3)Monitoring Report on Training Course for Technicians of Third Countries"Maintenance Techniques for Power Equipment" (July 2014)

Monitoring Report on the Training Course for Technicians of Third Countries (Gambia, Liberia, Sierra Leone)

"Maintenance Techniques for Power Equipment (Overhead Line)"

I. Outline for the Training Course

(1) Purpose

To learn basic concept and knowledge of power distribution maintenance work and to acquire practical techniques training of related equipment in the field

(2) Targets and numbers of trainees

Junior Technician less than 3-year experience in relevant field from following countries; Gambia (NAWEC, six (6)), Liberia (LAC, three (3)), Sierra Leone (NPA, three (3)); total 12 participants

(3) Duration of the Training

30 June ~ 11 July 2014 (10 days)

II. Implementation of the Training Course

(1) Program of the Training

Program of the training is shown in Table-1.

(2) Participants

Participants List of the Training are shown in Table-2.

III. Monitoring of the Training Course

(1) Pre-Training Questionnaires

Technological level including job experience of the trainee has been grasped through the Pre-training Questionnaires at the recruitment of the Training Course. The results of the technical level and job experiences of the trainees are shown in Table-3 taking self-evaluation of their own technologies into consideration.

In Table-3, the adequacy as the trainee of this Training Course is investigated by comparing with the nominee qualifications of the training course. As the result of this investigation, the participants L-3, G-2, G-3, G-4 and G-5 are considered appropriate as the trainees judging from their technological level and job experiences. Other participants are a little bit higher than the target of the training course.

From this result, we considered that the trainees should be divided into two groups when analyzing the Post-training Questionnaires. Two groups are Group-A (Junior Technicians) and Group-B (Experienced Technicians). Result of the Pre-training Questionnaires is shown in Table-4.

(2) Post-training Questionnaires and Criteria for Evaluation

At the end of the training course, Post-training Questionnaires were carried out for measuring the training effects. Post-training Questionnaires are prepared from the following view points; 1) Novelty of the program contents, 2) Possibility of practical use of acquired knowledge, 3) Usefulness in future, 4) Advanced level of technical contents, 5) Intelligibility of the lectures, 6) Satisfaction(comprehensive evaluation).

From the results of the comparison between Pre-training Questionnaire and 1) of Post-Questionnaires, the degree of each individual's technical improvement level is measured and the effect of a training course can be judged from the degree of improvement from the whole average value.

The possibility of the practical use of the knowledge and technology acquired in this training course can be known from the average value of 2) and 3) of each individual. If the average value is higher than 3.0, it will be regarded as effective.

From the average value of 4) and 5) of each individual, the appropriateness of methods of operation for training course can be evaluated. If the average value is less than 3.0, it can be considered that it is necessary to improve the methods of operation, a textbook, etc. of a training course.

From the average value of 6), the synthetic degree of satisfaction to a training course can be judged. If the average value is higher than 3.0, it can be considered that the training course was satisfactory contents.

(3) Results of the Post-training Questionnaires

1) Novelty of the program contents

The result of the question on "Novelty of the program contents" in the Post-training Questionnaire is shown in Table-5.

It can be confirmed that the average values of the individual of Group-A and B are improved from those of Pre-training Questionnaires as follows. (3.0 is an average and new knowledge can be mastered more as closer to 5.0. To the contrary, new knowledge cannot be mastered as closer to 1.0.)

Distribution Facilities	Pre-Q		Post-Q
Group-A (Junior Technicians):	2.5	--->	3.8 (+1.3)
Group-B (Experienced Technicians):	3.3	--->	3.7 (+0.3)

From these results, Project Team (hereinafter referred to as "PT") can observe the following.

i) New knowledge can be offered to Group-A. Effectiveness of the training (improvement of knowledge and technologies) is judged very high, as the figures of the Post-training Questionnaires is far exceeding the average. On the other hand, training effectiveness is able to be confirmed in the Group-B, the rate is lower than Group-A.

ii) Effectiveness of the training of Group-A (Junior Technicians) is bigger than that of Group-B (Experienced Technicians) group, because less knowledge and experience are considered to give bigger impact to the effectiveness of the training.

2) Possibility of practical use of acquired knowledge and technology

The result of the question on "Possibility of practical use of acquired knowledge and technology" in Post-Questionnaire is shown in Table-6. The average figure of each group is as follows.

Distribution Facilities

Group-A (Junior Technicians): 4.2

Group-B (Experienced Technicians): 4.0

From these results, we can observe the following.

i) Both groups felt that the knowledge and technology acquired in this training course could be utilized in their own jobs and quality of their jobs would be improved very much.

ii) As for the distribution facilities, there is not big difference between Group-A and B. Both groups recognized the possibility of practical use of acquired knowledge in this training course.

3) Usefulness in future

The result of the question on "Usefulness in future" in Post-training Questionnaire is shown in Table-7. The questions are about the knowledge which is not directly related to their current jobs, but will link to the improvement of their own technology in the future. The average figure of each group is as follows.

Distribution Facilities

Group-A (Junior Technicians): 4.3

Group-B (Experienced Technicians): 4.0

From these results, we can observe the following.

i) Both groups felt that the knowledge and technology acquired in this training course

would not be related to their current jobs directly but contained a lot of useful technology in the future.

4) Advanced level of technical contents

Technical level comparison between each individual and training course is asked in this item. If the technical level is the same, the value is set to 3.0, if the contents of training are felt to be quite advanced, the value is set to 5.0 and to the contrary if quite low, the value is set to 1.0.

The average figure of each group is as follows.

Distribution Facilities

Group-A (Junior Technicians): 3.4

Group-B (Experienced Technicians): 3.8

i) Prior to the training, it was assumed that the adequate training level would be from 4.0 to 4.5. However the average value is lower than PT expected.

ii) The figures of the evaluation, either group found it easier on the technical contents of the training course. In case of same contents of the training course for ECG's Technicians, PT got a completely different result that are that Group-A (4.2) and Group-B (4.4). From the observation of training course, PT was under the impression that ECG Technicians' background knowledge and technique is higher than third countries technicians'. Therefore, PT has a feeling of strangeness at this moment and needs to follow up them at monitoring occasions in the future.

5) Intelligibility of the lecture

The result of the question on "Intelligibility of the lecture" in Post-training Questionnaire is shown in Table-9.

The average figure of each group is as follows.

Distribution Facilities

Group-A (Junior Technicians): 4.5

Group-B (Experienced Technicians): 4.8

i) Prior to the training it was assumed that the adequate value would be from 4.0 to 4.5. Judging from above results, we could get the better results than our expectation. It was proved that ECG instructors had very high teaching techniques.

ii) As for the training items of "(8-1) the voltage regulation standards of distribution line" and "(9) earthing technology of distribution system" which were pointed out to

be difficult to understand, almost of the trainees scored four (4) or five (5) in these section. It means that those lectures were very intelligible. It means that the high level of technical contents were able to be taught plainly.

6) Satisfaction (comprehensive evaluation)

The result of the question on "Satisfaction (Comprehensive Evaluation)" in Post-training Questionnaire is shown in Table-10. The average figure of each group is as follows.

Distribution Facilities

Group-A (Junior Technicians): 4.4

Group-B (Experienced Technicians): 4.6

i) Prior to the training it was assumed that the adequate value would be from 4.0 to 4.5. Judging from above results, we could get the good results as we expected.

(4) General Overview of the monitoring by Pre- and Post-training Questionnaires

From the results of the Pre- and Post-Questionnaires, the training course is evaluated as follows;

i) This training course could provide the big technical improvement for the third countries' technicians. Especially, it is confirmed that technical improvement is particularly prominent among Group-A (Junior Technicians).
ii) We can expect that the knowledge and technology acquired in this training course will be utilized very much and contribute to enhance the quality of their jobs. In addition, we can also expect the usefulness of the technology in the future.
iii) The degree of satisfaction to this training is very high. (All the trainees evaluated this training very high.)
iv) We can say that we could obtain the expected outcome from this training course and this training course was implemented successfully.

IV. Comments/ Impressions /Suggestions from lecture observation

PT would like to point out some comments from the observation of lectures besides the questionnaires.

(1) Basic rule for the lecture

1) Lectures should be more punctual. (Starting time and rest time should be clearer and informed to trainees properly.)

2) It should be standardized a framework of the lecture among instructors of ECG Training Centre. Ex) Schedule, outline of lecture of the day should be briefed in the first session in the morning of the day and wrap-up and preliminary notice of next day should be announced at the end of session.
3) Preparation of lectures and field training is not enough. Sometimes instructor was away from the field during practical training to find items which were using in the training. At least ONE instructor should be in the field while trainees are working.

(2) Teaching method of the instructor

1) As for the explanation of the instructors, generally speaking an introduction is long and detail (technical lecture) is short. Allocation of time should be considered more to the detail.
2) Instructors should use a textbook more effectively in order to assist the trainees understanding. Power Point materials that is prepared by the instructors should link more clearly to the textbooks of the trainees. Instructor should bring textbook to the classes and indicate trainees the page of textbook that would be related in the lecture.
3) Instruction of remedy work should be carried out from the synthetic viewpoint. Work procedure was instructed during practical skill training.
4) Especially, ECG's standards of work procedures have not been established that is secured the safety of work environments.

(3) Atmosphere of the lecture

1) Attitude of the trainee is very good during the training course.
2) The way to proceed the lectures with exchanging views between instructor and trainees is very good.
3) However in such atmosphere, there are more senior's opinions than young people. It seemed that young people were hesitating to express their opinions.
4) It seemed that the senior brought the position of the job into the training course.

(4) Others

1) PT should put more photographs of facilities and equipment on the textbook so as to enhance the effectiveness of the lectures.
2) As for the daily inspection and safety education, more photographs should be used in the lectures for example in accordance with the inspection order.
3) Trainees from the third countries have an interested in the advanced technology of

power sector in Japan. Such kind of information would be inserted as a special column in the textbook. In doing so, instructors will be able to introduce it as advanced technology and also trainees will be able to use the textbook as a a reference book of power sector.

V. Recommendations to the next training courses

(1) Nominee Qualifications

If ECG would like to continue the training course for the junior engineers, we recommend ECG to add the age limit to the Nominee Qualifications.

Revised Nominee Qualifications are as follows.

- Junior Technician less than 3 years` experience in the relevant field
- Under the age of 40 is favorable.

(2) Revise of the Textbook

It may be necessary to revise the textbook in order to enhance the trainees' comprehension of lectures.

(3) Improvement in the practical skill training

1) Required appropriate preparation

In practical skill training, the tool and material which are needed for the training were not fully prepared beforehand. All tools and materials which are required appropriate capacity in the work that is planning, should be prepared in advance of the day.

2) Synthetic viewpoint of the remedy work

Work procedure was instructed during practical skill training. It is necessary to guide the contents of instruction (in practical skill training) from a viewpoint including all of following points.

- Keeping safety work (The work based on forecasting dangerous factors)
- The work for high quality (How to obtain high-quality results)
- Efficient work (How to implement work efficiently by an individual or a team)

3) ECG's standards of work procedures

Following cases were observed during practical skill training.

i) Improper action… A method of replacing pole mounted transformer

a. Shortage of strength of a pulley hanging transformer

Replacing work of transformer was interrupted due to the insufficient strength

of support metal fittings. An appropriate pulley which is applicable the weight should be used.

b. Improper use of guide rope

Two guide ropes used in replacing transformer should be attached to the side of getting down the transformer, and should be pulled in two different directions. Pulling one of two guide ropes toward supporting point side is a wrong way, because it is difficult to control the transformer position.

ii) Unsafe work

a. Work of lifting isolator

Work standard is that replacing isolator would be carried out by a team that is consisted of six workers, using a hoist (tiffor). It is impossible to carry out work of lifting isolator by humans power only.

b. Work on a cross arm

Workers should not work up on cross arm.

Workers should work on the step of a ladder and set a support point of the safety belt that should be fixed above the worker's center of gravity.

According to problematic circumstances above mentioned, ECG should establish standards of work procedures that is considered safety and work efficiency for technicians and also technicians training should be carried out under the standard.

TABLE-1. PROGRAMME OF THE TRAINING
WEEK-1

DAYS	8:30am – 9:00am	9:00am – 10:00am	10:00am-10:15am	10:15am –12noon	12noon – 1pm	1pm – 3:30pm
Day 1	**Registration and Opening Ceremony**	Outline of power distribution facilities ***Samuel Andoh***	Snack Break	Deterioration aspect and mechanism of equipment ***Bless Agbi***	Lunch Break	Patrol & inspection technique (Line and equipment) ***Samuel Andoh***
Day 2	Management and application of maintenance data ***Bless Agbi***			1. Distribution line faults and investigation 2. Voltage regulation of distribution system (1) and system (2)/ Load management ***Peter Asare***		Measuring skills (voltage, current, earth resistance) ***Samuel Andoh***
Day 3	Safety skills & procedures (isolation to allow work) ***Samuel Andoh***			Safety skills & procedures (Earthing to allow work) ***Samuel Andoh***		Safety skills and procedure (Reconnection of apparatus) ***Samuel Andoh***
Day 4	Key point & method of patrol (lecture) ***Samuel Andoh***			Key point & method of patrol (lecture) ***Samuel Andoh***		Practice of patrol (field) ***Samuel Andoh***
Day 5	Practice of remedy work (Broken tension wire) ***Samuel Andoh***			Practice of remedy work (broken tension wire) ***Samuel Andoh***		Practice of remedy work (broken jumper) ***Samuel Andoh***

Note: Name in bold means a name of Instructor

WEEK-2

DAYS	8:30am – 10:00am	10:00am-10:15am	10:15am –12noon	12noon – 1pm	1pm – 3:30pm
Day 6	Practice of remedy work (replacing transformer) ***Samuel Andoh***	Snack Break	Practice of remedy work (replacing transformer) ***Samuel Andoh***	Lunch Break	Practice of remedy work (replacing transformer) ***Samuel Andoh***
Day 7	Practice of remedy work (pin and post Insulator) ***Bless Agbi***		Practice of remedy work (pin and post Insulator) ***Bless Agbi***		Practice of remedy work (replacing arrester) ***Samuel Andoh***
Day 8	Practice of remedy work (Tension Insulator) ***Bless Agbi***		Practice of remedy work (Tension Insulator) ***Bless Agbi***		Practice of remedy work (Tilled pole) ***Bless Agbi***
Day 9	Practice of remedy work (Isolator) ***Samuel Andoh***		Practice of remedy work (Isolator) ***Samuel Andoh***		Practice of remedy work (primary cut out) ***Bless Agbi***
Day 10	Site visit to Legon workshop and primary substation ***Peter Asare***		Site visit to Legon workshop and primary substation ***Peter Asare***		Making action plan and questionnaire for evaluation Closing

Note: Name in bold means a name of Instructor

Table-2. List of the Participants

Course Title: Maintenance Techniques for Power Equipment (Overhead Lir

No.	Name	Age	Region	Organization
L-1	Mayango Koiyan	48	Engineer	LEC
L-2	Andrew M. Santee	44	Engineer	LEC
L-3	Michael G. Zologon	34	Engineer	LEC
S-1	George Seiya	40	Engineer	NPA
S-2	Samuel Lewis	35	Technician	NPA
S-3	Sheik Ahmed Koroma	30	Engineer	NPA
G-5	Ebrima M. Jallow	54	Linesman	NAWEC
G-6	Lamin Ceesay	38	Linesman	NAWEC
G-1	Lamin Darboe	39	Linesman	NAWEC
G-4	Omar Touray	35	Linesman	NAWEC
G-2	Yaya Dampha	39	Cable Jointing	NAWEC
G-3	Yamadou Camara	44	Linesman	NAWEC

