 workshops to support the outsourcing of heavy maintenance and repair for vehicles of another line.
- By the time that Phase 3 of Metro Line 3 is implemented, such spare capacity will no longer exist. Otherwise there would be no need to construct heavy maintenance/repair workshops for Metro Line 3 itself.
- It is unsafe to assume that the future Metro Line 3 heavy maintenance/repair workshops will be capable of undertaking outsourcing for Metro Line 4 rolling stock since nothing is known by the study team regarding these facilities.

Therefore, the JICA Study Team must work on the assumption that the Metro Line 4 maintenance depot and workshops will have to be self sufficient in terms of space, equipment and manpower.

Furthermore, during a meeting with Metro Line 2 depot staff on 9th July 2009, it was mentioned that the depot staff had been made aware that the maintenance and overhaul of Metro Line 3 rolling stock were planned to be undertaken at the Metro Line 2 depot. However, the Metro Line 2 depot staff did not believe that they had the spare capacity to undertake such work. It is, therefore, unsafe to assume that the further spare capacity, needed for the outsourcing of Metro Line 4 rolling stock maintenance, exists.

4.11.4 Potential Depot Location

The location of the future Metro Line 4 depot is constrained by the fact that the initial section of Metro Line 4 to be completed will be in the western section. Clearly, there is no possibility to locate such a facility near the city centre and therefore, a suitable location will need to be selected at the western extremity of the line, somewhere beyond the pyramids and the New Grand Egyptian Museum (GEM).

Potential sites had been identified by NAT, in the proximity of the military area beyond the New GEM, adjacent to the interchange of Alexandria Desert Bypass Road and Ring Road.

The location of the workshop/depot is as defined in NAT Letter No. PL/1428/700, dated 19th October 2009.

4.11.5 Train Washing Requirements

As trains are roistered in and out of the depot, they will require to be cleaned prior to departure. Interior cleaning will be performed in the stabling yard as described in the relevant section of this report. Two forms of exterior cleaning will be programmed:

- Exterior heavy cleaning, performed by hand in a dedicated area of the stabling sidings
- Exterior washing by fixed, automatic wash machine

Exterior heavy cleaning will be by hand in a dedicated area of the stabling sidings as described later in this report. Exterior washing shall be performed as described below.

For each visit to the depot, it is recommended that each train set is passed through an automatic exterior wash plant in order to preserve the general cleanliness and image of the Metro Line 4 fleet. Such cleaning can be performed upon arriving at the depot, on departing from the depot or once within the main depot facility (inside the depot complex). The latter, though, is not particularly recommendable unless arrival or departure washing is not considered feasible due to limitations of space or other constraints. Washing trains inside the depot complex can involve substantial shunting movements in order to ensure that trains are washed according to programme and should thus be avoided if possible.

Entry or exit washing seems feasible within the space available for the Metro Line 4 depot. For the particular circumstances in the depot location, entry washing presents some disadvantages to exit washing for the following reasons:

- Due to the rapid throughput required, vehicles may not have sufficient drying time before entering the servicing bays causing water contamination to the work area and presenting a certain nuisance for maintenance staff;
- The depot location is extremely dusty and if vehicles are washed upon entry, they are likely to accumulate sufficient dust and windborne dirt whilst stabled in the depot so that upon entry to service, they will already be dirty.

Exit washing presents the advantage of making it easier to stick to a regular and systematic washing programme. The trains leaving the depot will be doing so at the most reliable phase of operational plan, that being the daily start of operations. At such times, freshly maintained trains are dispatched to remote stations for the start of operations whilst other trains are injected into the service pattern for commencement of peak hour service, etc.

It should also be noted that modern carriage washing machines can be bi-directional with very modest additional capital cost. Having the flexibility to wash trains in either direction makes it increasingly possible to stick to a thorough and systematic cleaning programme, even after some disturbance to the programme has occurred.

It is therefore recommended that exterior washing is undertaken every three days upon exit from the depot. Supplemental to the planned, systematic, washing of trains, the facility will be capable of ad-hoc train washing in the reverse direction, upon entry to the depot, through a fixed, automatic, bi-directional carriage washing machine.

4.11.6 Stabling Requirements

Based on the traffic forecast data, it has been established that the depot will require the capacity to stable 20 trains for the initial period (short to medium term). For this purpose the depot stabling facility has been designed to accommodate, side by side, twenty trains in a single covered stabling shed.

In order to allow for daily servicing, removal of rubbish, replacement of lighting tubes and other such minor attention, a raised access platform is to be provided between each of the stabling tracks.

Adjacent to these stabling tracks and under the same train shed roof, four further tracks are provided to allow internal and external heavy cleaning.

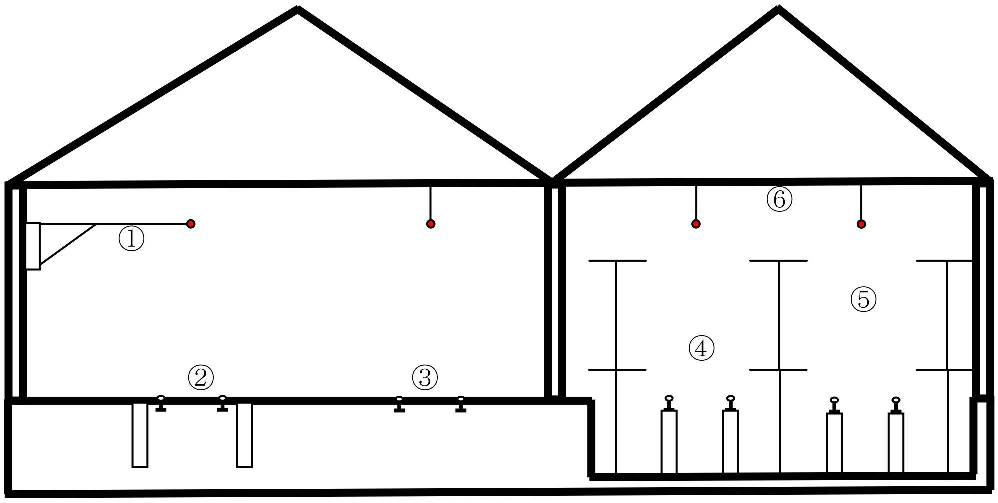
For future expansion, space has been allowed for the extension of this covered stabling facility in order to accommodate further ten trains. The eventual stabling capacity will be able to accommodate a total of 30 trains.

4.11.7 Berthing for Light Maintenance and Repair

Four train-length berths are planned in the Light Maintenance and Repair facility. The first two are dedicated to the planned periodic examination, maintenance and repair of Metro Line 4 rolling stock. The third bay is normally assigned for static testing of train sets, following in-service failure (diagnostics) or upon completion of periodic maintenance, or for overhaul (pre-service testing). A fourth bay is provided, mainly for the splitting/make-up of trains going to and coming from major overhaul. This bay has a full length system of pit jacks to allow for the rapid removal and replacement of bogies.

Each of these four bays can be served by the traverser, which connects the vehicle heavy cleaning bay to the bogie overhaul facility and the vehicle heavy repair/overhaul workshop.

The functioning of the lifting bay will be described in the following section, as its main role is to facilitate the operation of the heavy repair and overhaul workshops. A typical cross section of these bays is shown below:



① Retractable catenary, interlocked with jacking system and cranes
② In-floor pit jacks for bogies and vehicles, 8 cars
③ Test track with mobile access platforms, interlocked with catenary supply
④ Light maintenance tracks with depressed floor for ease of access
⑤ Body level access platforms along full length of train
⑥ Roof level access platforms, interlocked with catenary supply

4.11.8 Berthing for Heavy Maintenance and Repair

Vehicles arriving for heavy maintenance or repair will arrive normally as fully formed train units under their own power. The individual vehicles, being propelled into the facility for out of course repair, can directly access the heavy repair bays via the traverser which has a separate connecting line provided for this purpose.

Trains arriving under their own power will be berthed on the fourth line where a full-length set of pit jacks will be installed. Such facilities are very versatile as they allow the removal/replacement of any wheelset or bogie and/or all bogies in the train. Such operations can be performed rapidly through the simultaneous lifting of the entire train. When the pit jacks are retracted, flush with floor level, the whole floor area around the train can be accessed by fork lift trucks, etc.

Bogies having been liberated on the pit jacks can pass, via the traverser, directly to the bogie repair shop. Depending on the nature of the maintenance to be performed, either new or overhauled bogies can be installed under the train or the vehicles can be fitted with accommodation bogies and then pass, one by one, into the heavy repair and overhaul workshop. If heavy cleaning is required as part of the maintenance to be performed, vehicles can also pass into the heavy cleaning bay, using the traverser, prior to entering the heavy repair workshop.

The heavy repair/overhaul workshop has four tracks. Each track can accommodate two vehicles where major component removal, dismantling and/or body frame repairs will be performed. Following repair, the vehicles will be re-built and fitted out prior to testing. At the rear of this workshop, the various component overhaul and repair bays are located. The pneumatic workshop is adjacent and located inside the bogie overhaul area.

(1) Bogie Overhaul

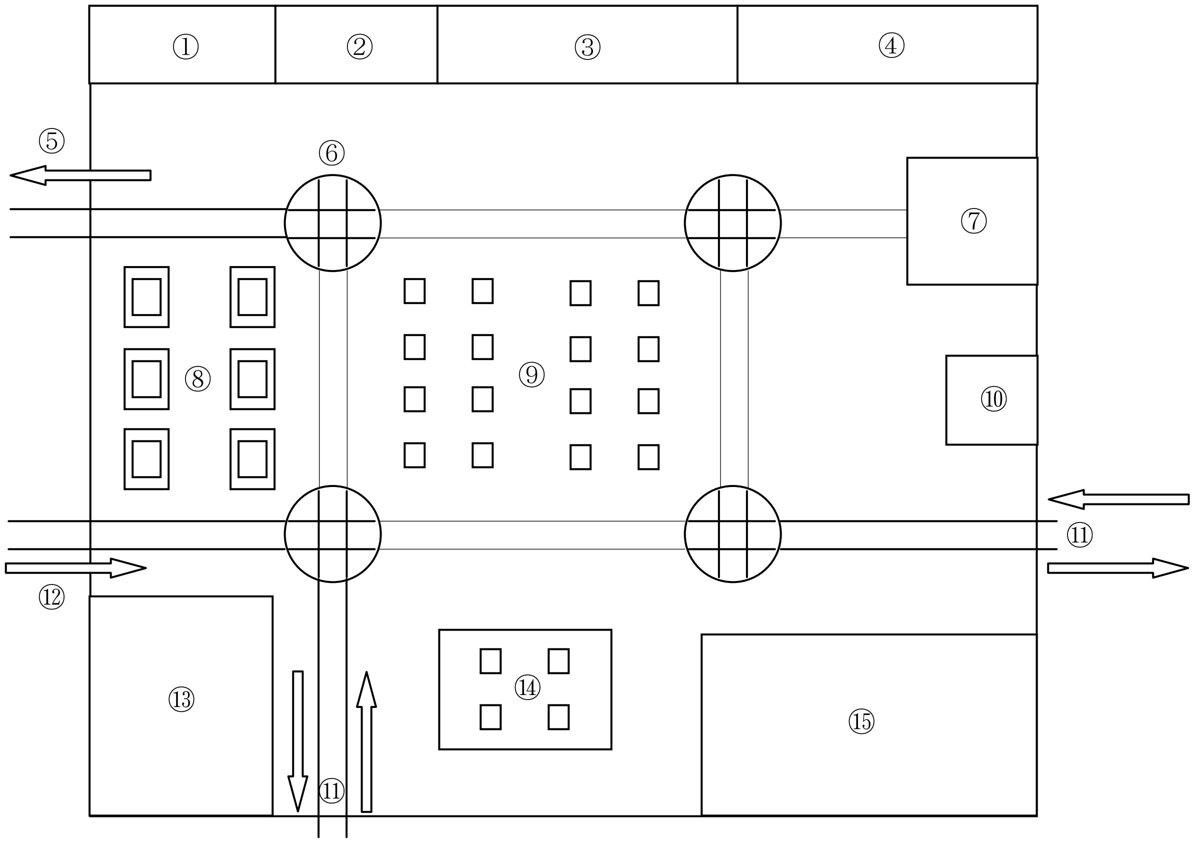
Bogies for repair or overhaul can be entered into the facility from the pit jack line, from the traverser or directly from the vehicle overhaul workshop. Such flexibility in the input and/or output of bogies allows for almost any eventuality or combination of circumstances concerning the flow of bogies for repair, or following repair and re-fitting to vehicles.

Detailed arrangements for the layout of machines, standage and mechanical handling and manipulation equipment shall be developed in the basic design stage of the project. However, the facility will be fully equipped to perform the following functions and operations:

- Bogies to be fully stripped down to all component parts,
- Wheelsets removed and sent for overhaul,
- Primary suspension units replaced,
- Secondary suspension systems overhauled,
- Brake system mechanisms removed and overhauled, all moving parts replaced,
- Gearboxes overhauled,
- Drive couplings overhauled.
- Traction motors overhauled,
- All cables and cleats replaced,
- Pneumatic systems overhauled,
- Bogie frames stripped, shot-blasted, crack tested, alignment checked, primed and painted.

After performing all of the above-listed component overhaul tasks, motor and trailer bogies will be fully rebuilt and tested. Repaired bogies will either be fitted to vehicles undergoing overhaul and repair or put into storage until needed.

The detailed workflows in the bogie repair workshop and layout of machinery and equipment within the shop shall be developed in the basic design stage of the project. The following sketch gives a preliminary layout plan for planning and cost estimation purposes only.



① Damper test and repair
② Welding bays
③ Brakegear strip down, overhaul and repair
④ Workbenches and small machining
⑤ Wheelsets to wheel shop for overhaul
⑥ Bogie turntable
⑦ Bogie wash machine
⑧ Traction motor repairs
⑨ Bogie frame stands for dismantling and re-building
⑩ Parts wash machine
⑪ Bogies for overhaul **IN** and overhauled bogies **OUT**
⑫ Overhauled wheelsets from wheel shop
⑬ Spare parts storage
⑭ Bogie final assembly and calibration
⑮ Pneumatic workshop

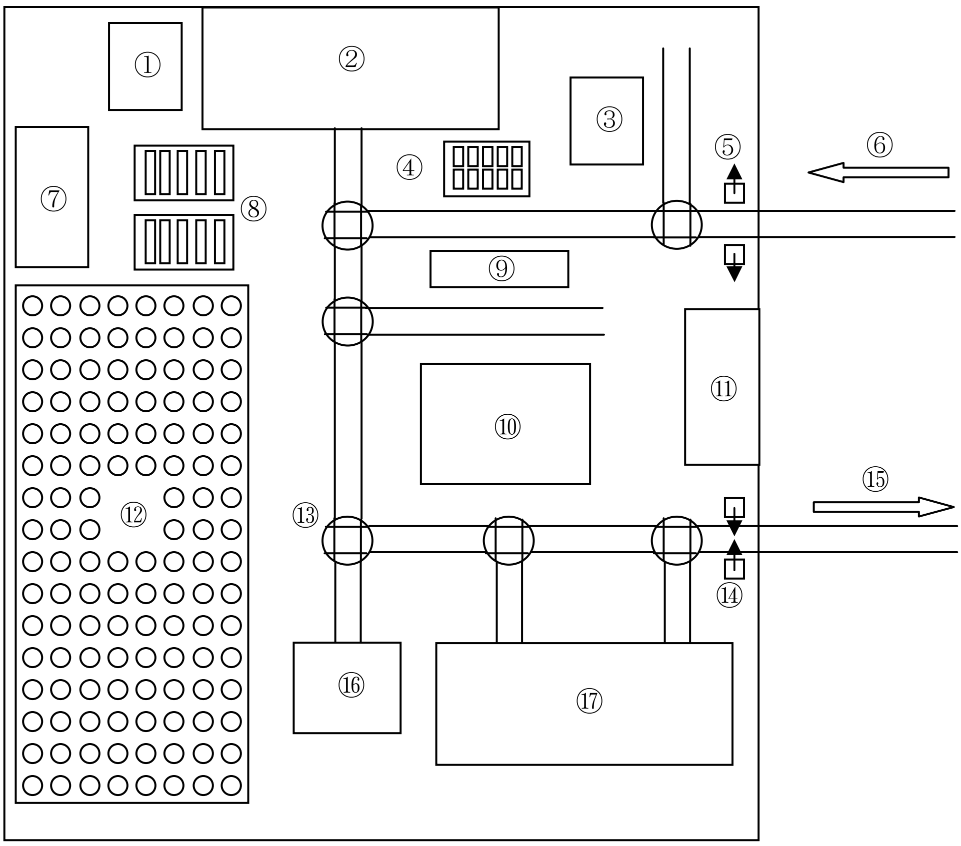
(2) Wheelset Repair

Wheelsets coming for repair will normally be those removed from bogies during the bogie overhaul process. However, it will also be possible that wheelsets for out of course repair will, from time to time, be dealt with in the facility.