Table-3. Technical level and job experiences of the trainees

Number	Age	Experience (years)	Academic background	Job experience	Self-evaluation(Distribution)	Self-evaluation(Substation)	Observation		Adequacy as the trainee
L-1	48	1	University	only one year experience in distribution field	23	36	hoping to acquire basic knowledge	B	Not adequate as the trainee, engineer is not a target.
L-2	44	2	University	Engineer, only two years experience in installation of power meter	23	36	big gap between contents of the training and his job (Commercial Tec. Manager)	B	Not adequate as the trainee, engineer is not a target.
L-3	34	4	University	Engineer, four years experience in the distribution planning and design	23	33	1. gap between contents of the training and his job Distribution planning and 2. doubtful to utilize the acquired knowledge in his job	A	Target of the training course considering his age and shortage of basic knowledge
S-1	40	2	College	Engineer, two years experience in distribution network (overhead line)	37	40	Having a concrete intension for improving his own capability but his request the training course is different for the contents offer in the training	B	Not adequate as the trainee, engineer is not a target. His requests to the training course is different from the contents offered in the training
S-2	35	6	National Technical school	Senior Technician, educated in London	36	44	ditto	B	Not adequate as the trainee
S-3	30	3	College	Engineer, three years experience in transmission and distribution line	32	44	ditto	B	Not adequate as the trainee, engineer is not a target. His requests to the training course is different from the contents offered in the training.
G-1	54	33	high school	33 years experience from construction to maintenance of the distribution network	33	30	Having an intension for improving his own capability (discussing among G-group, all same answers)	B	Not adequate as the trainee because of his long experience
G-2	38	10	?	Supervisor, 10 years experience in construction works	13	17	ditto	A	Target of the training course considering the shortage of experience in maintenance(2 years)
G-3	39	17	high school	Supervisor, 17 years experience in operation of the distribution network	22	21	ditto	A	Target of the training course considering the shortage of experience in maintenance(2 years)
G-4	35	8	Poly tech	5 years experience in maintenance of distribution network	22	21	ditto	A	Target of the training course
G-5	39	14	high school	14 years experience in maintenance of underground cable	32	33	Having more concrete requests to the training than the above	A	Target of the training course considering the shortage of experience in maintenance(overhead line)
G-6	44	20	Secondary Technical School	20 years experience from construction to maintenance works	30	43	gap between contents of the training and his requests	B	Not adequate as the trainee because of his long experience

A: Junior Technicians group B: Experienced Technicians group

Table-4. Results of Pre-training Questionnaires

I. Distribution Facilities

Person → / Question ↓	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
(1) Configuration of Distribution Facilities	3	3	3	4	4	4	5	3	2	3	3	2
(2) Configuration and function of the protection system of the distribution	1	1	1	4	3	3	5	1	2	3	3	2
(3) Deterioration Aspects and Mechanism of Equipment	3	3	3	4	4	3	3	2	3	3	3	3
(4-1) Points of Patrol & Inspection Technique and implementation procedure (Overhead Line)	3	3	3	5	5	4	3	2	3	0	3	5
(4-2) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	1	1	1	4	4	3	3	1	2	3	3	4
(5) Fault locating technique for underground cable (Underground Line)	3	3	3	4	4	4	3	1	2	1	4	3
(6) Significance of Management & Application of Maintenance Data	3	3	3	4	4	3	5	1	3	3	3	4
(7-1) The voltage reguration standards of distribution line	3	3	3	4	4	4	3	2	1	3	5	3
(7-2) Currenrt (load) management technique of distribution line	3	3	3	4	4	4	3	2	3	3	3	3
(8) Earthing technology of distribution system (The purpose and necessary part of earthing)	3	3	3	4	4	4	5	1	3	3	5	3
Total of Personal score	23	23	23	37	36	32	33	13	22	22	32	30
Average of Personal score	2.60	2.60	2.60	4.10	4.00	3.60	3.80	1.60	2.40	2.50	3.50	3.20
Deviation of Personal score	0.80	0.80	0.80	0.30	0.45	0.49	0.98	0.66	0.66	1.02	0.81	0.87

II. Maintenance skills of distribution facilities (practical training)

(1) Safety Skills & Procedure (Isolation to Allow Work)	3	3	3	4	4	4	3	2	1	1	3	3
(2) Safety Skills & Procedure (Earthing to Allow Work)	3	3	3	4	4	4	3	1	1	3	3	4
(3) Safety Skills & Procedure (Reconnection of Apparatu)	3	3	3	4	4	4	3	2	1	3	3	4
(4) Key point & Method of Patrol	3	3	3	0	4	4	3	1	1	1	3	4
(5) Practice of Remedy Work (Broken Tension Wire)	4	4	3	4	4	4	3	2	3	3	0	5
(6) Practice of Remedy Work (Broken Jumper)	4	4	3	4	4	4	4	2	3	3	3	5
(7) Practice of Remedy Work (Replacing Transformer)	4	4	3	4	4	4	1	1	1	1	5	0
(8) Practice of Remedy Work (Replacing Arrester)	3	3	3	4	4	4	1	1	1	1	5	3
(9) Practice of Remedy Work (Replacing Insulator) ①Practice of Remedy Work (Pin & Post Insulator)	3	3	3	4	4	4	3	2	3	3	3	5
(9) Practice of Remedy Work (Replacing Insulator) ②Practice of Remedy Work (Tension Insulator)	3	3	3	4	4	4	3	0	3	1	2	5
(10) Practice of Remedy Work (Titled Pole)	3	3	3	4	4	4	3	3	3	1	3	5
Total of Personal score	36	36	33	40	44	44	30	17	21	21	33	43
Average of Personal score	3.27	3.27	3.00	3.64	4.00	4.00	2.73	1.55	1.91	1.91	3.00	3.91
Deviation of Personal score	0.45	0.45	0.00	1.15	0.00	0.00	0.86	0.78	1.00	1.00	1.28	1.44

Table-5. Novelty of the program contents (Post-training Questionnaires)

⇔ (1) Novelty of the program contents

Q⇒ How much new knowledge for yourself were included in this chapter ?

I. Distribution Facilities

Person →	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
Question ↓												
(1) Configuration of Distribution Facilities	3	3	3	3	5	3	3	4	4	4	4	4
(2) Configuration and function of the protection system of the distribution system	4	4	4	4	5	2	4	4	4	4	4	4
(3) Deterioration Aspects and Mechanism of Equipment	4	4	4	5	5	3	3	3	3	3	3	3
(4) Points of Patrol & Inspection Technique and implementation procedure (Overhead	4	5	3	2	5	3	2	3	5	4	3	3
(5) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	3	4	3	3	5	3	2	4	4	4	3	3
(6) Fault locating technique for underground cable (Underground Line)	3	4	3	4	4	3	3	3	3	4	5	3
(7) Significance of Management of Maintenance Data	4	4	4	5	5	3	3	3	4	4	4	4
(8-1) The voltage reguration standards of distribution line	3	5	3	3	5	3	4	3	4	4	5	4
(8-2) Currenrt (load) management technique of distribution line	4	5	4	4	4	3	3	4	5	4	5	3
(9) Earthing technology of distribution system (The purpose and necessary part of	3	5	4	4	4	3	4	4	4	4	5	4
Total of Personal score	32	40	32	34	42	26	28	31	36	35	37	31
Average of Personal score	3.50	4.30	3.50	3.70	4.70	2.90	3.10	3.50	4.00	3.90	4.10	3.50
Deviation of Personal score	0.50	0.64	0.50	0.90	0.46	0.30	0.70	0.50	0.63	0.30	0.83	0.50

Ⅱ. Maintenance skills of distribution facilities (practical training)

(1) Safety Skills & Procedure (Isolation to Allow Work)	5	5	4	5	5	5	3	0	4	3	5	5
(2) Safety Skills & Procedure (Earthing to Allow Work)	5	5	4	5	5	2	2	0	5	3	5	5
(3) Safety Skills & Procedure (Reconnection of Apparatu)	4	5	4	3	4	4	4	0	4	3	4	5
(4) Key point & Method of Patrol	4	4	4	3	5	5	0	0	5	5	4	3
(5) Practice of Remedy Work (Broken Tension Wire)	4	4	4	4	5	4	0	0	4	4	4	3
(6) Practice of Remedy Work (Broken Jumper)	4	5	4	5	5	5	3	0	5	4	5	5
(7) Practice of Remedy Work (Replacing Transformer)	4	5	4	5	4	4	0	0	5	3	5	5
(8) Practice of Remedy Work (Replacing Arrester)	5	4	4	4	5	5	0	0	5	3	5	3
(9) Practice of Remedy Work (Replacing Insulator) ①Practice of Remedy Work (Pin & Post Insulator)	5	5	4	4	5	5	0	0	5	3	4	5
(9) Practice of Remedy Work (Replacing Insulator) ②Practice of Remedy Work (Tension Insulator)	4	4	4	4	5	4	0	0	5	3	4	5
(10) Practice of Remedy Work (Titled Pole)	4	4	4	5	5	5	0	0	0	3	4	3
Total of Personal score	48	50	44	47	53	48	12	0	47	37	49	47
Average of Personal score	4.36	4.55	4.00	4.27	4.82	4.36	1.09	0.00	4.27	3.36	4.45	4.27
Deviation of Personal score	0.48	0.50	0.00	0.75	0.39	0.88	1.50	0.00	1.42	0.64	0.50	0.96

Table-6 Possibility of practical use of acquired knowledge (Post-training Questionnaires)

Effectiveness evaluation caused by tr ⇔ (2) Possibility of practical use of acquired knowledge

Q⇒ How much content that leads to improving the quality of your current work were acquired in this chapter ?

Ⅰ. Distribution Facilities

Person →	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
Question ↓												
(1) Configuration of Distribution Facili	4	4	4	4	4	3	3	4	4	5	4	4
(2) Configuration and function of the protection system of the distribution system	4	5	4	4	4	4	5	5	5	5	5	5
(3) Deterioration Aspects and Mechanism of Equipment	4	4	5	4	4	4	5	4	4	4	4	4
(4) Points of Patrol & Inspection Technique and implementation procedure (Overhead Line)	4	4	3	5	4	4	3	3	5	3	4	4
(5) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	4	4	3	4	4	3	2	4	5	3	3	4
(6) Fault locating technique for underground cable (Underground Line)	3	4	4	5	3	3	2	3	4	5	4	4
(7) Significance of Management of Maintenance Data	4	4	4	4	4	4	5	4	5	5	4	4
(8-1) The voltage reguration standards of distribution line	4	5	4	4	4	4	5	3	4	5	4	4
(8-2) Currenrt (load) management technique of distribution line	5	4	4	4	4	4	2	4	4	5	5	4
(9) Earthing technology of distribution system (The purpose and necessary part of earthing)	4	5	4	5	4	4	5	4	5	5	5	5
(10)	0	0	0	0	0	0	0	0	0	0	0	0
Total of Personal score	36	39	35	39	35	34	34	34	41	40	38	38
Average of Personal score	4.00	4.30	3.90	4.30	3.90	3.70	3.70	3.80	4.50	4.50	4.20	4.20
Deviation of Personal score	1.23	1.31	1.23	1.31	1.16	1.15	1.67	1.23	1.38	1.50	1.34	1.27

Table-7 Usefulness in future (Post-training Questionnaires)

(3) Usefulness in future

Q⇒ How much content that is not directly related to the charge of current

Ⅰ. Distribution Facilities

Person →	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
Question ↓												
(1) Configuration of Distribution Facili	4	3	4	3	4	3	4	4	4	5	4	5
(2) Configuration and function of the protection system of the distribution system	4	5	3	5	4	4	5	5	5	5	5	5
(3) Deterioration Aspects and Mechanism of Equipment	3	3	4	3	4	3	5	5	5	5	5	5
(4) Points of Patrol & Inspection Technique and implementation procedure (Overhead Line)	4	4	4	4	4	4	3	4	4	5	3	5
(5) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	4	4	4	4	4	4	3	3	4	5	4	5
(6) Fault locating technique for underground cable (Underground Line)	3	4	3	4	3	4	2	4	4	5	5	5
(7) Significance of Management of Maintenance Data	4	4	4	4	4	3	4	4	4	5	5	5
(8-1) The voltage reguration standards of distribution line	4	4	4	4	4	3	2	4	5	5	4	5
(8-2) Currenrt (load) management technique of distribution line	4	4	4	4	4	4	3	4	4	5	4	5
(9) Earthing technology of distribution system (The purpose and necessary part of earthing)	4	5	4	5	4	4	4	3	5	4	5	5
(10)	0	0	0	0	0	0	0	0	0	0	0	0
Total of Personal score	34	37	34	37	35	33	31	36	40	44	40	45
Average of Personal score	3.80	4.00	3.80	4.00	3.90	3.60	3.50	4.00	4.40	4.90	4.40	5.00
Deviation of Personal score	1.16	1.30	1.16	1.30	1.16	1.14	1.40	1.30	1.35	1.44	1.41	1.44

Table-8. Advanced level of the technical content (Post-training Questionnaires)

Effectiveness evaluation caused by training ⇔ (4) Advanced level of the technical content

Q⇒ How sophisticated is the level of this chapter compared with your current technical level?

Ⅰ. Distribution Facilities

Person →	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
Question ↓												
(1) Configuration of Distribution Facili	3	3	3	5	5	3	4	3	3	3	3	3
(2) Configuration and function of the protection system of the distribution	3	3	3	4	5	4	3	4	4	4	4	4
(3) Deterioration Aspects and Mechanism of Equipment	3	3	3	5	5	5	3	3	3	3	4	3
(4) Points of Patrol & Inspection Technique and implementation procedure (Overhead Line)	4	4	4	3	5	4	3	3	2	5	4	4
(5) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	4	3	4	4	5	4	3	3	3	4	4	3
(6) Fault locating technique for underground cable (Underground Line)	3	4	3	4	4	2	3	3	3	3	5	4
(7) Significance of Management of Maintenance Data	4	3	3	5	5	3	3	3	2	3	4	3
(8-1) The voltage reguration standards of distribution line	4	4	4	5	5	4	3	3	3	4	4	4
(8-2) Currenrt (load) management technique of distribution line	4	4	3	3	4	4	4	3	3	3	4	4
(9) Earthing technology of distribution system (The purpose and necessary part of earthing)	4	4	3	4	5	5	5	3	2	4	5	4
(10)	0	0	0	0	0	0	0	0	0	0	0	0
Total of Personal score	33	32	30	37	43	35	30	28	25	33	38	33
Average of Personal score	3.60	3.50	3.30	4.20	4.80	3.80	3.40	3.10	2.80	3.60	4.10	3.60
Deviation of Personal score	1.14	1.11	1.04	1.40	1.43	1.37	1.16	0.94	0.99	1.21	1.29	1.14

Table-9 Intelligibility of the lecture: (Post-training Questionnaires)

Effectiveness evaluation caused by training (5) Intelligibility of the lectures

Q⇒ Was the explanation method of a text or a lecturer intelligible?