The following standard range of wheelset repair operations will be performed and the workshop will be provided with a full range of machinery and equipment to perform such tasks:

- Cartridge bearing removal,
- Ultrasonic flaw detection, for the diagnosis of sub-surface defects,
- Measurement of wear limits for wheels and axle-mounted components,
- Removal of wheels and axle-mounted components as required,
- Axle body cleaning and corrosion protection removal,
- Magnetic particle inspection of axles for the detection and diagnosis of surface fractures,
- Wheelset re-building, mounting of wheels and axle-mounted components as required,
- Electrical continuity testing,
- Wheelset balancing,
- Application of corrosion protection, and
- Fitting of cartridge bearings.

The detailed workflows in the wheel shop, as well as the layout of machinery and equipment within the shop, will be developed in the basic design stage of the project. The following sketch gives a preliminary layout for planning and cost estimation purposes only.



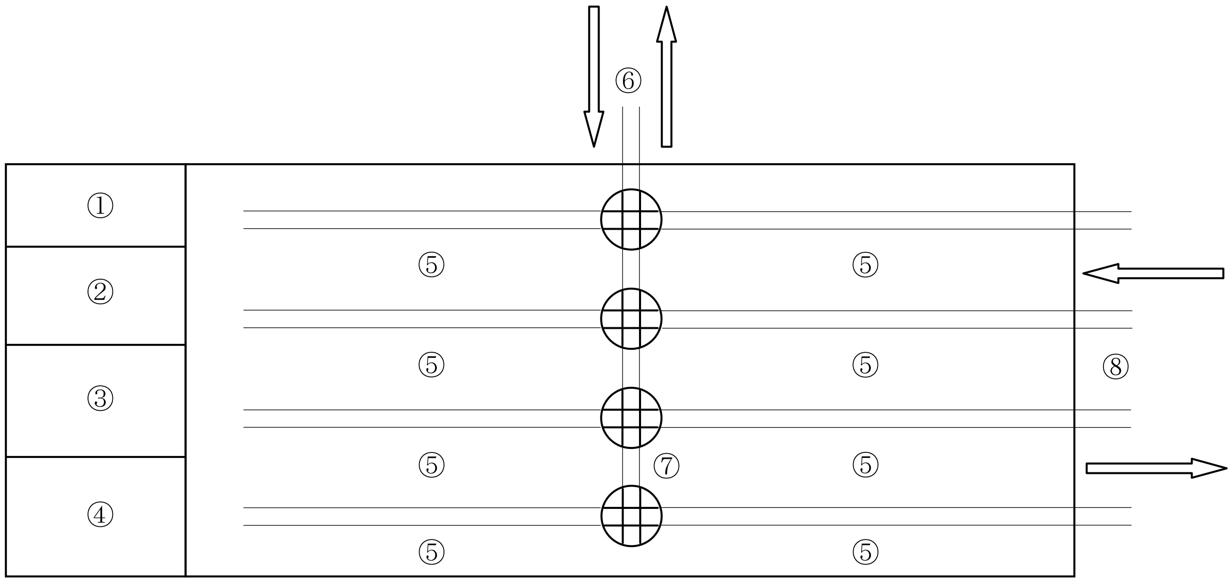
① Magnetic Particle Inspection (MPI)
② Axle/Wheel press
③ Ultrasonic Axle Testing (UAT), gauging and measurement
④ Wheel pan stands
⑤ Cartridge bearing removal, double sided
⑥ Wheelsets for overhaul/repair
⑦ Axle cleaning machine
⑧ Axle stands
⑨ Electrical continuity testing
⑩ Wheel balancing machine
⑪ Bearing repair shop
⑫ Wheel pan storage
⑬ Wheelset turntable
⑭ Cartridge bearing re-fitting, double sided
⑮ Overhauled wheelsets to bogie shop
⑯ Vertical boring machine
⑰ Corrosion protection application and curing area

After performing all the above-listed overhaul tasks, wheelsets will be returned to the bogie repair facility for assembly into bogies being re-built. Wheelsets not required for immediate fitting into bogies will be put in storage until needed.

(3) Vehicle Overhaul and Repair

Vehicles, coming into the facility for overhaul or repair, enter the facility via the traverser. Each of the four tracks in the vehicle workshop has two workstations and, therefore, the facility can accommodate one complete train of eight cars at any one time.

The detailed workflows in the vehicle repair shop shall be developed in the basic design stage of the project. The following sketch gives a preliminary layout for planning and cost estimation purposes only.



① Pantograph repair, overhaul and test
② Air conditioning unit/equipment overhaul and repair
③ Power control equipment test and repair
④ Electronic clean room, repair and test laboratory
⑤ Vehicle overhaul workstation, eight cars
⑥ Bogies **TO** and **FROM** bogie overhaul shop
⑦ Bogie turntables, four units
⑧ **TO** and **FROM** traverser

4.11.9 Principal Machinery, Tools and Equipment by Location

The following tables list the principal items of machinery, tools and equipment to be installed in the various workshops and facilities:

Light Maintenance and Repair		
Item	Description	Qty
1	Retractable catenary system running for the full length of the shop	1
2	Synchronised in-floor pit jack system covering 8 car EMU	1
3	Mobile, elevating access platforms, each side of repair/static test track	4
4	Fixed access platforms for body level and roof level access	3
5	Pit bottom, mobile drop table	2
6	Compressed air operated grease dispensing trolley	4
7	Movable access platforms	Lot
8	Hydraulic bench press and puller station	1
9	Workbenches	12
10	Tool lockers	30
11	Small machine tools, pedestal drill, bench grinder, etc.	Lot
12	Portable machine tools, drills, angle grinders, etc.	Lot
13	Tool sets	30
14	Slings, hooks, lifting rigs and general tackle	Lot

Bogie Overhaul and Repair		
Item	Description	Qty
1	Damper tester and hysteresis recorder	1
2	Spot welder for damper dust shields	1
3	TIG welding set	2
4	Oxy-acetylene welding set	2
5	Oxy-propane cutter	1
6	Bogie turntables	4
7	Bogie frame stands	16
8	Combined bogie frame jig and manipulator	1
9	Traction motor stands	6
10	Bogie bolster jig	1
11	Bogie press and wheel weighing machine, load distribution and calibration	1
12	Bogie wash machine	1
13	Parts washing machine	1
14	Spring tester	1
15	Parts shot blasting machine	1
16	Paint spray booths	1
17	Magnetic particle crack testing machine	1
18	Movable hydraulic press and puller set	1
19	Hydraulic bench press and puller station	3
20	Brake cylinder test bench	1
21	Brake control valves test bench	1
22	Test bench for various pneumatic equipment and valves	1
23	Slings, hooks, lifting rigs and general tackle	Lot
24	Workbenches	30
25	Tool lockers	60
26	Small machine tools, pedestal drill, bench grinder, etc.	Lot
27	Portable machine tools, drills, angle grinders, etc.	Lot
28	Tool sets	60

Wheelset Repair		
Item	Description	Qty
1	Magnetic particle axle testing rig	1
2	Axle press	1
3	Ultrasonic axle testing machine	2
4	Stands for wheel pans	1
5	Cartridge bearing press, removal, double headed	1
6	Cartridge bearing press, re-fitting, double headed	1
7	Axle cleaning machine	1
8	Axle stands	2
9	Wheelset electrical continuity tester	1
10	Wheelset balancing machine	1
11	Wheelset turntable	6
12	Vertical boring machine	1
13	Hydraulic bench press and puller station	1
14	Slings, hooks, lifting rigs and general tackle	Lot
15	Workbenches	12
16	Tool lockers	24
17	Small machine tools, pedestal drill, bench grinder, etc.	Lot
18	Portable machine tools, drills, angle grinders, etc.	Lot
19	Tool sets	24