Ⅰ. Distribution Facilities

Person →	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
Question ↓												
(1) Configuration of Distribution Facili	5	5	5	5	5	5	5	4	5	5	5	5
(2) Configuration and function of the protection system of the distribution	4	5	5	4	5	5	5	3	5	5	5	4
(3) Deterioration Aspects and Mechanism of Equipment	5	5	5	5	5	5	5	2	3	5	5	4
(4) Points of Patrol & Inspection Technique and implementation procedure (Overhead Line)	5	5	5	5	5	5	5	5	4	5	5	5
(5) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	5	5	5	5	5	5	5	4	5	5	5	5
(6) Fault locating technique for underground cable (Underground Line)	4	5	5	4	5	4	5	1	5	5	5	4
(7) Significance of Management of Maintenance Data	5	5	5	5	5	4	5	2	4	5	5	5
(8-1) The voltage reguration standards of distribution line	5	5	5	4	5	4	5	3	5	5	5	5
(8-2) Currenrt (load) management technique of distribution line	5	5	5	4	5	4	5	4	4	5	5	5
(9) Earthing technology of distribution system (The purpose and necessary part of earthing)	5	5	4	4	5	5	5	5	5	5	5	5
(10)	0	0	0	0	0	0	0	0	0	0	0	0
Total of Personal score	43	45	44	40	45	41	45	29	40	45	45	42
Average of Personal score	4.80	5.00	4.90	4.50	5.00	4.60	5.00	3.30	4.50	5.00	5.00	4.70
Deviation of Personal score	1.43	1.44	1.44	1.38	1.44	1.40	1.44	1.54	1.44	1.44	1.44	1.42

Table-10. Satisfaction (Comprehensive Evaluation) (Post-training Questionnaires)

Effectiveness evaluation caused by training ⇔ (6) Satisfaction (Total evaluation)

Q⇒ How sophisticated is the level of this chapter compared with your current technical level?

Ⅰ. Distribution Facilities

Person →	L1	L2	L3	S1	S2	S3	G1	G2	G3	G4	G5	G6
Question ↓												
(1) Configuration of Distribution Facili	5	5	5	4	4	5	5	5	5	5	5	5
(2) Configuration and function of the protection system of the distribution	4	5	5	4	5	2	5	4	4	4	4	4
(3) Deterioration Aspects and Mechanism of Equipment	5	5	5	5	5	5	5	4	4	4	4	4
(4) Points of Patrol & Inspection Technique and implementation procedure (Overhead Line)	5	5	5	4	4	5	5	4	5	3	4	5
(5) Points of Patrol & Inspection Technique and implementation procedure (Overhead Equipment)	5	5	5	4	5	4	5	4	4	4	4	5
(6) Fault locating technique for underground cable (Underground Line)	4	5	5	4	5	3	5	3	4	5	5	4
(7) Significance of Management of Maintenance Data	5	5	5	5	4	4	5	3	5	4	4	5
(8-1) The voltage reguration standards of distribution line	4	5	5	4	4	4	5	3	4	5	5	5
(8-2) Currenrt (load) management technique of distribution line	5	5	5	4	5	4	5	4	5	5	4	5
(9) Earthing technology of distribution system (The purpose and necessary part of earthing)	5	5	5	4	5	5	5	4	4	5	5	5
(10)	0	0	0	0	0	0	0	0	0	0	0	0
Total of Personal score	42	45	45	38	42	36	45	33	39	39	39	42
Average of Personal score	4.70	5.00	5.00	4.20	4.60	4.10	5.00	3.80	4.40	4.40	4.40	4.70
Deviation of Personal score	1.42	1.44	1.44	1.27	1.40	1.48	1.44	1.23	1.35	1.41	1.35	1.42

4)Amendment of Teaching Materials on "Maintenance Techniques for Power Equipment" (July 2014)

Base on the result of the Monitoring Report on Training Course for Technicians of ECG "Maintenance Techniques for Power Equipment and Implementation Procedure" and Training Course for Technicians of Third Countries "Maintenance Techniques for Power Equipment", teaching materials were revised as documents attached hereto.

Number of revised parts are eight items in the Distribution Line Maintenance (Part-I) and 12 items in the Substation Equipment Maintenance (Part-II.

The textbook used in the nest training course will be changed to Version 1.1 from 1.0.

18th July 2014

- Part I Distribution Line Maintenance

BEFORE（**1. Outline of Power Distribution Facilities** ）	AFTER（**1. Outline of Power Distribution Facilities** ）
(5) Switchgears Switchgears have a role to disconnect fault sections when a system fault have occurred, so as to limit the influence to the minimum by preventing the effects over normal sections, as well as to switch load current, such as when changing the system configuration in the normal condition.	**(5) Switchgears** Switchgears have a role to disconnect fault sections when a system fault have occurred, so as to limit the influence to the minimum by preventing the effects over normal sections, as well as to switch load current, such as when changing the system configuration in the normal condition.  Isolator (Opposite side of the poles)  Operation Handle of Isolator  Sectionalizer (Gas Insulation Type)
	Some Photos of the equipment showing their actual appearance are added in the page where the explanation only by the words is not easy to understand.

BEFORE (2-2. Deterioration Progress Mechanism of Distribution Equipment)

(2) Transformers

Deterioration progress mechanism for pole-mounted transformers is classified into that of cases, packing, bushings, lead wires and windings.

-Deterioration of Case

The coating film of cases, which is exposed by rainwater, air, ultraviolet rays and pollutants, deteriorates with the time. Once local breakage occurs on the film, a local cell will be formed to generate a corrosion reaction on the iron surface. This forms rusting, which develops laterally or in the direction of the depth, resulting in holes on the case or developed corrosion to the seal surface. This could result in deterioration in insulation through oil leakage or moisture absorption into the insulation oil, or water infiltration to transformer cases.

-Infiltration of water into the case

Deterioration of packing, damages on bushings, or corrosion of cases may generate gaps, where water gradually infiltrates into the inside of the transformer. This may cause deteriorated dielectric strength, leading layer-short-circuit, and finally dielectric breakdown.

-Deterioration of insulating paper

Insulating paper dividing the layers of windings is made of cellulose molecules, which are decomposed acceleratingly by heat as its nature. Insulating paper in a transformer operated in an overloaded condition for a long time may deteriorate in mechanical strength and may break by mechanical actions when a large current goes through the winding, such as by magnetizing inrush current, causing layer-short-circuit and dielectric breakdown.

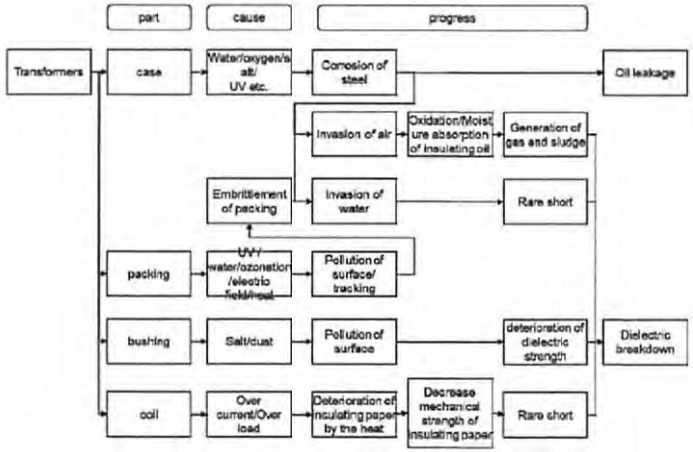

Fig 2-5 deterioration progress mechanism of transformers

AFTER (2-2. Deterioration Progress Mechanism of Distribution Equipment)

(2) Transformers

Deterioration progress mechanism for pole-mounted transformers is classified into that of cases, packing, bushings, lead wires and windings.

-Deterioration of Case

The coating film of cases, which is exposed by rainwater, air, ultraviolet rays and pollutants, deteriorates with the time. Once local breakage occurs on the film, a local cell will be formed to generate a corrosion reaction on the iron surface. This forms rusting, which develops laterally or in the direction of the depth, resulting in holes on the case or developed corrosion to the seal surface. This could result in deterioration in insulation through oil leakage or moisture absorption into the insulation oil, or water infiltration to transformer cases.

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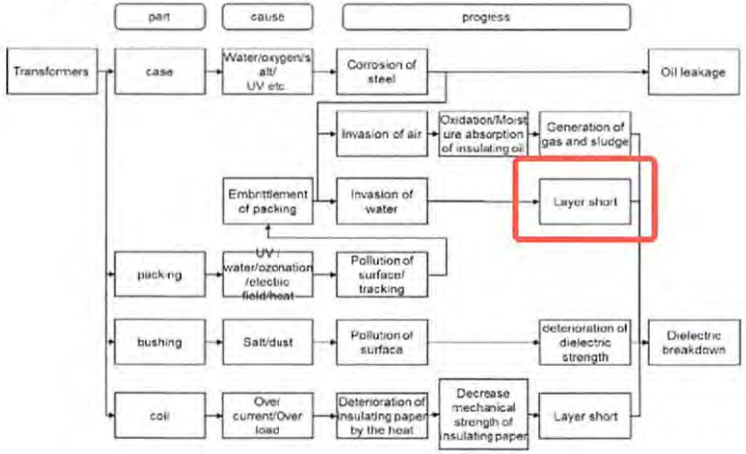

Fig 2-5 deterioration progress mechanism of transformers

A technical term is corrected
(Rare Short →Layer Short)

BEFORE (3-2. Methods of Inspection and Preventative maintenance)

TABLE I: SIZES OF MV FUSES FOR POLE MOUNTED TRANSFORMERS

Transformer Rating KVA	11 kV Rated Transformer Current A	11kV Rated Fused Current A	LV Switch Fuse Current A (number of switches/Tr)	33 kV Rated Transformer Current A	33kV Rated Fused Current A
25	1.4	2	36 (1)	0.5	2
50	2.9	6	36 (2) 72 (1)	1	2
100	5.8	10	72 (2) 144 (1)	1.9	4
200	11.5	20	144 (2)	3.8	6
			Distribution Box Main Fuse Current A		
315	18.2	32	455	6	10
500	29	50	722	9.6	16

TABLE II: SIZES OF MV FUSES FOR GROUND MOUNTED TRANSFORMERS

	11 kV Rated Transformer Current A	11kV Rated Fused Current A	Distribution Box Main Fuse Current A	33 kV Rated Transformer Current A	33kV Rated Fused Current A
200	11.5	20	288	3.8	6
315	18.2	32	455	6	10
500	29	50	722	9.6	16
800	46.2	80	MCCB 1200	15.4	25
1250		NA	MCCB 2000	24	40

AFTER (3-2. Methods of Inspection and Preventative maintenance)

TABLE I: SIZES OF MV FUSES FOR POLE MOUNTED TRANSFORMERS

Transformer Rating KVA	11 kV Rated Transformer Current A	11kV Rated Fused Current A	LV Switch Fuse Current A (number of switches/Tr)	33 kV Rated Transformer Current A	33kV Rated Fused Current A
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50	2.9	6	36 (2) 72 (1)	1	2
100	5.8	10	72 (2) 144 (1)	1.9	4
200	11.5	20	144 (2)	3.8	6
			Distribution Box Main Fuse Current A		
315	18.2	32	455	6	10
500	29	50	722	9.6	16

TABLE II: SIZES OF MV FUSES FOR GROUND MOUNTED TRANSFORMERS

	11 kV Rated Transformer Current A	11kV Rated Fused Current A	Distribution Box Main Fuse Current A	33 kV Rated Transformer Current A	33kV Rated Fused Current A
200	11.5	20	288	3.8	6
315	18.2	32	455	6	10
500	29	50	722	9.6	16
800	46.2	80	MCCB 1200	15.4	25
1250		NA	MCCB 2000	24	40

LV Fuse (Installed in the Fuse Box)

MCCB (Installed in the distribution box)

Some Photos of the equipment showing their actual appearance are added in the page where the explanation only by the words is not easy to understand.

BEFORE (3-2. Methods of Inspection and Preventative maintenance)

(1) Distribution Transformers

(a) Inspection

Recommended Schedules : Quarterly

Equipment / Items to be Inspected	Points to be checked / noted	Remarks
a) Supports	Check for proper supporting and level of the transformer	
b) Connections	Check for tightness of connections	Tighten, add conductive grease and cover with petrolatum tape.
c) Fuses (HT & LT)	1. Check for tightness & continuity 2. Check for correct ratings	Refer Table - I for fuse ratings.
d) Oil	Check for leakage of oil 1. From drain off valve 2. From gaskets 3. From tank leak etc	In case of appreciable leakage of oil, check up its level and report immediately.
e) Bushings	Check for chipped & broken porcelain	
f) Arcing horns	Check for the following : 1. Any damage due to flash over 2. Correct alignment and proper gap adjustment between arcing rods	Note: If the transformer is equipped by Lightning Arrester – check whether the arcing horns are required at all

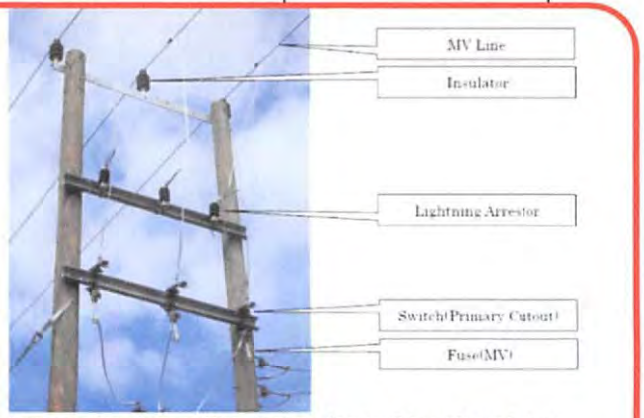
AFTER (3-2. Methods of Inspection and Preventative maintenance)

(1) Distribution Transformers

(a) Inspection

Recommended Schedules : Quarterly

Equipment / Items to be Inspected	Points to be ch
a) Supports	Check for prope
b) Connections	Check for tightn
c) Fuses (HT & LT)	1. Check fo tigl ratings
d) Oil	Check for leaka gaskets 3. Fro
e) Bushings	Check for chipp
f) Arcing horns	Check for the fo 2. Correct align arcing rods



Upper part (from the top: MV line, Insulator, Arrester, Primary Cutout Switch)

Middle part (Transformer and LV lines)

Lower part (LV Fuse Boxes)

Fitting of Pole mount Transformer

Some Photos of the equipment showing their actual appearance are added in the page where the explanation only by the words is not easy to understand.