Vehicle Overhaul and Repair		
Item	Description	Qty
1	Vehicle overhaul workstation with fixed access platforms and body jacks	8
2	Bogie turntable	4
3	Capstan hauling system	Lot
4	Pantograph wash machine	1
5	Pantograph contact surface grinder	1
6	Pantograph deployment test rig	1
7	Air-conditioning unit evacuation and refrigerant recovery station	1
8	Air-conditioning circuit rinsing and cleaning unit	1
9	Air-conditioning refrigerant gas re-charge station	1
10	Air-conditioning pressure and thermostatic test and calibration rig	1
11	Inverter test bench	1
12	Traction control unit test bench	1
13	Power supply unit test bench	1
14	Movable equipment stands; inverter, control unit, etc.	Lot
15	Fully equipped electronic clean room, repair and test laboratory	1
16	Compressor test rig	1
17	Door equipment workstation and test equipment	Lot
18	Slings, hooks, lifting rigs and general tackle	Lot
19	Workbenches	30
20	Tool lockers	60
21	Small machine tools, pedestal drill, bench grinder, etc.	Lot
22	Portable machine tools, drills, angle grinders, etc.	Lot
23	Tool sets	60

Workshop Ancillary Equipment		
Item	Description	Qty
1	Fork lift truck, 5 tonne, 4 WD, all terrain	1
2	Fork lift truck, 2.5 tonne	4
3	Palette truck, 600 kg, motorised	6
4	Floor cleaning machine	3
5	Movable access platforms, wheeled	Lot

Cranes		
Item	Description	Qty
1	5 tonne capacity, 6.5 m span, LRW + Vehicle overhaul bays	5
2	25 tonne capacity, 10 m span, Bogie Shop	1
3	5 tonne capacity, 5 m span, Bogie Shop + Wheel Shop	4
4	3 tonne capacity, 2.5 m Jib Cranes, Bogie Shop	4
5	1.5 tonne capacity, 2.5 m Jib Cranes, Various Ancillary Shops	10

Yard Equipment and Installations		
Item	Description	Qty
1	Standby generator set	1
2	Yard compressor, main air supply to workshops	1
3	Dust extraction bay, complete	1
4	Cleaning product mixing and dosing plant	1
5	Bi-directional carriage wash machine	1
6	Ground wheel lathe with hauling system, chip crusher and swarf conveyor	1
7	Woodworking shop	1

8	Fabrication shop	1
9	Light machining workshop and tool room	1
10	Traverser	1

Road Vehicles		
Item	Description	Qty
1	Stores lorry, 40 tonne	1
2	Stores lorry, 15 tonne	1
3	Ambulance	1
4	Fire tender	1
5	Mini-bus	2
6	Saloon car	2
7	Pickup truck	4

4.11.10 Typical Examples of Depot Equipment

The following section shows some of the principal machinery currently installed in depots and workshops around the world, as examples of the available technologies for maintenance of modern rolling stock.

(1) Jacking System

Full Length In-floor Pit Jacks

The free and clear space left when the jacks are retracted after lifting operations is clearly illustrated above.

Free Standing Above-floor Synchronised Jacks

Free standing jacks can also provide complete train lifting but remain an obstacle to free circulation when not in use.

Fixed Body Jacking System with Access Platforms (Individual Vehicles)

(2) Pantograph Inspection Gantries

Such inspection equipment allows the examination and inspection, in complete safety, of pantographs or other roof-mounted equipment, prior to entry to the depot.

(3) Environmental System

Cleaning Product Dosing Plant

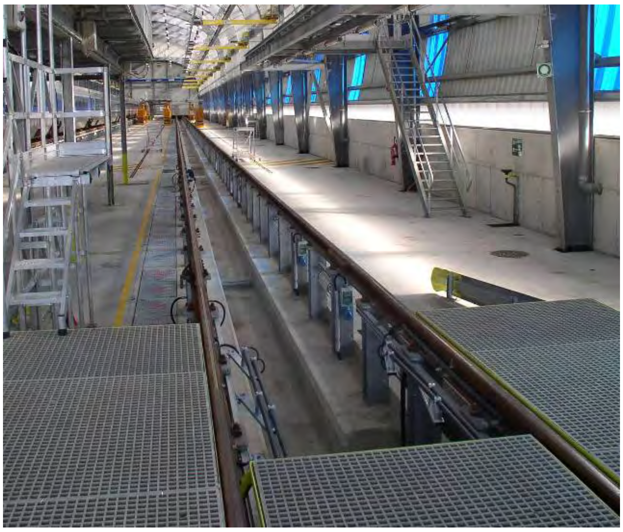
Traditional hand cleaning, as currently performed at the existing Metro Line 2 maintenance depot for example, relies upon the cleaning staffs themselves for the correct dosing and mixing of various concentrated chemical cleaning products. Therefore, these mixes will almost certainly be either too strong or too weak to varying degrees, due to human error. This can result in very poor cleaning results or, in the case of exterior acid washing, may be a health hazard if the chemical mixture is, accidentally, too strong.

The mechanised mixing and dosing of cleaning products permits more effective and safe interior and exterior heavy cleaning, without relying on cleaning staff to achieve the correct product dosage.

Water Treatment and Refuse Collection

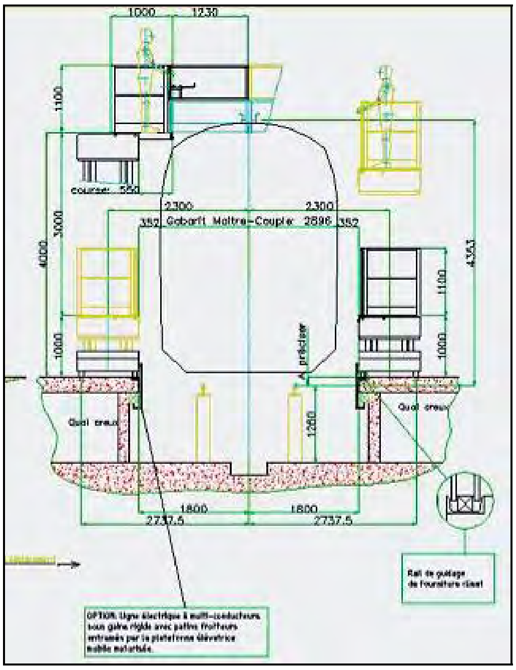
The treatment and purification of depot effluents as well as the controlled collection of refuse are essential to ensure the protection of the environment.

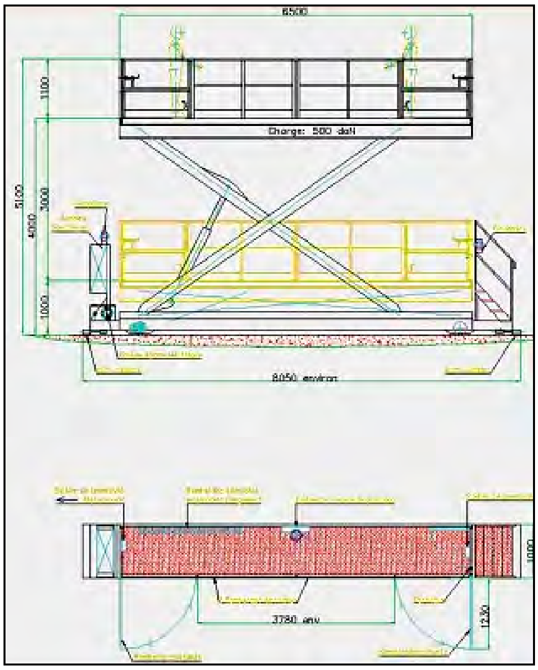
(4) Depressed Floor Working Areas



Depressed floor areas, where the rails are supported on columns, can be very effective in permitting free access to all parts of the train for light maintenance and repair. When these are combined with mobile access platforms, they give the benefit of free and clear access to vehicles whilst also permitting the use of fork lift trucks, etc.

(5) Mobile Access Platforms





Mobile access platforms of typical dimensions as shown above are frequently used to permit free access to body sides and roofs, where it is either uneconomical or impractical to use full length access platforms and it is desirable to allow free circulation of fork lift trucks, etc.

(6) Ground Wheel Lathe

Ground wheel lathes are commonly used throughout most modern maintenance depots. They permit rapid and accurate re-profiling of wheels on vehicles and complete trains, without the need to split the train or remove the wheelsets from the vehicles.

(7) Carriage Washing Machines

Various types of carriage wash plants exist for the exterior washing of trains, operating safely and effectively, with or without the existence of an overhead catenary.

(8) Pantograph Repair Equipment



For the safe handling and effective repair and testing of pantographs, the above facilities for washing, contact surface grinding and assembly and testing of pantographs are usually provided.

(9) Repair and Testing of Air-conditioning Equipment




Various equipment, as shown above, are used to evacuate and recover used refrigerant gases, perform internal cleaning of refrigerant circuits and re-charge and test evaporator units, pumps, etc.

4.11.11 Yard Facilities and Equipment for Phase 1

The Metro Line 4, Phase 1 depot yard is divided into two distinct parts. One part is associated with stabling and cleaning and another part is dedicated to maintenance and repair. In addition to these two complexes, there are buildings for administration, signalling and control as well as for traction power supplies.

In addition to the train washing, stabling, light maintenance and heavy maintenance facilities described in the previous chapters, there are yard facilities provided for the re-profiling of wheels by a ground wheel lathe; stabling, maintenance and repair of two diesel shunting locomotives; stabling, maintenance and repair of on-track plant for track maintenance and other works. In addition, there is an outdoor compound for the storage of permanent way and other large materials such as rail sections, etc. A diesel fuel storage and dispensing facility is located in the vicinity of the shunting locomotive and on-track plant buildings.

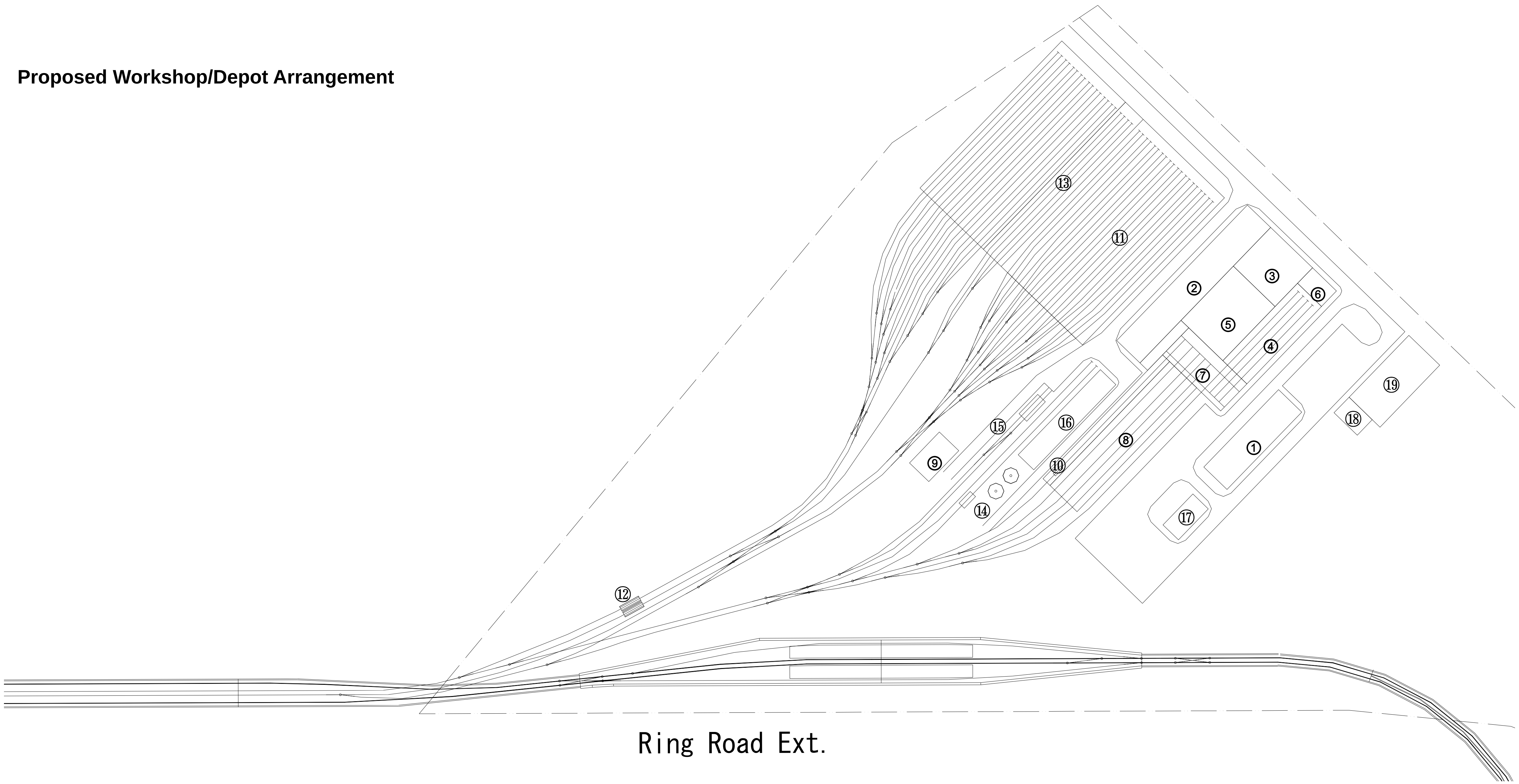
All the main yard facilities are connected by an internal circulatory road network. This road network does not cross any of the electrified tracks due to the obstacle of the traction power distribution system.

The ultimate capacity of the workshops is intended to permit the throughput of 20 full trainsets, annually, for 3-yearly and 6-yearly planned maintenance and overhaul during full 24-hour shift operation. This capacity should be adequate to cater to the needs of the Phase 1 initial fleet and for its later expansion to 30 trains as well as for the future needs of the Phase 2 fleet, projected to be additional 30 trains.

However, the Phase 1 depot will only be able to accommodate 30 trains in total for stabling and light maintenance. Therefore, Metro Line 4 Phase 2 will need to have a depot facility for the stabling and light maintenance of its own fleet of 30 trains in the future.

Layout of yard facilities are shown in the figure overleaf.

Proposed Workshop/Depot Arrangement



①	**Administration Building**	⑧	**Light Maintenance/Repair + Full Length Jacking**	⑮	**On-Track Machines, Tamper and Other Civil Works Vehicles**
②	**Main Stores Complex**	⑨	**Rectifier Sub-station**	⑯	**Permanent Way and Large Materials Storage, etc.**
③	**Wheel Repair Area**	⑩	**Ground Wheel Lathe**	⑰	**Combined Signalling and Traction Power Control Centre**
④	**Vehicle Heavy Repair and Overhaul**	⑪	**Covered Stabling 30 x 8 Car Trains**	⑱	**Lighting Power Sub-station**
⑤	**Bogie Repair and Overhaul**	⑫	**Bi-Directional Automatic Train Wash**	⑲	**High Voltage Sub-station**
⑥	**Ancillary Workshops: Machining, Fabrication, etc.**	⑬	**Heavy Cleaning, Interior/Exterior (4 tracks)**		
⑦	**Traverser**	⑭	**Diesel Shunting Locomotive + Road Vehicle Maintenance + Fuel Storage**		

4.12 Central Control Point (CCP)

CCP is the centre of the urban transport system and it consists of various equipment that are connected to the trains and stations. Since it is a complicated system, understanding of the whole system at once is very difficult.

Hence, the CCP operation plan is firstly described and then each component of CCP, i.e., signalling system, communications system and power SCADA system related to CCP, is introduced.

4.12.1 CCP Operation Plan

The CCP will be established on Metro Line 4 as has been the case with other lines in Cairo. This section describes the role, equipment and detailed tasks of CCP.

Even if some incident will happen on the urban railway system, continuing its operation as much as possible will be important since the urban railways will be an indispensable transit system for urban life. In these cases, a degraded operation will be necessary. The degraded operation will be discussed in this section, since these operations will be conducted by the controllers in CCP, although the drivers and station staff will also be involved.

(1) Roles of CCP

The following are the roles of the CCP. It can be seen that the CCP has the central role of controlling train operations on urban commuter lines.

Train operations will be conducted through communication between the controllers in the CCP and the train drivers, with CCP being in charge of route control. Specifically, CCP controls routes in the following ways:

- Route control for trains is done normally by the Automatic Train Supervisor (ATS);
- Route control in a contingency operation is done by ATS with instruction of the controller;
- Basically, route control of shunting inside the depot is done manually;
- Route control for maintenance vehicle at night time is done manually;
- Every morning, before start of revenue operation, the operation of the routes will be checked through an ATS confirmation test; and
- The SCADA system for power control will be operated at the CCP except in the case that maintenance staff will directly operate the SCADA.

When an incident happens, CCP controls train traffic in consideration of the following issues:

- Keeping the safety of passengers and staff as a top priority;
- Reporting the occurrence of the incident to the relevant authorities as soon as possible;
- Maintaining system capacity as much as possible when an incident happens at the peak time;
- Quick recovery to the normal operation as soon as possible; and
- Provision of transport as much as possible for sections other than the affected section.

CCP delivers traffic information to the stations, drivers' depot, maintenance workshop and so on through the following means:

- Direct communication with stations or maintenance depot;
- Internal broadcasting when some incident happens; and
- Train describers which, at minimum, display the location and delay of trains.