BEFORE (3-2. Methods of Inspection and Preventative maintenance)

(2) Overhead Lines
(a) Inspection

Recommended Schedules : Quarterly

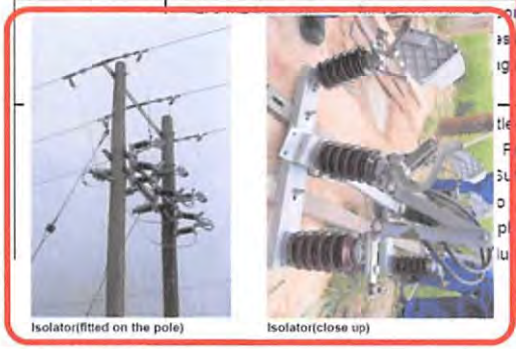
Equipment / Items to be Inspected	Points to be checked / noted	Remarks
Poles a)concrete b)tubular steel c)folded steel d)lattice steel poles e)wooden poles	Check for the following in case of all the 4 types 1. Damaged/broken poles or for ground level erosion and corrosions where the pole is not capable of safely supporting its load 2. Bowed or leaning poles due to improper guying or overloading 3. Unauthorised attachments such as fencing, aerial wires etc 4. Poles are very much exposed to accident due their being near or in common way 5. Condition of foundation 6. Missing parts or bracings (lattice steel pole only) 7. Ground level erosion or rotting of poles (wooden only)	
Stays	Check the following: 1. Correct direction and proper angle of the stays 2. Loose, broken or any other damage done to stays 3. Whether stay insulator is intact/whether stay is properly earthed 4. If stay - rods are corroded	NOT APPLICABLE FOR LATTICE STEEL POLES
Cross Arms	Check the following: 1. If the cross arms / Clamps have slipped 2. Bending of cross arms due to uneven tension 3. Twisting or other deformation of wooden crossarms	
Insulators and Fittings	Check the following: 1. Broken or chipped porcelain, flash over marks 2. Tilted post/pin insulators 3. Excessive rusting of fittings 4. Shattered glass insulators 5. Damaged composite insulator	
Conductors	Check the following: 1. Examine, if severely tied to the insulator/pole/ Crossarm 2. Proper sag 3. Proximity of trees and other objects including building etc 4. Sufficient clearances between conductors and earthwires, and also from the ground 5. Sufficient clearances from other electric/ telephone lines passing along, below or above it 6. If joints in the lumpers and	

AFTER (3-2. Methods of Inspection and Preventative maintenance)

(2) Overhead Lines
(a) Inspection

Recommended Schedules : Quarterly

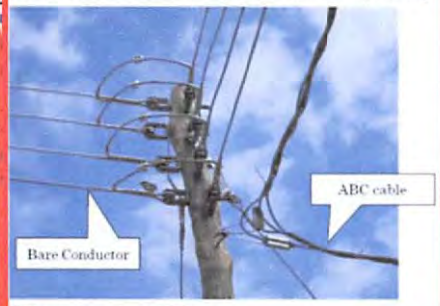
Equipment / Items to be Inspected	Points to be checked / noted	Remarks
Poles a)concrete b)tubular steel c)folded steel d)lattice steel poles e)wooden poles	Check for the following in case of all the 4 type 1. Damaged/broken poles or for ground level e corrosions where the pole is not capable of s load 2. Bowed or leaning poles due to improp overloading 3. Unauthorised attachments suc aerial wires etc 4. Poles are very much expos due their being near or in common way 5. Co foundation 6. Missing parts or bracings (lattice Ground level erosion or rotting of poles (woode	
Stays	Check the following: 1. Correct direction and proper angle of the sta 2. Loose, broken or any other damage done t 3. Whether stay insulator is intact/whether sta earthed 4. If stay - rods are corroded	
Cross Arms	Check the following: 1. If the cross arms / Clam Bending of cross arms due to uneven tension 3 deformation of wooden crossarms	


Isolator(fitted on the pole)

Isolator(close up)

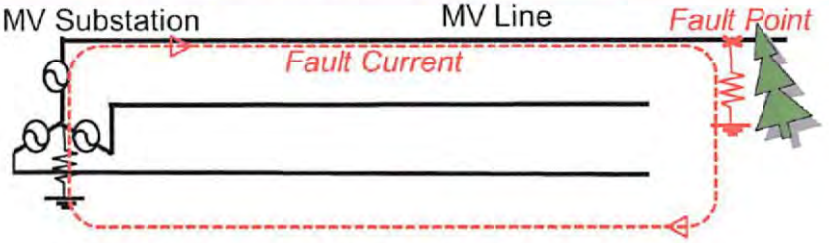

Fittings of Overhead MV lines (Intermediate position)

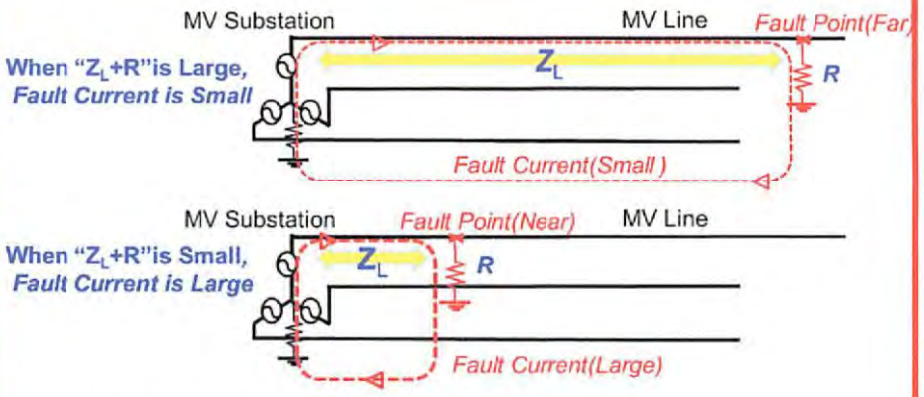

Fittings of Overhead MV lines (Jumper Connected position)

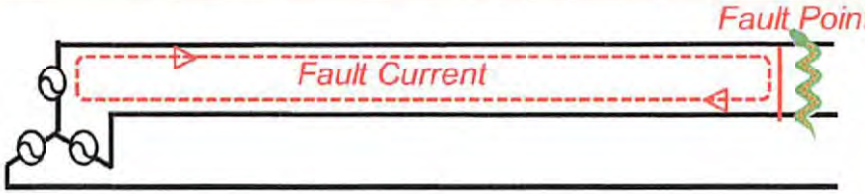


Fittings of Overhead LV lines
(Bare conductor(left side) and ABC cable(right side))

Some Photos of the equipment showing their actual appearance are added in the page where the explanation only by the words is not easy to understand.

BEFORE (5-1 Types of Faults)	AFTER (5-1 Types of Faults)
1. Types of Faults (1) Faults of MV Distribution Lines Faults of MV(Medium Voltage) distribution lines are classified roughly into ground faults and short-circuit (overcurrent) faults. One-line ground fault is the most common. (i) Ground fault Ground fault is the state that insulation between a circuit and the earth abnormally lowers and arc or some conductive substance causes bridging. In this situation, dangerous voltage occurs on the wires or equipment or current flows into the earth. Ground fault of MV distribution lines can be caused by a faulty insulator, a burned transformer, contact with a tree, etc. The possible forms of ground fault are one-line, two-line and three-line ground fault, and one-line fault is the most common.	1. Types of Faults (1) Faults of MV Distribution Lines Faults of MV(Medium Voltage) distribution lines are classified roughly into ground faults and short-circuit (overcurrent) faults. Single-line ground fault is the most common. (i) Ground fault Ground fault is the state that insulation between a circuit and the earth abnormally lowers and arc or some conductive substance causes bridging. In this situation, dangerous voltage occurs on the wires or equipment or current flows into the earth. Ground fault of MV distribution lines can be caused by a faulty insulator, a burned transformer, contact with a tree, etc. The possible forms of ground fault are single-line, double-line and triple-line ground fault, and single-line fault is the most common.  Fig. 5-1 Circuit diagram of Ground Fault(example of Single-line Ground Fault)
	Figure of Circuit Diagram is added in the page where the explanation only by the words is not easy to understand.

BEFORE (5-1 Types of Faults)	AFTER (5-1 Types of Faults)
The magnitude of the electrical current varies depending on the line distance and conditions of the ground fault point.	The magnitude of the fault current varies depending on the line distance and conditions of the ground fault point. As is shown in the Circuit diagram of Fig.2, Fault current depends on "ZL+R" where 1) ZL:Line Impedance(The value is rather large when fault point is far from the Substation) 2) R:Resistance of Fault Point(The value depends on the Condition of Fault Point)  Fig. 5-2 Circuit diagram of Ground Fault(Cause of Variation of Fault Current)
	Figure of Circuit Diagram is added in the page where the explanation only by the words is not easy to understand. This Figure is based of the one drawn in the Training Course.

BEFORE (5-1 Types of Faults)	AFTER (5-1 Types of Faults)
(ii) Short circuit fault Short circuit faults are classified roughly into two-line short circuit and three-line short circuit. As the short circuit fault current is always larger than the ground fault current, there is a risk that abnormal rise of temperature of lines and devices or generation of arc may lead to a serious incident such as explosion of equipment. In order to stop a fault from expanding and prevent a public disaster, protection devices are installed at distribution substations and on MV distribution lines so that fault current can be immediately interrupted. Such measures as adequate daily maintenance are also required to reduce faults. Generally, common causes are an object on a line blown by a strong wind, contacts of lines caused by a collapsed support, and arc short circuit caused by lightning.	**(ii) Short circuit fault** Short circuit faults are classified roughly into double-line short circuit and triple-line short circuit. As the short circuit fault current is always larger than the ground fault current, there is a risk that abnormal rise of temperature of lines and devices or generation of arc may lead to a serious incident such as explosion of equipment. In order to stop a fault from expanding and prevent a public disaster, protection devices are installed at distribution substations and on MV distribution lines so that fault current can be immediately interrupted. Such measures as adequate daily maintenance are also required to reduce faults. Generally, common causes are an object on a line blown by a strong wind, contacts of lines caused by a collapsed support, and arc short circuit caused by lightning.  Fig. 5-3 Circuit diagram of Short Circuit Fault(example of Double-line Short Circuit)
	Figure of Circuit Diagram is added in the page where the explanation only by the words is not easy to understand.

- Part II Substation Equipment Maintenance

Before modification (Textbook: Patrol for Substation Equipment)

3. The important notice at the time of the patrol

There are many live- parts in the substation, so pay attention to safety. In addition, the patroller should conduct the patrol with an attention to the following.

- Conduct the patrol according to the patrol route which was specified from the safety and effectiveness (The example of route map is shown in '5. Practical example of patrol')
- The patroller should wear a safety helmet, a working wear and safety shoes. Don't use an umbrella, wear a raincoat in the rain.
- At the time of patrol, make sure not touch the switch other than the need. And also, if the patroller operates it as needed, make sure recover it to its original position certainly.
- The patroller should lock the gate of substation during patrol, and also lock the door of buildings and cubicles as soon as possible after inspection.
- When the patroller must approach a live part at the time of an inspection, don't approach within the minimum working clearance as mentioned below.

Nominal voltage (kV)	Minimum working clearance (mm)
3.3 - 22	600
33	700
66	1,000
110	1,500

- Don't enter the protective fence that is installed for the equipment with live outer case and the equipment with low height live part.
- Don't remove the protective barrier of high-voltage or low-voltage circuits of cubicles and switchboard.
- Don't wipe leaked oil easily near the live part and the rotation part.
- Don't approach the operating mechanism of equipment even if equipment stopped, since there is a case to start suddenly.

After modification (Textbook: Patrol for Substation Equipment)

3. The important notice at the time of the patrol

There are many live- parts in the substation, so pay attention to safety. In addition, the patroller should conduct the patrol with an attention to the following.

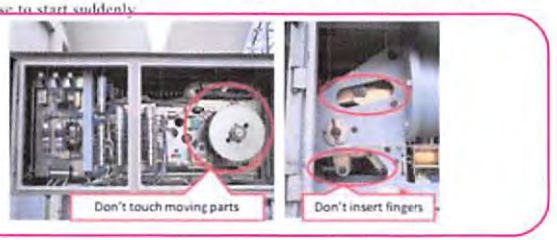
- Conduct the patrol according to the patrol route which was specified from the safety and effectiveness (The example of route map is shown in '5. Practical example of patrol')
- The patroller should wear a safety helmet, a working wear and safety shoes. Don't use an umbrella, wear a raincoat in the rain.
- At the time of patrol, make sure not touch the switch other than the need. And also, if the patroller operates it as needed, make sure recover it to its original position certainly.
- The patroller should lock the gate of substation during patrol, and also lock the door of buildings and cubicles as soon as possible after inspection.
- When the patroller must approach a live part at the time of an inspection, don't approach within the minimum working clearance as mentioned below.

The limits of close proximity of live unscreened apparatus at ECG

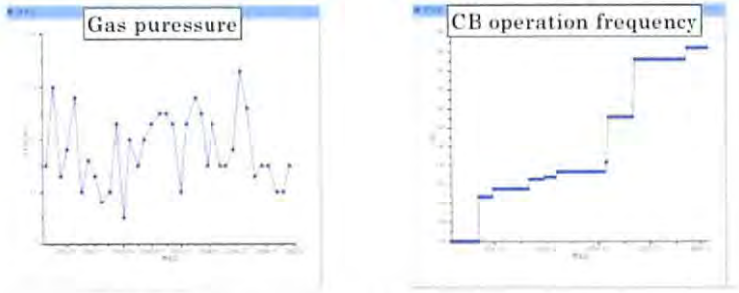
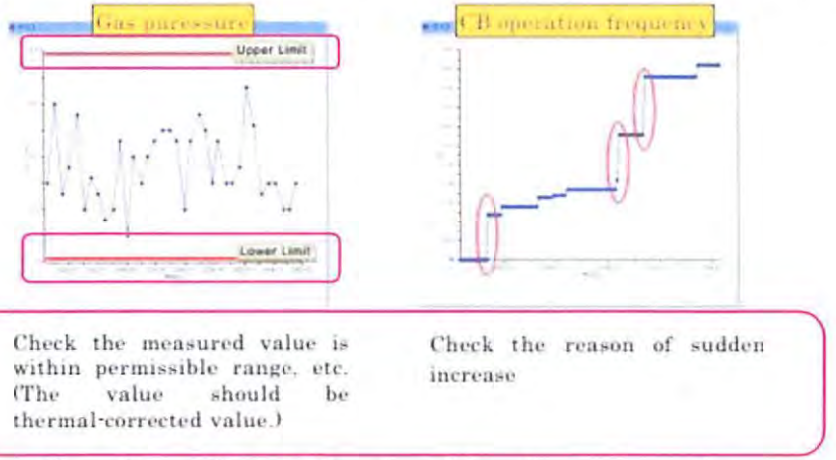
Nominal voltage (kV)	Minimum working clearance (m)
11	2.65
33	2.80
69	3.10

- Don't enter the protective fence that is installed for the equipment with live outer case and the equipment with low height live part.
- Don't remove the protective barrier of high-voltage or low-voltage circuits of cubicles and switchboard.

- Don't wipe leaked oil easily near the live part and the rotation part.
- Don't approach the operating mechanism of equipment even if equipment stopped, since there is a case to start suddenly.



Regarding expressions which seem to be difficult to understand, we added photos and comments about the cases for easy understanding.

Before modification (Textbook: Patrol for Substation Equipment)	After modification (Textbook: Patrol for Substation Equipment)
5. Aging management The inspection items and criteria of the patrol in the substation are shown in the next section. In particular, inspection items that need numerical value management, such as operation frequency, oil temperature, gas (air) pressure, operating time and so on, need aging management. Specifically, those items need to grasp the aging for short-time and long-time by using the trend graph as shown below, etc. in order to find a fault and to manage the next inspection timing. **(The inspection items shown in the next section with '†' mark are the aging management items.)** In addition, it is preferable to add the aging management item except specified items in consideration of the inspection result, current condition, age of service and so on.  **Figure 5-1 Example of trend graph for aging management items**	**5. Aging management** The inspection items and criteria of the patrol in the substation are shown in the next section. In particular, inspection items that need numerical value management, such as operation frequency, oil temperature, gas (air) pressure, operating time and so on, need aging management. Specifically, those items need to grasp the aging for short-time and long-time by using the trend graph as shown below, etc. in order to find a fault and to manage the next inspection timing. **(The inspection items shown in the next section with '†' mark are the aging management items.)** In addition, it is preferable to add the aging management item except specified items in consideration of the inspection result, current condition, age of service and so on.  **Figure 5-1 Example of trend graph for aging management items**
	Regarding inspection items that need aging management, we added comments in order to understand the concrete checkpoints easily.

<table>
<tr>
<th>Before modification (Textbook: Patrol for Substation Equipment)</th>
<th>After modification (Textbook: Patrol for Substation Equipment)</th>
</tr>
<tr>
<td>
6. Inspection items and criteria
The inspection items and criteria of the patrol in the substation are as follows.
'†' mark shows the item needs aging management.

(1) Ambient temperature
<table>
<tr><td>Ambient temperature [deg C]</td><td>It records as the data that is used for the temperature rise analysis of the equipment, the temperature correction of gas pressure and air pressure.</td></tr>
</table>
</td>
<td>
6. Inspection items and criteria
The inspection items and criteria of the patrol in the substation are as follows.
'†' mark shows the item needs aging management.

(1) Ambient temperature
<table>
<tr><td>Ambient Temperature [deg C]</td><td>It records as the data that is used for the temperature rise analysis of the equipment, the temperature correction of gas pressure and air pressure.

Ex. Conversion Formula of Gas (Air) Pressure
(Convert P_t[MPa] at t [deg C] to P_{25}[MPa] at 25[deg C])
$$P_{25} = \frac{273.15 + 25}{273.15 + t} \times P_t$$</td></tr>
</table>
</td>
</tr>
<tr>
<td></td>
<td>Regarding ambient temperature that is one of inspection items, it is used for the temperature correction of gas pressure that is measured in the patrol. Therefore, we added conversion formula of gas pressure to show the concrete way of temperature correction.</td>
</tr>
</table>

Before modification (Textbook: Patrol for Substation Equipment)	After modification (Textbook: Patrol for Substation Equipment)
Oil discharge Make sure if there is any sign of the operation of pressure relief device and its damage. Pressure relief devices are installed to relieve excess internal pressure, in order to prevent the tank from being destroyed by the tank pressure increase due to the internal fault. Therefore, when there is a large amount of oil discharge, stop the operation immediately in order to conduct the internal inspection and find the cause. In case of a little discharge, oil discharge may occur due to the crack of the pressure relief device, or the increase of oil pressure due to the valve closing between the conservator and the main tank. In general when oil discharge occurs, other protective devices operate at a time, it is necessary to make a comprehensive judgement by checking those operations.	Oil Discharge Make sure if there is any sign of the operation of pressure relief device and its damage. Pressure relief devices are installed to relieve excess internal pressure, in order to prevent the tank from being destroyed by the tank pressure increase due to the internal fault. Therefore, when there is a large amount of oil discharge, stop the operation immediately in order to conduct the internal inspection and find the cause. In case of a little discharge, oil discharge may occur due to the crack of the pressure relief device, or the increase of oil pressure due to the valve closing between the conservator and the main tank. In general when oil discharge occurs, other protective devices operate at a time, it is necessary to make a comprehensive judgement by checking those operations.  The above figure is the device of the main tank. When LTC chamber has the pressure relief device, check the LTC chamber in the same manner.
	Regarding inspection items about the oil discharge from pressure relief devices which seem to be difficult to understand, we added photos and comments about the cases for easy understanding.

Before modification (Textbook: Patrol for Substation Equipment)

Item	Judgement criteria and troubleshooting
2) Gas detection relay	
Amount of gas ↑	- Check the amount of gas and color of gas from from the inspection window - Make sure if the amount is increasing than the previous record The purpose of the gas detection relay is in order to detect the air suction from the breakage point of diaphragm conservator and the decomposed-gas due to the internal fault of transformers. The check point of decomposed-gas is shown in the right table. When the amount of gas increases, there is a possibility that internal abnormality shown in the right table has occurred. So, the gas analysis and the internal inspection should be necessary.
3) Temperature	
Maximum temperature ↑	Record the maximum oil temperature. In particular, check whether the maximum temperature exceeds the caution level or not after overload operation.

Color	Cause
Black, Gray	Oil decomposition
Yellow	Wood decomposition
White	Overheat of insulation paper

After modification (Textbook: Patrol for Substation Equipment)

Item	Judgement Criteria and Troubleshooting
2) Gas Detection Relay	
Amount of Gas ↑	- Check the amount of gas and color of gas from from the inspection window - Make sure if the amount is increasing than the previous record The purpose of the gas detection relay is in order to detect the air suction from the breakage point of diaphragm conservator and the decomposed-gas due to the internal fault of transformers. The check point of decomposed-gas is shown in the right table. When the amount of gas increases, there is a possibility that internal abnormality shown in the right table has occurred. So, the gas analysis and the internal inspection should be necessary.
3) Oil Temperature	
Maximum Temperature ↑	Record the maximum oil temperature. In particular, check whether the maximum temperature exceeds the caution level or not after overload operation.

Gas detection relay

Color	Cause
Black, Gray	Oil decomposition
Yellow	Wood decomposition
White	Overheat of insulation paper

Regarding inspection items about gas detection relays and oil temperature gauges, we added photos for easy understanding.

Before modification (Textbook: Patrol for Substation Equipment)

4) Operating mechanism	
Overall condition	- Make sure if there is no oil leakage and humidity. - When there is an oil leakage, investigate the point of leakage. - When there is an oil leakage from the transmission mechanism, the damage of the gasket for the penetration point to the tank might be considered. In case of it, it is necessary to replace it.
Motor drive	- Check the operation sound, if it operates. - When it is an abnormal noise, it is necessary to investigate it. The lack of bearing grease, the abnormal wear of gears, magnetic contactors the brush of motor might be considered. If the cause is the lack of bearing grease, lubricate it.
Operation frequency of LTC	- Make sure if current value is appropriate from the past trend. - Appropriate operation frequency for distribution transformers is about 30 times / day. When the frequency increases or decreases rapidly, the fault of voltage regulators might be considered. - The wear degree of contactors of the diverter switch can be presumed, from the accumulated frequency of LTC and the next inspection timing is decided based on the result. Therefore, regarding the operation frequency, daily and accumulated frequency should be managed.
Tap indicator	- Make sure if the active pointer of tap indicators is in the proper position. - When the indicator is not in the proper position, brake circuit fault, breakage of magnetic contactor or gears and etc. can be considered, there is a possibility that the incomplete tap changing operation has occurred.

After modification (Textbook: Patrol for Substation Equipment)

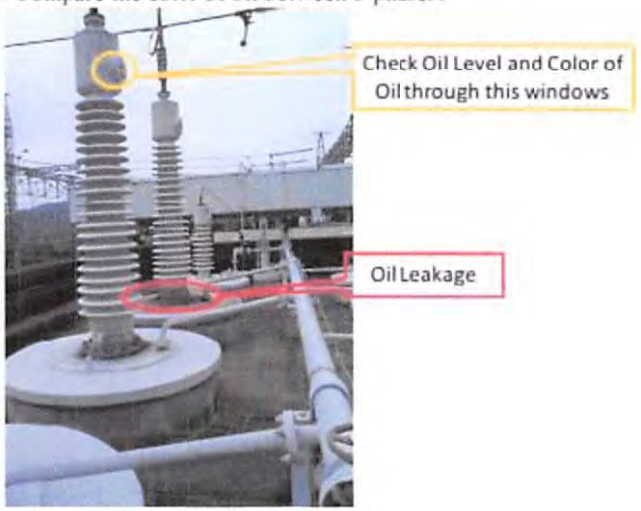
4) Operating Mechanism	
Overall Condition	- Make sure if there is no oil leakage and humidity. - When there is an oil leakage, investigate the point of leakage. - When there is an oil leakage from the transmission mechanism, the damage of the gasket for the penetration point to the tank might be considered. In case of it, it is necessary to replace it.
Motor Drive	- Check the operation sound, if it operates. - When it is an abnormal noise, it is necessary to investigate it. The lack of bearing grease, the abnormal wear of gears, magnetic contactors the brush of motor might be considered. If the cause is the lack of bearing grease, lubricate it.
Operation Frequency of Load Tap Changer (LTC)	- Make sure if current value is appropriate from the past trend. - Appropriate operation frequency for distribution transformers is about 30 times / day. When the frequency increases or decreases rapidly, the fault of voltage regulators might be considered. - The wear degree of contactors of the diverter switch can be presumed, from the accumulated frequency of LTC and the next inspection timing is decided based on the result. Therefore, regarding the operation frequency, daily and accumulated frequency should be managed.
Tap Indicator	- Make sure if the active pointer of tap indicators is in the proper position. - When the indicator is not in the proper position, brake circuit fault, breakage of magnetic contactor or gears and etc. can be considered, there is a possibility that the incomplete tap changing operation has occurred. Therefore, it is necessary to conduct inspection immediately. 

Regarding inspection items about tap indicators which seem to be difficult to understand, we added photos and comments about the cases for easy understanding.

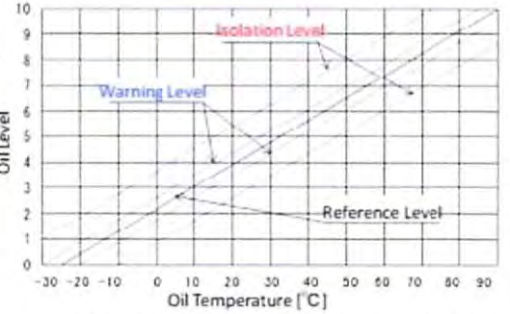
Before modification (Textbook: Patrol for Substation Equipment)

6) Main terminal and Bushing	
Overheating	Make sure if there is no change in color of the thermal indicators attached on the terminal of bushings or conductors, due to the overheating. The cause of the overheating is due to the looseness of bolts or corrosion of the surface of terminals. Therefore, when there is an overheating part, stop the operation and then brush the contact face and fix it tightly.
Dirt	Make sure if there is no dirts due to the attachment of dusts and salts, etc. on the surface of bushings. When the surface is dirty, clean the surface at the time of dead-line work. Because increase of the leakage current, corona discharge and bushing breakage by the flashover, due to the terrible dirt might occur.
Crack	Make sure if there is no cracks or breakages of bushings. When there is a small crack on the rib portion of bushing, caulk the crack for waterproof. But if a crack is large, it is necessary to replace it. Because the rain water penetrates into transformers from the crack, as a result, the insulation resistance decreases due to the absorbed water from the crack.
Oil level	- Make sure if the oil level is appropriate by the oil temperature-oil level curve. - Compare the color of oil between 3 phases.

After modification (Textbook: Patrol for Substation Equipment)

Item	Judgement Criteria and Troubleshooting
	stop the operation and then brush the contact face and fix it tightly.
Dirt	Make sure if there is no dirts due to the attachment of dusts and salts, etc. on the surface of bushings. When the surface is dirty, clean the surface at the time of dead-line work. Because increase of the leakage current, corona discharge and bushing breakage by the flashover, due to the terrible dirt might occur.
Crack	Make sure if there is no cracks or breakages of bushings. When there is a small crack on the rib portion of bushing, caulk the crack for waterproof. But if a crack is large, it is necessary to replace it. Because the rain water penetrates into transformers from the crack, as a result, the insulation resistance decreases due to the absorbed water from the crack.
Oil Level	- Make sure if the oil level is appropriate by the oil temperature-oil level curve. - Compare the color of oil between 3 phases. 

Regarding inspection items about bushings, we added photos and comments about the cases for easy understanding.

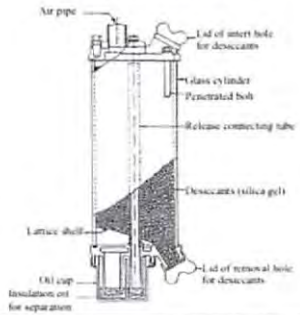
Before modification (Textbook: Patrol for Substation Equipment)	After modification (Textbook: Patrol for Substation Equipment)
7) Oil level of Main tank and LTC Main tank and LTC chamber: Make sure if the oil level is appropriate by the oil temperature-oil level curve.	7) Oil Level of Main Tank and Load Tap Changer (LTC) Main Tank and LTC Chamber: Make sure if the oil level is appropriate by the oil temperature-oil level graph.   Example of Characteristic between Oil Temp. and Oil Level
	Regarding inspection items about oil level management which seem to be difficult to understand, we added photos and example of graphs which show the relation between oil temperature and oil level.

Before modification (Textbook: Patrol for Substation Equipment)

Item	Judgement criteria and troubleshooting
8) Breather	
Degree of breathing	- Make sure that breathers can breathe normally. Transformers should breathe from breathing holes (provided in breather) only. If air enters through any other portion of the breather except breathing holes it is called leakage of air. Leakage of air will lead to entrance of air with moisture & particles in the transformer, which ultimately may lead to formation of spark, and short circuit in the transformer.

Item	Judgement criteria and troubleshooting
Silica gel & Oil in the oil cup	- A silica gel changes color from deep blue to pinkish white as it absorbs moisture. By reheating, the Gel becomes free from moisture & hence transformers always breathe in dry air. Visibility of Gel color is very important to decide when to reheat the Gel. [Deep Blue: Completely dry, Light Blue: Partly humid. (Absorbed water for about 15% of its weight), Pink: Saturated with moisture, so replace (reheat) it. (Absorbed water for about 30 - 40% of its weight)] - Oil in the oil cup allows dust particles of air to settle in the oil. By changing the oil & cleaning the oil cup air becomes free from dust particles. Visibility of oil level & dust particle in the oil cup is very important to decide when to change the oil.

After modification (Textbook: Patrol for Substation Equipment)

Item	Judgement Criteria and Troubleshooting
8) Breathers	
Degree of Breathing	- Make sure that breathers can breathe normally. Transformers should breathe from breathing holes (provided in breather) only. If air enters through any other portion of the breather except breathing holes it is called leakage of air. Leakage of air will lead to entrance of air with moisture & particles in the transformer, which ultimately may lead to formation of spark, and short circuit in the transformer. Structure of Breather 
Silica Gel & Oil in the Oil Cup	- A silica gel changes color from deep blue to pinkish white as it absorbs moisture. By reheating, the Gel becomes free from moisture & hence transformers always breathe in dry air. Visibility of Gel color is very important to decide when to reheat the Gel. ✓ Deep Blue: Completely Dry ✓ Light Blue: Partly Humid. (Absorbed water for about 15% of its weight) ✓ Pink: Saturated with Moisture, so replace (reheat) it. (Absorbed water for about 30 - 40% of its weight) - Oil in the oil cup allows dust particles of air to settle in the oil. By changing the oil & cleaning the oil cup air becomes free from dust particles. Visibility of oil level & dust particle in the oil cup is very important to decide when to change the oil. 