CCP supports drivers, station staff and maintenance staff when they have some difficulties in operation as follows:

- Support of drivers for troubleshooting when their trains have failures; and
- Support for the safety of maintenance staff who are engaged in trouble shooting or urgent maintenance works. In particular, the controller will stop the related trains or issue orders to reduce the train speed in order to assure the safety of maintenance staff in these situations.

(2) Location and Organization of CCP

Location of CCP

The CCP of Metro Line 1 and Metro Line 2 of the Cairo Metro are located at the Ramses complex. Ideally, it will be preferable for the CCP of all metro lines in Cairo to be centrally located, in order to enhance the network consolidation and facilitate communications among the metro lines.

From an operational point of view, the specification of the CCP facilities for a line need not have the same specifications as the other lines.

It is suggested that the CCP should be located adjacent to the headquarters of the Operation Department of Metro Line 4 in Cairo. In case of train contingency operations, the following activities will increase substantially:

- Communication with drivers and station staff;
- Manual operation of the route control; and
- Provision of traffic information to the mass media.

Back up from the headquarters will be indispensable during the contingency train operations. If the headquarters is not adjacent to the CCP, the CCP will have to maintain spare staff to deal with contingency operations. This will not be efficient.

In reality, it will be difficult to provide a large space for a consolidated CCP for all lines in Cairo and the operation headquarters for new lines at the headquarters of Egyptian Company for Metro (ECM) in Ramses complex. The CCP of Metro Line 3 will be located at Attaba Station since the operation headquarters of Metro Line 3 is required to be located at a central place of the line for the convenience of the station managers to visit the operation department and near to the Ramses complex for close communication with the headquarters. For Metro Line 4, the

CCP and its operations headquarters may have to be located at El Malek El Saleh Station. In such a case, provision of an advanced communication system among the CCPs will be needed.

Organization of CCP

The major roles of controllers are expressed in the following Table 4-122. Here, it is assumed that route control inside the depot will be done from the CCP.

Table 4-122 Major Roles of Controllers

CCP Component	Major Roles
Chief	• Management of the CCP • Decision of the operation policy or strategy in a contingency situation • Delivery of various information to the stations and publicity media in a contingency situation
Traffic	• Route control for trains • Drivers' operation planning in contingency situation
Rolling stock and depot	• Instruction of troubleshooting to the drivers when trouble or failures occur on their train-sets • Route control in the depot
Equipment supervising	• Delivery of information on facility trouble or problems to the related work sites • Operation of SCADA system • Route control for the facility maintenance work at night

Source: JICA Study Team

(3) Facilities Required at CCP

Table 4.123 shows the following facilities required at the CCP.

Table 4-123 Facilities Required at CCP

Facility	Required functions or system
Information collection	• Status of train operation (Automatic Train Supervisor) • Alarm from the disaster prevention system for underground stations • Status of facilities (Provided by Facility SCADA) • Pictures of the situation of each station through CCTV
Control	• Route control (Automatic Train Supervisor; Spare terminal of ATS should be provided for training) • Button for detention of trains at stations (by pushing this button, all the trains will be detained at stations) • Power supply control with Power SCADA
Communication with drivers and staff at sites	• Radio between controllers and the drivers in the cabin of trains • Direct telephone to the various sites • Normal telephone system
Documentation	• Records of communication with drivers and staff at sites • Record of the result diagram for the daily train operation (May be a part of the function of ATS)

Source: JICA Study Team

(4) Required Functions of the ATS

The basic principle and some important functions that should be provided in the ATS are described below.

Basic Segregation of Roles between ATS and Controllers

The ATS at the CCP has functions to reduce the controllers' work load as much as possible. Basically, the role of ATS is to carry out tasks that can be logically calculated/estimated and to provide the reference data required by the controllers. In contrast, it is the role of controllers to do what the ATS cannot carry out. The controllers make the decisions when alternatives are presented.

Daily Route Control

On this line, trains will be operated according to the train diagram. ATS makes the routes for each train according to the train diagram on behalf of the controllers.

Quick Recovery from the Contingency Operation

One of the most important roles of controllers is to restore the contingency train operations to normal operations as soon as possible. Major ATS roles required for this operation are listed as follows:

- ATS should provide proper information such as forecasted train diagrams on various preconditions to the controllers; and
- When there is a discrepancy in the instructions from the controllers, this will be identified and reported to the controllers by the ATS.

Maintenance of Uniform Headway

On urban railways, maintaining the interval of trains will be more important than maintaining the time table since passengers will crowd over the stations and disorder will be observed in the station premises when train intervals are extended. When the operation schedule is disturbed even slightly, it is important to restore the headway to regular intervals on the urban railways. Even when there are trains that could be operated on schedule, it is common practice on the urban railways to stop them temporarily to reduce the interval from the succeeding trains that are delayed. With this, the rush of passengers to the succeeding trains can be avoided and, consequently, lead to the early recovery of the normal operation. ATS has the function of supporting the controllers in this respect.

Registration of Train Diagram

ATS has a function of registering the timetable into the system to ease the timetable preparation works, including the following features:

- Displays needed for various timetable patterns; and
- Modification functions of timetable to ease the entry works.

Recording of the Operation

ATS also provides the following functions:

- Recording of operated trains on the diagram;
- Recording of communication between controllers and drivers or station staff; and
- Provision of statistics such as train operation km and average train delay.

4.12.2 Signalling Component Related to CCP

In this section, signalling component related to CCP is described.

(1) Remote Control Function (CCP Function):

Controls of the entire route of entire stations are performed by remote control from a single CCP. When the same railway operator is operating numerous lines within the same area, it is best to have the same CCP room for all lines. The function of the existing operation control system is limited within route control consisting of only the automatic route setting and manual one. It's impossible for the system to add functions of data communication, operation logging or statistical data processing because the system is not computerized. By the way, the layout of CCPs of Metro Line 1, 2 and 3 within one room is suitable for the communication among operation staffs and for treatment during emergency case. This method is used by subways and urban railways worldwide. However, when there is a rapid increase in the number of lines, there may not be sufficient space in the original CCP. When the new line sections cannot be handled by the existing CCP, building another independent CCP to handle these lines may be unavoidable. However, under such conditions, it would be beneficial to make preparations that would enable the combining of all line sections in the future. The following shows the functions of the CCP. Note that traffic control within the depot, which controls up to the departure/arrival track, is controlled by the CCP using the programmed traffic control device (PTC). After that, route control is performed by the programmable route control device (PRC) located at the depot.

a) Programmed Traffic Control (PTC) Device:

The PTC uses computers that follow an established train schedule to automatically control trains at each station and their dispatch routes, using the schedule and train position as conditions. Then, the dispatch staff can use the information about the concentrations of passengers on trains, or if failures on cars or equipment have caused a disruption of operations, to change the train schedule. The PTC has each type of method in it. This system is characterized by two methods, namely: an overall centralized control method that utilizes the centralized control devices installed at the CCP and a distributed method in which there is autonomous control by the PTC Local Control Unit (LCU) device installed at each station and the PTC station devices, which contain each train schedule for each station. Generally speaking, since the control cycles per unit of time needed for route control is low on small-scale track sections, there is no need for high-speed data transmission and the centralized method alone can easily handle it. However, the distributed method has its benefits on large scale sections where there are high-density operations. If passenger guidance systems are going to be utilized (such as automatic announcements and destination displays), the distributed method has advantages. We recommend the distributed method for this section.

b) Mimic Panel:

In the past, the mimic panel (MP), which used folding screen panels such as mosaic panels with LEDs embedded in them, was used to show the position of trains, open status of routes, open status of point machines, current display status of the signal equipment, codes for existing tracks inside stations and between stations, and numbers for train numbers. With this method, the mosaic board has to be replaced each time the track configuration is changed, which requires changing the electrical wiring and other related construction works. In comparison, a more recent method uses a projector (PRJ) to project the images of the above-referenced conditions. Because a projector is used, changes in the display accompanying the reconfiguration of tracks can be easily performed by software changes. In addition, using a projector makes it easier to increase or decrease the size of the screen area, which means that it can be used more effectively than a mosaic panel or other such hardware-based panels. We recommend the PRJ system.

c) PTC Functions:

The following Table 4.124 shows the basic functions of the PTC:

Table 4-124 Basic Functions of the PTC

Train tracking function:	The position of occupied track after the train has passed can be determined based on the train position and open route information.
Traffic control function:	Traffic/route control can be controlled using train position information and train schedule information.
Time control function and scheduled processing function:	Controls the standard time and operation control time.
Operation display function:	Track circuit information for the entire track system, open route conditions, train numbers and other information needed for train operation are shown on the operation display projector and dispatcher's console.
Operation monitoring function:	This function monitors the operating conditions and provides warnings when delays or other such problems have been detected.
Human-machine-interface (HMI) function:	This function performs changes, command inputs, monitoring and other such activities of the operating information for the train.
Traffic operation arrangement function:	This is the function for changing the train schedule and it provides the operating environment in summary form.
Passenger information display and public address function:	This function controls passenger information display (PID) and automatic public address system (PA).
Input and output condition I/F function:	This function controls the I/F processing among the other systems (such as interlocking devices, power supply control, disaster prevention along the track).
Event statistics recording function:	This function records and stores the operating conditions of the trains and the actions taken by the dispatching staff.
Traffic information display (TID) function:	Displays the train route status for the entire track system and delay conditions on the station terminal screen and traffic

	information display.
Simulation function:	Conditions can be recreated using the stored data and this can be used for training the dispatch staff for simulating operation.
Depot PRC I/F function:	Performs I/F processing with the train depot PRC.