Regarding inspection items about breathers which seem to be difficult to understand, we added equipment diagram and the photo of silica gel that shows the replacement period.

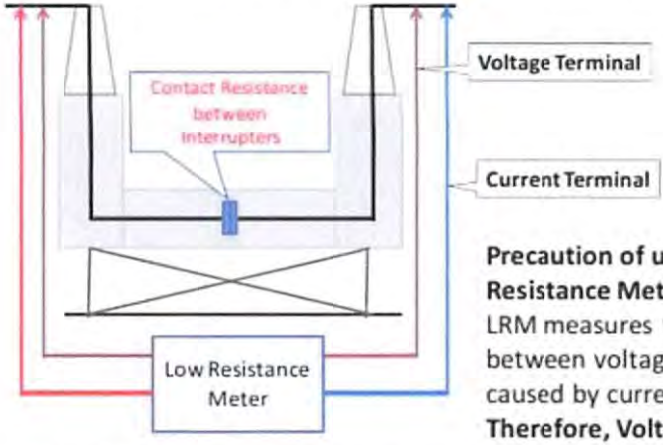
Before modification (Textbook: Patrol for Substation Equipment)

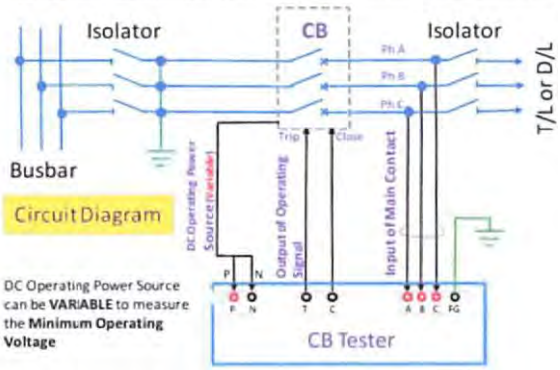
9) Radiators	
Appearance	Make sure if there is no paint deterioration, rusts, dirts. If it is a minor defect, repair it.
Oil leakage	Make sure if there is no oil leakage from welding area, jointing area or other flange. Since the oil leakage affect the appearance of equipment and also may make the equipment stop, repair it at an early stage. In case of oil leakage from the jointing area, retighten the bolt at first. if the leakage continues, replace a gasket or a container since the deterioration of the gasket or seam failure are considered as the cause.
10) Other	
Grounding wire	Make sure the tightening condition of grounding wires.
Foundation	Make sure if there is no cracks or subsidence.

After modification (Textbook: Patrol for Substation Equipment)

Item	Judgement Criteria and Troubleshooting
9) Radiators	
Appearance	Make sure if there is no paint deterioration, rusts, dirts. If it is a minor defect, repair it.
Oil Leakage	Make sure if there is no oil leakage from welding area, jointing area or other flange. Since the oil leakage affect the appearance of equipment and also may make the equipment stop, repair it at an early stage. In case of oil leakage from the jointing area, retighten the bolt at first. if the leakage continues, replace a gasket or a container since the deterioration of the gasket or seam failure are considered as the cause.  [Example of Oil Leakage] Oil leakage from the butterfly valve between the main tank and the radiator
10) Others	
Grounding Wire	Make sure the tightening condition of grounding wires, etc.  Rust of Supporting Structure; Make sure the tightening condition of grounding wires
Foundation	Make sure if there is no cracks or subsidence.

Regarding inspection items about radiators and others, we added the example of oil leakage that is easy to leak, the rust of supporting structures and the checkpoint for tightening of ground wires.

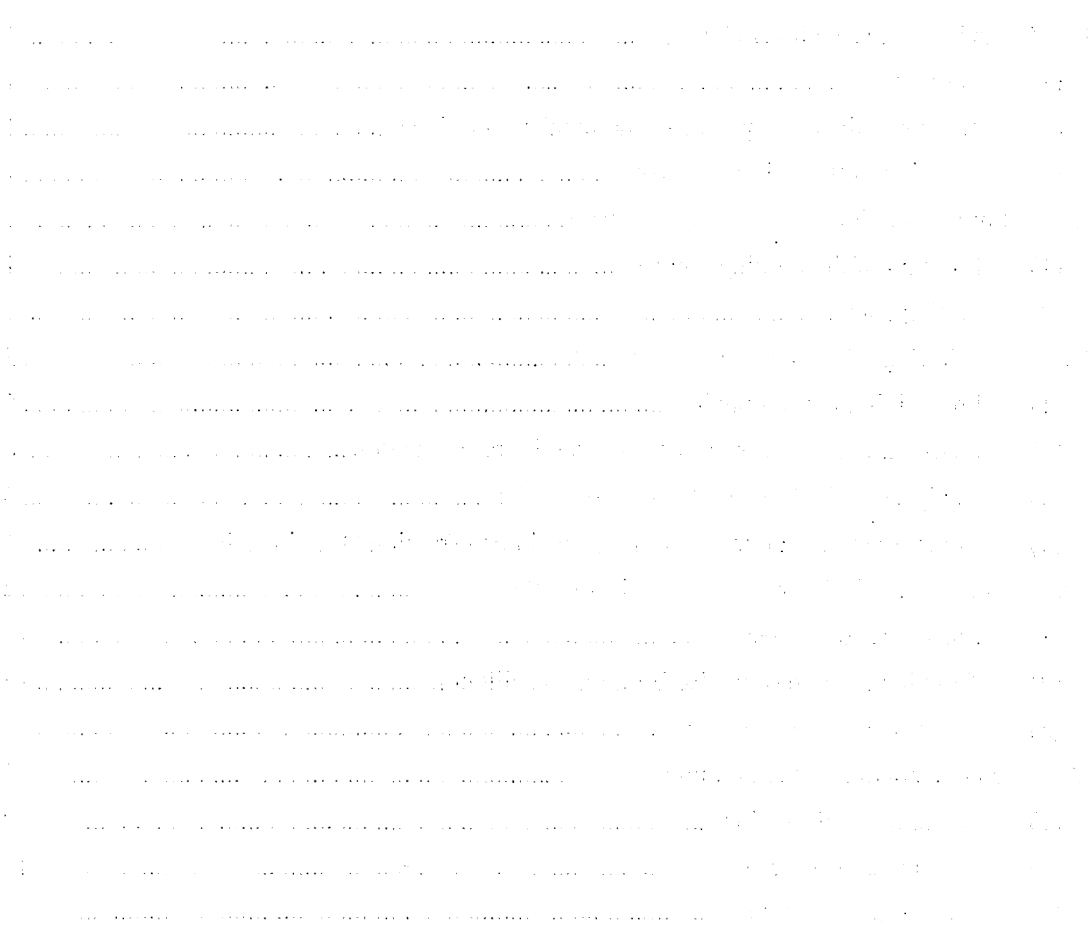
Before modification (Textbook: Periodic Inspection Items for Substation)	After modification (Textbook: Periodic Inspection Items for Substation Equipment)
3. Measurement of Contact Resistance for Direct Current Stationary and moving contacts are built from alloys that are formulated to endure the stresses of electrical arcing. However, if contacts are not maintained on a regular basis, their electrical resistance due to repeated arcing builds up, resulting in a significant decrease in the contact's ability to carry current. Excessive corrosion of contacts is detrimental to the breaker performance. One way to check contacts is to apply DC and measure the contact resistance or voltage drop across the closed contacts. The breaker contact resistance should be measured from bushing terminal to bushing terminal with the breaker in closed position. It is recommended that for MV and HV the resistance test be made with 50A or higher DC. The use of a higher current value gives more reliable results than using lower current values. The manufacturers' standards are applied as the judgment criteria.	**3. Measurement of Contact Resistance for Direct Current** Stationary and moving contacts are built from alloys that are formulated to endure the stresses of electrical arcing. However, if contacts are not maintained on a regular basis, their electrical resistance due to repeated arcing builds up, resulting in a significant decrease in the contact's ability to carry current. Excessive corrosion of contacts is detrimental to the breaker performance. One way to check contacts is to apply DC and measure the contact resistance or voltage drop across the closed contacts. The breaker contact resistance should be measured from bushing terminal to bushing terminal with the breaker in closed position. **It is recommended that for MV and HV the resistance test be made with 50A or higher DC. The use of a higher current value gives more reliable results than using lower current values.** The manufacturers' standards are applied as the judgment criteria.  **Figure 5-1 Test Circuit for Measurement of Contact Resistance**
	Regarding the measurement of contact resistance that is one of the periodical inspection items for Circuit Breakers, we added the circuit diagram of inspection and the precaution for easy understanding.

Before modification (Textbook: Periodic Inspection Items for Substation)	After modification (Textbook: Periodic Inspection Items for Substation Equipment)
6. Measurement of Opening and Closing Characteristics (1) Contact opening time and closing time Contact opening time and closing time shall be measured and checked if they are within the manufacturers' standards. (2) Minimum operational voltage (pressure) In the state which voltage is not applied to the primary circuit, either the voltage of electromagnetic coil or the pressure of compressed air (oil) shall be maintained at the rated value, and the minimum voltage or pressure shall be measured by changing the other parameter (pressure or voltage). At this time, the opening-and-closing speed characteristic of GCB does not meet the manufacturers' specifications. The value of minimum operating voltage (pressure) is shown in Table 5-3. **Table 5-3 Minimum operating voltage (pressure)** (IEC62271-100) Items / Standards Minimum closing voltage / 85% of the rated voltage Minimum opening voltage / 85% of the rated voltage if AC; 70% of the rated voltage if DC Minimum closing pressure (For pneumatic or oil pressure drive) / 85% of the rated pressure Minimum opening pressure (For pneumatic or oil pressure drive) / 85% of the rated pressure	**6. Measurement of Opening and Closing Characteristics** (1) Contact Opening Time and Closing Time Contact opening time and closing time shall be measured and checked if they are within the manufacturers' standards. (2) Minimum Operating Voltage (Pressure) In the state which voltage is not applied to the primary circuit, either the voltage of electromagnetic coil or the pressure of compressed air (oil) shall be maintained at the rated value, and the minimum voltage or pressure shall be measured by changing the other parameter (pressure or voltage). At this time, the opening-and-closing speed characteristic of GCB does not meet the manufacturers' specifications. The value of minimum operating voltage (pressure) is shown in Table 5-3. **Table 5-3 Minimum Operating Voltage (Pressure)** (IEC62271-100) Items / Standards Minimum Closing Voltage / 85% of the Rated Voltage Minimum Opening Voltage / AC: 85% of the Rated Voltage; DC: 70% of the Rated Voltage Minimum Closing Pressure (For pneumatic or oil pressure drive) / 85% of the Rated Pressure Minimum Opening Pressure (For pneumatic or oil pressure drive) / 85% of the Rated Pressure  Ex. Measurement Items to be measured by CB Tester ✓Contact Opening Time (Including Imbalance of Three-Phase) ✓Contact Closing Time (Including Imbalance of Three-Phase) ✓Minimum Opening Voltage ✓Minimum Closing Voltage ✓Motor Current and Duration of Spring winding ✓Operating Sequence (Ex. O - 0.3s - CO - 3min - CO) **Figure 5-3 Circuit Diagram of Measurement of CB Characteristics**
	Regarding the measurement of switching characteristics that is one of the periodical inspection items for Circuit Breakers, we added the circuit diagram of inspection and the explanation for easy understanding.

5) Monitoring Report on the Training Course for ECG Engineers "System Protection and Control "(March, 2015)

Monitoring Report on the Training Course for ECG Engineers
"System Protection and Control"

Contents:



Monitoring Report on the Training Course for ECG Engineers
"System Protection and Control"

I. Overview of the Training Course

(1) Purpose

To learn and acquire basic concept and knowledge of system protection and control in electric power system

(2) Targets of the training course and number of trainees

Total Twenty (20) Engineers; two trainees who are engaging technical occupations of system protection and control from each ECG regional offices.

(3) Duration of the training course

From Monday, 23rd February, 2015 to Friday, 27th February, 2015 (5days)

II. Implementation of the Training Course

(1) Program of the training course

Program of the training course is shown in Table-1.

(2) Participants

List of participants of the training course is shown in Table-2.

Table-1 Curriculum for the Training Course on the System Protection and Control for ECG Engineers

DAYS	8:30 – 9:00am	9:00 – 10:00am	10:00am-10:15am	10:15am –12noon	12noon - 1pm	1:00 – 3:30pm
Day 1	**Registration and Opening Ceremony**	0. Orientation 1. Overview of Electric Power System ***Name (lecturer):*** ***ING. George Hommey***	S n a c k B r e a k	1. Overview of Electric Power System ***ING. George Hommey***	L u n c h B r e a k	2. Overview of protection relay system ***ING. George Hommey***
Day 2	3. Neutral Grounding System ***ING. Rodnell Bilson***			4. Protection System for Substation (Transformer Protection System) ***ING. Rodnell Bilson***		4. Protection System for Substation (Transformer Protection System) ***ING. Rodnell Bilson***
Day 3	4. Protection System for Substation (Bus Protection System) 5. Transmission Line Protection System ***ING. Rodnell Bilson***			5. Transmission Line Protection System ***ING. Rodnell Bilson***		6. Distribution line Protection System ***ING. Frank Osei Owusu***
Day 4	6. Distribution line Protection System ***ING. Frank Osei Owusu***			7. Fault Calculation ***ING. Frank Osei Owusu***		8. Relay Setting ***ING. Frank Osei Owusu***
Day 5	8. Relay Setting (Practice using Simulator) ***ING. Frank Osei Owusu*** ***ING. Maxwell Graham*** ***Engr. Maxwell Essel***			8. Relay Setting (Practice using Simulator) ***ING. Frank Osei Owusu*** ***ING. Maxwell Graham*** ***Engr. Maxwell Essel***		8. Relay Setting (Practice using Simulator) ***ING. Frank Osei Owusu*** ***ING. Maxwell Graham*** ***Engr. Maxwell Essel*** Evaluation

Table-2 Participants List for the Training Course on System Protection and Control for ECG Engineers

No.	Name	Designation	Region	Job category
1	Richard Ankomah	Electrical Engineer	Central	Operations
2	Henry Quartey	Electrical Engineer	Central	Metering
3	Fred Kotey	Snr Artisan	Sub. T	Substation
4	Christian Dzikunu	Electrical Engineer	Sub. T	Operations
5	Annibella Ofori	Technician Engineer	Accra East	Fault
6	Osei Louis Kwasi	Snr. Artisan	Accra East	Substation
7	Andrews Owasu Preprah	Princ. Technician Eng.	Ash. West	Project
8	Kofi Danso	Electrical Engineer	Ash. West	Operations
9	Kingsley Agbesi	Snr. Technician Eng.	Eastern	Operations
10	Evans Ebo Sarpong	Snr. Artisan	Eastern	Operations
11	Carl Ankrah	Electrical Engineer	Accra West	Project
12	Mawuli Salah	Electrical Engineer	Accra West	Substation
13	Victor Awuku	Asst. Electrical Engineer	Tema	Metering

Table-2 Participants List for the Training Course on System Protection and Control for ECG Engineers

No.	Name	Designation	Region	Job category
14	Franicis Atsyatsa	Snr. Electrical Engineer	Tema	Operations
15	Eugene Oware Nyanor	Electrical Engineer	Ash. East	Operations
16	Samuel Bakye Twumasi	Asst. Electrical Engineer	Ash. East	Project
17	Castro Dogbeda	Electrical Engineer	Volta	Project
18	Michael Engmann	Technician	Volta	Operations
19	William Fua	Electrical Engineer	Western	Project
20	Godwin Yabameh	Asst. Electrical Engineer	Western	Project

III. Monitoring of the Training Course

(1) Pre-training Questionnaires

In order to identify trainees' technical background (knowledge and capacity) including job experience, the Pre-training Questionnaires was done during the orientation in the opening of the Training Course. A form of the Pre-training Questionnaires is attached in Appendix-A.

As results of the Pre-training questionnaire, overview of trainees who participated this training course is indicated in figures below. Age composition of trainees is shown in Fig.-1, years of experience in ECG is shown in Fig.-2 and current jog category is shown in Fig.-3. Result of the Pre-training Questionnaire is provided in Appendix-B.

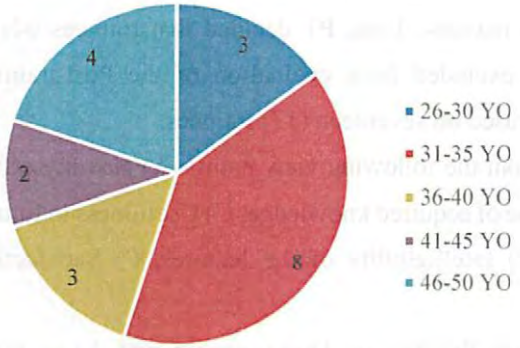


Fig.-1 Age composition of trainees

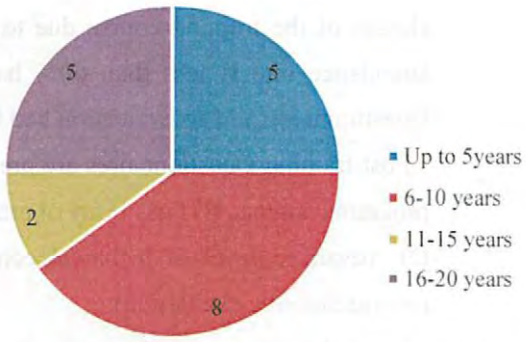


Fig.-2 Years of experience in ECG

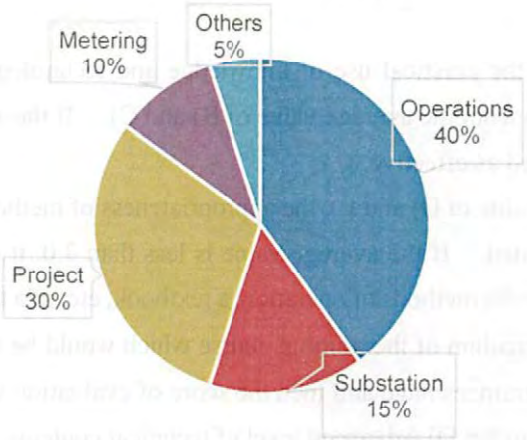


Fig.-3 Current job category

In the light of the each questions in the pre-training questionnaires, most of trainees have enough skills and knowledge on Electric Power System, prior to the participation of the training course. On the other hand, there is great variability among trainees on the subject of "Bus Protection System" and "Fault Calculation". In addition, most of trainees lack experience in the

"Relay Setting", "Relay Testing" and "Procedure of the Relay Setting".

(2) Post-training Questionnaires and Criteria for Evaluation

In order to measure the effect of the training course, the Post-training Questionnaire and Action Plan were collected from all trainees in advance of evaluation and closing of the training course. Project Team on the Electrical Engineer Training for African Countries (hereinafter referred to as "PT") requested trainees that the Post-training Questionnaire should be filled in immediately after subject of the class. A form of the Post-training Questionnaire and Action Plan is attached Appendix-A, and the result of the Post-training Questionnaire is provided in Appendix-C.

Number of registered trainees is twenty (20). However, some of trainees could not attend some classes of the training course due to various reasons. Thus, PT decided that trainees whose attendance rate is less than 60% had been excluded from evaluation of the Post-training Questionnaire, and so evaluation had been focused on seventeen (17) trainees.

Post-training Questionnaires are prepared from the following view points; A) Novelty of the program contents, B) Possibility of practical use of acquired knowledge, C) Usefulness in future, D) Advanced level of technical contents, E) Intelligibility of the lectures, F) Satisfaction (comprehensive evaluation).

From the results of the comparison between Pre-training Questionnaire and A) of Post-Questionnaires, the degree of each individual's technical improvement level is measured and the effect of a training course can be judged from the degree of improvement of the whole average value.

The possibility of the practical use of knowledge and technology acquired in this training course can be known from the average value of B) and C). If the average value is higher than 3.0, it will be regarded as effective.

From the average value of D) and E), the appropriateness of methods of operation for training course can be evaluated. If the average value is less than 3.0, it can be considered that it is necessary to improve the methods of operation, a textbook, etc. of a training course. PT prepared the syllabus and curriculum of the training course which would be set a little higher than skills and knowledge that trainees have and then the score of evaluation would be targeted the range of 3.5-4.5 regarding to the D) Advanced level of technical contents.

From the average value of F), the synthetic degree of satisfaction to a training course can be judged. If the average value is higher than 3.0, it can be considered that the training course was satisfactory contents.

(3) Analyses of the Pre and Post-Questionnaires

A) Novelty of the program contents

The result of the question on "Novelty of the program contents" in the Post-training Questionnaire is shown in Table-4.

It can be confirmed that the average values of all subjects are improved from those of Pre-training Questionnaires except for "(1) Overview of Electric Power System". Accordingly, most of trainees have basic skills and knowledge of electric engineering.

Table-4 Novelty of the program contents

		Pre	Post
(1) Overview of Electric Power System	Average score	3.421	3.118
	SD (σ)	1.374	1.231
(2) Overview of Protection Relay System	Average score	2.850	3.529
	SD (σ)	1.236	0.915
(3) Neutral Grounding System	Average score	3.350	3.471
	SD(σ)	1.014	1.144
(4-1) Transformer Protection System	Average score	3.050	3.412
	SD(σ)	1.431	1.088
(4-2) Bus Protection System	Average score	2.700	3.412
	SD(σ)	1.221	0.911
(5) Transmission Line Protection System	Average score	3.250	3.294
	SD(σ)	1.135	1.015
(6) Distribution Line Protection System	Average score	3.316	3.471
	SD(σ)	1.526	1.036
(7) Fault Calculation	Average score	2.700	3.563
	SD(σ)	1.145	1.223
(8) Relay Setting	Average score	1.600	3.882
	SD(σ)	0.917	0.963
(9) Simulator Practice	Average score		3.882
	SD(σ)		1.022

SD: standard deviation

B) Possibility of practical use of acquired knowledge and technology

The result of the question on "Possibility of practical use of acquired knowledge and technology" in the Post-Questionnaire is shown in Table-5. Most of average scores are improved in each subjects except for the "(8) Relay Setting". Average of the "Relay Setting" is scored below 3.0. From these results, PT can observe as following;

i) Most of trainees felt that the knowledge and technology acquired in this training course could be utilized in their own jobs and quality of their jobs would be improved

very much.

ii) It is likely to be caused by following two reasons to be low score on the subject of "(8) Relay Setting"; a) "Relay Setting" is not a work for ECG Regional Offices at this moment and b) class period for the "Relay Setting" in this training course was too short and the lecture was insufficient to explain to trainees in detail.

Table-5 Possibility of practical use of acquired knowledge and technology (Average)

	Pre	Post
(1) Overview of Electric Power System	3.421	3.647
(2) Overview of Protection Relay System	2.850	3.000
(3) Neutral Grounding System	3.350	3.588
(4-1) Transformer Protection System	3.050	3.412
(4-2) Bus Protection System	2.700	3.471
(5) Transmission Line Protection System	3.250	3.588
(6) Distribution Line Protection System	3.316	3.647
(7) Fault Calculation	2.700	3.125
(8) Relay Setting	1.600	2.941
(9) Simulator Practice		3.300
Overall mean	2.679	3.372

C) Usefulness in future

The result of the question on "Usefulness in future" in Post-training Questionnaire is shown in Table-6. The questions are about the knowledge which is not directly related to their current jobs, but scores of each subjects exceeded 3.0 substantially, and will link to the improvement of their own technology in future.

PT confirms from the result of evaluation as follows.

i) All trainees felt that knowledge and technology acquired in this training course would not be related to their current jobs directly but contained a lot of useful technology in their future. This result is link to the following question of "D) Advanced level of technical contents".

Table-6 Usefulness in future (Average)

	Pre	Post
(1) Overview of Electric Power System	3.421	4.529
(2) Overview of Protection Relay System	2.850	4.176
(3) Neutral Grounding System	3.350	4.294
(4-1) Transformer Protection System	3.050	4.412

	Pre	Post
(4-2) Bus Protection System	2.700	4.000
(5) Transmission Line Protection System	3.250	4.235
(6) Distribution Line Protection System	3.316	4.471
(7) Fault Calculation	2.700	3.875
(8) Relay Setting	1.600	4.059
(9) Simulator Practice		3.824
Overall mean	2.679	4.168

D) Advanced level of technical contents

Technical level of the training course is asked in this question. If technical level is the same as trainee has, the value is marked to 3.0, if the contents of training are felt to be quite advanced, the value is marked to 5.0 and to the contrary if quite low, the value is marked to 1.0.

The average figure of each subjects is as Table-7.

Table-7 Advanced level of technical contents (Average)

	Pre	Post
(1) Overview of Electric Power System	3.421	3.353
(2) Overview of Protection Relay System	2.850	3.471
(3) Neutral Grounding System	3.350	3.353
(4-1) Transformer Protection System	3.050	3.294
(4-2) Bus Protection System	2.700	3.529
(5) Transmission Line Protection System	3.250	3.471
(6) Distribution Line Protection System	3.316	3.529
(7) Fault Calculation	2.700	3.563
(8) Relay Setting	1.600	3.176
(9) Simulator Practice		3.647
Overall mean	2.679	3.438

i) Prior to the training, it was assumed that the adequate training level would be from 3.5 to 4.5 of the average score of the Post-training Questionnaire. Therefore, PT evaluates that contents and constitution of the training course was appropriate level.

ii) On the other hand, the score of "Relay Setting" is a little lower than average. PT is thought to be aftereffects of the class period that wasn't allocated enough to explain to trainees and they couldn't understand important points.

iii) In addition, most of trainees marked 3 and higher but a few trainees marked 1 or 2 on the subject of "(3) Neutral Grounding System" and "(4-1) Transformer Protection System". PT is thought to be aftereffects of they have detailed skills and knowledge of such types of system through their daily work. This is very limited part of training course and it is singular case from the view of whole training course.

E) Intelligibility of the lecture and practical work

The result of the question on "Intelligibility of the lecture" in Post-training Questionnaire is shown in Table-8.

Table-8 Intelligibility of the lecture and practical work (Average)

	Pre	Post
(1) Overview of Electric Power System	3.421	4.706
(2) Overview of Protection Relay System	2.850	4.706
(3) Neutral Grounding System	3.350	4.765
(4-1) Transformer Protection System	3.050	4.647
(4-2) Bus Protection System	2.700	4.529
(5) Transmission Line Protection System	3.250	4.529
(6) Distribution Line Protection System	3.316	4.529
(7) Fault Calculation	2.700	4.313
(8) Relay Setting	1.600	4.294
(9) Simulator Practice		4.294
Overall mean	2.679	4.503

i) Overall mean is over 4.5 and thus all classes were intelligible and valuable. Judging from the results, PT could get the better results than our expectation. It was proved that ECG Internal Facilitators had very high teaching techniques.

ii) This was the first occasion to use the simulator in the training courses of the ECG Training Centre. As for the training items of "(9) Simulator Practice ", also average score is over 4.0 and most of trainees answered that Simulator Practice had been intelligible. Therefore, it will be able to develop promising training courses using simulator in the ECG Training Centre in future.

F) Satisfaction (comprehensive evaluation)

The result of the question on "Satisfaction (Comprehensive Evaluation)" in Post-training Questionnaire is shown in Table-9. The average figure of each subjects is as follows.

i) Prior to the training, it was assumed that the adequate value would be from 4.0 to 4.5.

Judging from the results, we could get the good results as we expected.

Table-9 Satisfaction (comprehensive evaluation, Average)

	Pre	Post
(1) Overview of Electric Power System	3.421	4.529
(2) Overview of Protection Relay System	2.850	4.647
(3) Neutral Grounding System	3.350	4.529
(4-1) Transformer Protection System	3.050	4.529
(4-2) Bus Protection System	2.700	4.412
(5) Transmission Line Protection System	3.250	4.588
(6) Distribution Line Protection System	3.316	4.529
(7) Fault Calculation	2.700	4.250
(8) Relay Setting	1.600	4.294
(9) Simulator Practice		4.412
Overall mean	2.679	4.473

(4) Comprehensive summary of the Pre and Post-Training Questionnaires

From the results of the Pre- and Post-Questionnaires, the training course is evaluated as follows;

i) This training course could provide a substantial technical improvement for the ECG Engineers.

ii) We can expect that the knowledge and technology acquired in this training course would be utilized very much and contribute to enhance the quality of their jobs. In addition, we can also expect the usefulness of the technology in trainees' future career.

iii) Class period of "Fault calculation" and "Relay Setting" wasn't allocated enough to explain to trainees and also there were no time to do practical exercise.

iv) Trainees couldn't operate and install a simulator during practical exercises by themselves.

v) The degree of satisfaction to this training is very high. (All the trainees evaluated this training very high.)

vi) PT can say that we could obtain the expected outcome from this training course and this training course was implemented successfully.

IV. Comments and impressions from lecture observation

PT would like to point out some comments from observation of lectures besides the questionnaires.

(1) Basic rule for the lecture

i) Facilitators/ Instructors never be late classes. At least they should arrive the Training Centre 30 minutes in advance of first class and prepare for classes very well.

ii) Most of trainees sit backwards and aside of the classroom and there were few trainees who were sitting in front and middle. Organizer would lead trainees to have a seat in front and middle of a classroom before a class starts.

iii) Mobile phone and smart phone should be turned off during a class.

iv) Facilitators/ Instructors should be more punctual. (Time of starts, ends snack and lunch time should be informed to trainees properly.)

v) Trainees who is working at offices near the ECG Training Centre such as Accra East and West, Sub-T and Tema were sometimes late to a class in the morning. PT felt their commitments to participation to the training course had been low and some of them couldn't exceed 61% of attendance rate.

(2) Teaching method of the ECG Internal Facilitators

i) Facilitators/ Instructors should use a textbook more effectively in order to assist the trainees understanding. Power Point materials that is prepared by the facilitators/ instructors should link to the textbook more clearly.

ii) Facilitators/ Instructors should understand textbook deeply. If they need to know more advanced information, they should ask JICA Team.

(3) Atmosphere of the lecture

i) Attitude of trainees is very good during the training course.

ii) The way to proceed the lectures with exchanging views between instructor and trainees is very good.