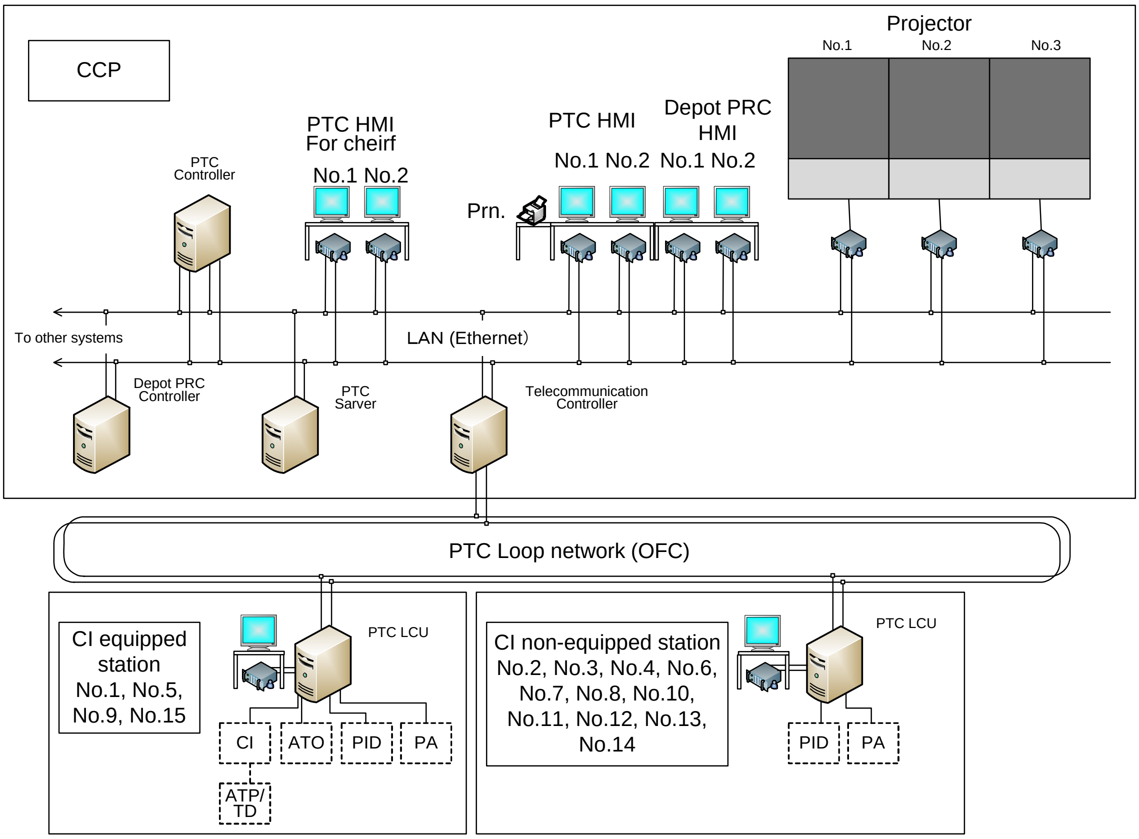
Source: JICA Study Team

d) Transmission Line:

Optical fiber cable (OFC) is used for the dedicated transmission cable used for transmitting the PTC information, forming a link between the central PTC devices installed at the CCP and the PTC station devices at each station.

e) PTC system and Pjc system

The configuration of the PTC system is shown in Figure 4-331 and the example of the application of Pjc system is shown in Figure 4-332



Source: JICA Study Team

Figure 4-331 Configuration of PTC system

Source: JICA Study Team

Figure 4-332 Example of the Application of Pjc System (TUKUBA EXPRESS in Japan)

(2) Maintenance Support Function: Signal Equipment Condition Monitoring Equipment

This signal system is a critical facility entrusted with train operation safety so it will require daily maintenance. Moreover, if even one part of the equipment fails, the railway will not be capable of fulfilling its responsibility as a transportation system because the failure of the signal equipment will cause the stoppage of train operation which will in turn cause disruptions of train operation and service to the passengers. Because of this responsibility and the desirability of safe and stable operation, the use of a multiple system arrangement is necessary to ensure reliability. However, this will make the signal system more complex which means that the places to be maintained will increase. Because of this, it is desirable to install a system that monitors the condition of the signal equipment as a means of supporting the maintenance operations. In particular, we strongly recommend that a condition monitoring system be used for equipment such as electric point machines, track circuits and other such devices that cannot be made redundant. Such a system would regularly monitor and record the amperage at the time the electric point machine is rotated, rotation time, torque and other such data. This system is effective because if a device being monitored shows signs of deterioration, preventive maintenance can be performed before an actual failure occurs.

(3) Power Supply Equipment: Rectifier Equipment (Rf), Uninterruptable Power Supply Equipment (UPS) and Emergency Power Generation Equipment.

Each type of power supply is installed at the CCP and each interlocking and non-interlocking station signal equipment rooms. Each power supply device is a redundant system in order to ensure the necessary level of reliability. Uninterrupted power supply systems and emergency generators are installed as countermeasures to a power outage. The power supply receives the low voltage power supply that has been fed as high voltage from the distribution transformer and then reduced at each power distribution location.

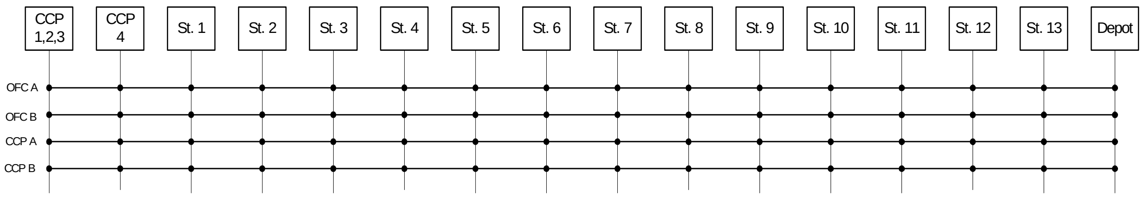
a) CCP Power Supply:

Power supply devices are installed to supply the power, both AC and DC, needed by the equipment in the CCP. An uninterruptible power supply and emergency generators are installed so that the CCP power supply can respond to both short-term and long-term power outages.

4.12.3 Telecommunication System Related to CCP

(1) Communication Trunk System

OFC and CCP are laid as the backbone transmission system throughout all lines. The configuration of telecommunication lines is shown in Figure 4-333.



Source: JICA Study Team

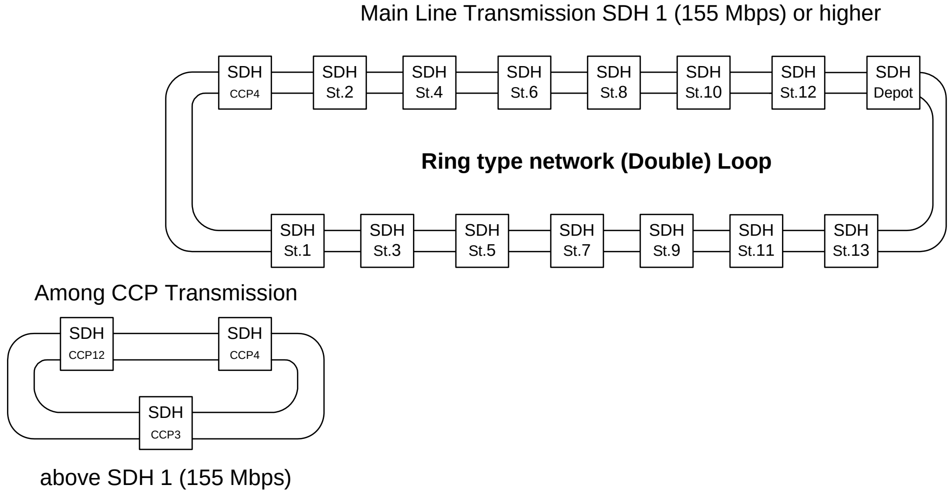
Figure 4-333 Configuration of Telecommunication Lines

a. OFC: Two SM100C cables for OFC are laid for each up and down line. These are pulled into the communication equipment room at each station, depot and CCP. Furthermore, PTC for signal is included in the OFC and various types of core wires are included for electronic interlocking and electric substation system for SCADA.
b. City cables: The CCP will have two city unit cables (CPEE) 0.9 mm φ 50 p each for the up and down lines. These are pulled into the communication equipment room at each station, depot and CCP.
c. Wayside telephone units: Telephone units will be placed at strategic locations along the track, such as at both ends of the platform, at entrances used for maintenance and every 200 meters along the track. It is possible to directly talk with the staff at the CCP from a wayside telephone as well as call maintenance sections and other such places using switched lines.

(2) Optical Carrier System

a. Synchronous digital hierarchy system (SDH) is used as the trunk transmission route. This forms an optical link. Critical lines, such as the train radio, each type of telephone and telephone switching lines, are contained here The capacity of this system must be capable of ensuring the necessary data volume of approximately STM-1 (155 Mbps), as based on the scale of the line sections and the equipment used. SDH forms the link and ensures redundancy. The configuration of SDH systems is shown in Figure 4-334.

b. A multimedia transmission route is installed for high-speed, high-capacity transmission. Gigabit Ethernet optical transmission is used as the transmission standard. It contains ITV image transmissions, command telephone and other such items.



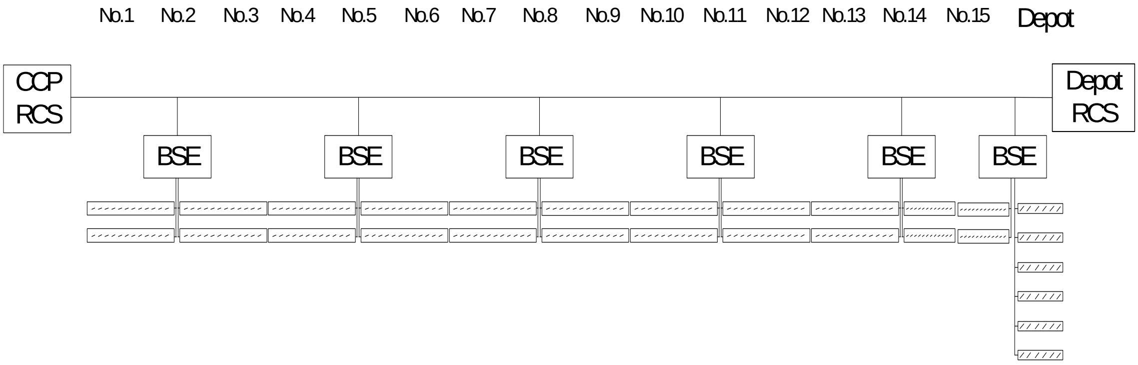
Source: JICA Study Team

Figure 4-334 Configuration of SDH Systems

(3) Train Radio Equipment

a. Digital radio system is used for the train radio. This is a time-division multiplexed method system using TDM/TDMA.
b. Since the majority of train travel is in tunnels, the transmission method for the train radio is leaky coaxial cable (LCX), which ensures high transmission quality. This method is also used in the car depot.
c. Five channels or more are assured for the channels for the train radio. These include the operation command channel (CCP-train), data channel (CCP-train), train protection channel (train itself-CCP-other trains), maintenance audio channel (portable terminals-switching lines, portable terminals-portable terminals) and the control channel.
d. The data channel is used for the command ticket system and the car information data transmission system.
e. We recommend the use of 150 to 300 MHz in the VHF band as the frequency band.
f. There will be more than three hours of compensatory power for the train radio equipment during a power outage.

The configuration of train radio system using LCX is shown in Figure 4-335.



Source: JICA Study Team

Figure 4-335 Configuration of Train Radio System Using LCX

(4) Video Monitoring System

a. ITV for monitoring is installed at each station platform, concourse, ticket gate, elevator, escalator and others.
b. The video images for each station can be monitored in the station master's office.
c. The video images for each station can be sent to the CCP, dispatchers can observe their video images in CCP.

(5) CCP Communication Equipment

a. Train radio central operation console: There is a train radio central operation console for the operation dispatch staff at the CCP and at the command director's seat. It is possible to operate all train radio controls from this operation console. There are several consoles for use by the operation dispatch staff, with a total of more than three consoles to ensure redundancy.
b. Centralized telephone equipment: Centralized telephone equipment is installed for the operation dispatch staff, SCADA operation staff and command director. The centralized telephone system makes it possible to connect with each dedicated line for operation, track, substations and signal communication, as well as with switching lines for railway business.
c. Video selection device: A video selection device that enables selective display on the screen display panel built into one part of the operation display panel (mimic panel) makes it possible to show ITV images from the platforms and others at each station. This enables the operation dispatch staff to use the selection device to directly select information about an accident or other such event or locations that can be displayed.
d. Centralized equipment conditions monitoring device: This enables the CCP to regularly monitor the operation conditions of each type of equipment installed between stations, such as in tunnels, including mechanical equipment, lighting and power equipment, communication equipment and signal equipment. If a failure of any one unit of this equipment occurs, an alarm and indication is made to warn the facility dispatch staff. The equipment command staff can assess the extent of the failure and direct a response by station staff or dispatch the maintenance staff.

e. Power supply device: The necessary power supply equipment for the CCP communication equipment are installed. Uninterrupted power supply systems are installed as countermeasures to a power outage. Furthermore, emergency power generators are installed as part of the power supply system.

4.12.4 Power SCADA

Power SCADA that monitors and controls electrical equipment in all electrical related facilities, HVS, RS, and LPS is an essential system for managing the power supply system in Metro Line 4. Power SCADA system will be managed and controlled in the Power Control Point (PCP). PCP should be located in the same room where CCP will be located for coordinating the operation with train operation.

(1) Function of Power SCADA

Power SCADA enables the comprehensive monitoring and control of the status of the electrical equipment and facilities, and the labour-saving and efficient management of power systems. Power SCADA also detects the abnormal conditions of equipment, and shows the detected information to the operators to take appropriate actions cooperating with other systems such as train operation and signalling systems.

Examples of control and monitoring items of the power supply system are as shown in Table 4-125.

Table 4-125 Example of Control and Monitoring Items

Electrical facilities	Control and Monitoring Items
HVS, RS and LPS	Voltage of all 220kV, 20kV, 380V AC and 1,500V DC busbars Current of all 220kV, 20kV, 380V AC and 1,500V DC busbars Status of circuit breakers and disconnecting switches Status of all protection equipment Operation of alarm and protection devices Rectifier current

Source: JICA Study Team

Power SCADA consists of three parts, namely: operator console, information processing equipment and remote control system. These systems have independent hardware from telecommunication and signalling system except the transmission network.

(2) Operator Console

Operator console, as a man-machine interface for operators, consists of projectors and LCD displays similar to the PTC interface. Large-sized projectors show the overview of the status of power supply system such as the real-time power consumption, single line diagram and status of switches and other equipment. LCD displays and workstations or PCs with graphical user interface are equipped as the interface to the operators.

(3) Information Processing Equipment

Information processing equipment is a dedicated computer for Power SCADA that should be independent from other systems. At least, double redundancy configuration is required to secure the reliability of the system. The major functions of the information processing equipment are as follows:

- Management of operation records of power supply system
- Control of individual or grouped equipment
- Automated switching for scheduled power supply
- Monitoring of the status of operator console, information processing equipment, remote control system and transmission lines
- Statistical processing of the equipment data

(4) Remote Control System

The remote electrical equipment in each HVS, RS, and LPS is monitored and controlled through the Remote Terminal Unit (RTU) and transmission line of the OFC. RTUs are located in each HVS, RS and LPS, and connects the controlled equipment and the remote control system. A part of OFC used in the telecommunication is used as a transmission line for remote control system. Four cores of an SM100C OFC are required for remote control system. Similar to the telecommunication system, SDH and Ethernet are used as transmission systems.