V. Recommendation to next training courses

(1) Nominee Qualifications

Theoretical lectures and practical exercises in the classroom can be organized for twenty (20) trainees. But the simulator room of the ECG Training Centre doesn't have enough space. In addition, in order to configure and operate simulators by trainees, number of participants should be under ten (10).

(2) Rearrange the curriculum

According to some subjects, classes were over earlier that PT expected. Thus curriculum is needed to rearrange and class period should be allocated properly.

(3) Challenges in the future

i) Reduction of assignment for ECG Internal Facilitators

ECG Internal Facilitators who is belonging to the Project Office were proceeding at this training course. But they had to prepare teaching materials for the training course while dealing with their original works in the Project Office. Therefore, it is difficult to prepare adequately and they didn't have much capacity to do it.

In order to sustain training courses which are leading by ECG Internal Facilitators in future, ECG Instructors who is belonging to ECG Training Centre should take a part of responsibility to reduce their load of the training course.

ii) Utilization of simulator

This was the first training course in ECG which was using the simulator that is owned by the ECG Training Centre. During this training course, an electric power system network was simulated and reaction of relay settings were demonstrated in case of faults happen on each type of electric power system equipment. Contents suffices as a training course that is targeted for young and inexperienced protection engineers. If ECG wants to develop senior experts on protection relay, practical training using simulator is very useful and effective. The course could be developed that trainees install the protection relay by themselves and understand what happens in case of faults occur in power system network, in order to understand the "Protection Relay" deeply.

Also, simulator that ECG Training Centre owns, is able to install SCADA system. From the aspects of human resources development of ECG, advanced training courses would be able to develop that is targeted for those who completed the basic course on "System Protection and Control". This advanced course purposes as following two points;

A) Understanding on characteristics of power system

Trainees can understand characteristics of power system to install power system by themselves, simulate and confirm reactions.

B) Understanding on coordination between protection relays

Trainees can deeply understand importance of coordination between protection relays to simulate difference of relay setting and remove fault area from power system.

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Appendix-A Forms of Training Monitoring

1) Pre-training Questionnaire
2) Post-training Questionnaire
3) Action Plan

Pre-training Questionnaires

Training Course Name: System Protection and Control

1. Background

Name		Age		Experience in ECG		Years
Graduate school		Major in school				
Dept./ Section in ECG:						
Type of job (currently engaged)		Job title				

Work experience	Total years	Stage of Work				
		Planning	Design	Consutruction	Operation	Maintenance
Substation						
T&D department						
Underground cable						
Overhead line						
Other ( )						

2. Current Capacity and Knowledge on System Protection and Control

(1) Overview of Electric Power System (Configuration and characteristics of each equipment)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(2) Overview of Protection Relay System (Configuration and objectives, type of relay, fail-safe system)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(3) Neutral Grounding System (Type and purpose of each neutral grounding system)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(4) Protection System for Substation

(4-1) Transformer Protection System (Configuration and objectives of electrical relay and mechanical relay)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(4-2) Bus Protection System (Configuration and characteristics of system for each bus arrangement)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(5) Transmission Line Protection System (Type configuration and characteristics of each protection system)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(6) Distribution Line Protection System (Type configuration and characteristics of each protection system)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(7) Fault Calculation

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

(8) Have you experienced Relay Setting?

proficient — some experience — never

5 4 3 2 1

(9) Have you experienced Relay Testing? (Commissioning test and scheduled test)

proficient — some experience — never

5 4 3 2 1

(10) Relay Setting (How to calculate the setting value, time coordination and sensitivity coordination)

enough knowledge — roughly understand — less knowledge

5 4 3 2 1

3. Motivation to the Training Course

(1) Please make a list of problems and barriers in your daily work that you are recognizing.

- _____
- _____
- _____

(2) What do you expect to learn from this training course?

1) Please describe technical knowledge that you want to obtain from the training course.

- _____
- _____
- _____

2) Please describe business knowledge that you want to obtain from this training course.

- _____
- _____
- _____

That's all of the questionnaires of Pre-training course. Thank you for your cooperation.

For ECG Engineers (Pre-Questionnaires)

Post-training Questionnaires

Course Name: **System Protection and Control**

Name:	Dept./ Section:

● **Method of Evaluation**

Please evaluate on each subjects of the training course to use following scales and aspects from A to F.

A. Novelty of the training course contents

Q: How much new knowledge for yourself were included in the subject?

more than 80% (5) — 4 — about 50% (3) — 2 — less than 20% (1)

B. Possibility of practical use of acquired knowledge

Q: How frequently do you use acquired knowledge from the subject to improve quality of your current work?

always (5) — usually (4) — often (3) — sometimes (2) — few (1)

C. Technical utility in your future career

Q: How effective do you think technical knowlege that was learnt from the subject in your future career?

more than 80% (5) — 4 — about 50% (3) — 2 — less than 20% (1)

D. Advanced level of technical content

Q: How sophisticated is the level of the subject that compared with your current engineering capacity?

fairly sophisticated content (5) — 4 — comparable to your level (3) — 2 — much lower content (1)

E. Intelligibility of the lecture and practical work

Q: Did instructors/ lecturers provide a clear description of the subject?

easy-to-understand (5) — 4 — neither agree nor disagree (3) — 2 — hard to understand (1)

F. Satisfaction (comprehensive evaluation)

Q: Please evaluate on the subject in a comprehensive manner.

very satisfied (5) — 4 — neither agree nor disagree (3) — 2 — rather dissatisfied (1)

Course Name: **System Protection and Control**

Name:	Dept./ Section:

1. Evaluation

Please score in each columns using the scale that is presented in the Evaluation Method.

I. System Protection and Control

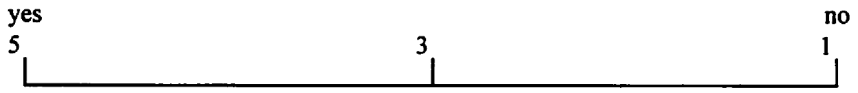
#	Viewpoin / Subject	A. Novelty	B. Practical use	C. Usefulness	D. Technical Level	E. Intelligibility	F. Satisfaction	Comments/ Questions (Especially, if you scored 1 or 2 in the question of E. and F., please describe reasons.)
(1)	Overview of Electric Power System							
(2)	Overview of Protection Relay System							
(3)	Neutral Grounding System							
(4) Protection System for Substation								
(4)-1	Transformer Protection System							
(4)-2	Bus Protection System							
(5)	Transmission Line Protection System							
(6)	Distribution Line Protection System							
(7)	Fault Calculation							
(8) Relay Setting								
(8)-1	Theory of Relay Setting							
(8)-2	Simulator Practice							

Course Name: **System Protection and Control**

Name:	Dept./ Section:

2. Feedback to the Training Course

1. Have you found any solutions from the training course to current issues of your daily work?
   Before answering, please reconfirm the list that you made in the pre-training course questionnaires.



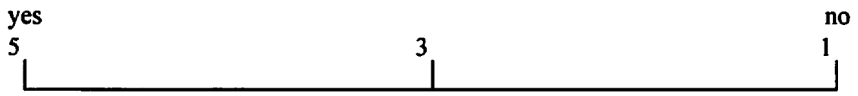
   If "yes", please let us know what kind of solutions that you found in the training course.

   •

   •

   •

2. Did you obtain technical knowledge from the training course that you had expected?



   If "yes", please let us know what is useful technical knowledge for your work.

   •

   •

   •

3. Comments on implementation of this training course
   Please write comments/ suggestions to the training course.
   Curriculum and subjects of the training/ duration (time)/ practical training (including using simulator), etc

   •

   •

   •

That's all of the questionnaires of Post-training course. Thank you for your cooperation.

Action Plan

Date: _____

Name: _____

Designation: _____

Region: _____

Training Course: Training Course for ECG Engineers on System Protection and Control

Please develop the Action Plan how to utilize the knowledge and techniques which you learnt in this training course improving and/or enhancing the quality of your job.

(1) Please write your Action Plan in a short-term.

(Action Plan in a short-term (approx. 1-year))

_____

_____

_____

_____

_____

_____

_____

_____

(2) Please write your Action Plan in a long-term.

(Action Plan in a long term)

_____

_____

_____

_____

_____

_____

_____

_____

Thank you very much.

Appendix-B Result on Pre-training Questionnaires

Pre-training Questionnaires

Course Name: System Protection and Control

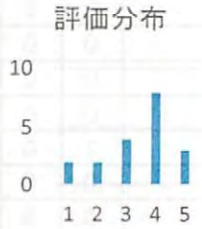
Initial condition

2. Current Capacity and Knowledge on System Protection and Control

(1) Overview of Electric Power System (Configuration and characteristics of each equipment)

score	1	2	3	4	5	Score
Person 1	0	0	1	0	0	3
Person 2	0	1	0	0	0	2
Person 3	0	0	0	0	1	5
Person 4	0	0	0	1	0	4
Person 5	0	0	1	0	0	3
Person 6	0	0	1	0	0	3
Person 7	0	0	0	1	0	4
Person 8	0	0	0	1	0	4
Person 9	0	0	0	0	1	5
Person 10	0	0	0	1	0	4
Person 11	0	0	0	0	1	5
Person 12	0	0	0	0	0	0
Person 13	1	0	0	0	0	1
Person 14	0	0	0	1	0	4
Person 15	0	1	0	0	0	2
Person 16	0	0	1	0	0	3
Person 17	0	0	0	1	0	4
Person 18	1	0	0	0	0	1
Person 19	0	0	0	1	0	4
Person 20	0	0	0	1	0	4
Score Distribution	2	2	4	8	3	

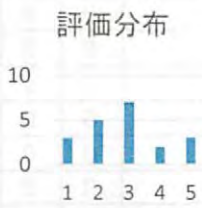
total of P	19
sum of S	65
average	3.4211
STDEVP	1.3739



(2) Overview of Protection Relay System (Configuration and objectives, type of relay, fail-safe system)

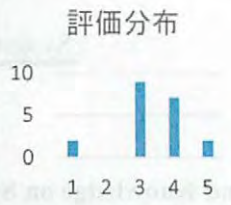
P1	1	0	0	0	0	1
P2	0	1	0	0	0	2
P3	0	0	0	0	1	5
P4	0	0	1	0	0	3
P5	0	0	1	0	0	3
P6	0	0	1	0	0	3
P7	0	0	0	1	0	4
P8	0	0	1	0	0	3
P9	0	0	1	0	0	3
P10	0	0	0	1	0	4
P11	0	0	1	0	0	3
P12	0	0	0	0	1	5
P13	1	0	0	0	0	1
P14	0	0	0	0	1	5
P15	0	1	0	0	0	2
P16	0	1	0	0	0	2
P17	0	0	1	0	0	3
P18	1	0	0	0	0	1
P19	0	1	0	0	0	2
P20	0	1	0	0	0	2
Score Distribution	3	5	7	2	3	

total of P	20
sum of S	57
average	2.85
STDEVP	1.2359



(3) Neutral Grounding System (Type and purpose of each neutral grounding system)

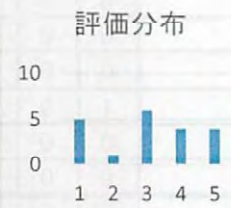
P1	0	0	1	0	0	3
P2	1	0	0	0	0	1
P3	0	0	0	1	0	4
P4	0	0	0	1	0	4
P5	0	0	1	0	0	3
P6	0	0	0	1	0	4
P7	0	0	0	0	1	5
P8	0	0	0	1	0	4
P9	0	0	0	1	0	4
P10	0	0	0	1	0	4
P11	0	0	1	0	0	3
P12	0	0	0	0	1	5
P13	0	0	1	0	0	3
P14	0	0	0	1	0	4
P15	1	0	0	0	0	1
P16	0	0	1	0	0	3
P17	0	0	1	0	0	3
P18	0	0	1	0	0	3
P19	0	0	1	0	0	3
P20	0	0	1	0	0	3
Score Distribution	2	0	9	7	2	



total of P	20
sum of S	67
average	3.35
STDEVP	1.0137

(4-1) Transformer Protection System (Configuration and objectives of electrical relay and mechanical re

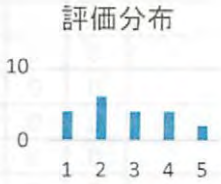
P1	1	0	0	0	0	1
P2	1	0	0	0	0	1
P3	0	0	0	0	1	5
P4	0	0	0	1	0	4
P5	0	0	1	0	0	3
P6	0	0	1	0	0	3
P7	0	0	0	0	1	5
P8	0	0	0	1	0	4
P9	0	0	1	0	0	3
P10	0	0	0	1	0	4
P11	0	0	0	1	0	4
P12	0	0	0	0	1	5
P13	1	0	0	0	0	1
P14	0	0	0	0	1	5
P15	0	0	1	0	0	3
P16	0	0	1	0	0	3
P17	0	0	1	0	0	3
P18	1	0	0	0	0	1
P19	0	1	0	0	0	2
P20	1	0	0	0	0	1
Score Distribution	5	1	6	4	4	



total of P	20
sum of S	61
average	3.05
STDEVP	1.4309

(4-2) Bus Protection System (Configuration and characteristics of system for each bus arrangement)

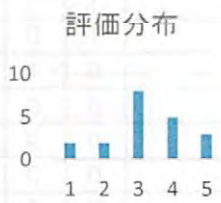
P1	0	1	0	0	0	2
P2	1	0	0	0	0	1
P3	0	0	0	0	1	5
P4	0	0	0	1	0	4
P5	0	1	0	0	0	2
P6	0	1	0	0	0	2
P7	0	0	0	1	0	4
P8	0	0	1	0	0	3
P9	0	1	0	0	0	2
P10	0	0	0	1	0	4
P11	0	0	1	0	0	3
P12	0	0	0	1	0	4
P13	1	0	0	0	0	1
P14	0	0	0	0	1	5
P15	0	1	0	0	0	2
P16	0	0	1	0	0	3
P17	0	0	1	0	0	3
P18	1	0	0	0	0	1
P19	0	1	0	0	0	2
P20	1	0	0	0	0	1
Score Distribution	4	6	4	4	2	



total of P	20
sum of S	54
average	2.7
STDEVP	1.2207

(5) Transmission Line Protection System (Type configuration and characteristics of each protection syst

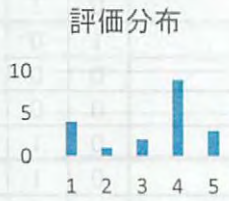
P1	0	1	0	0	0	2
P2	0	1	0	0	0	2
P3	0	0	0	0	1	5
P4	0	0	0	1	0	4
P5	0	0	1	0	0	3
P6	0	0	1	0	0	3
P7	0	0	0	1	0	4
P8	0	0	0	1	0	4
P9	0	0	1	0	0	3
P10	0	0	0	1	0	4
P11	0	0	0	1	0	4
P12	0	0	0	0	1	5
P13	1	0	0	0	0	1
P14	0	0	0	0	1	5
P15	0	0	1	0	0	3
P16	0	0	1	0	0	3
P17	0	0	1	0	0	3
P18	0	0	1	0	0	3
P19	0	0	1	0	0	3
P20	1	0	0	0	0	1
Score Distribution	2	2	8	5	3	



total of P	20
sum of S	65
average	3.25
STDEVP	1.1347

(6) Distribution Line Protection System (Type configuration and characteristics of each protection syste

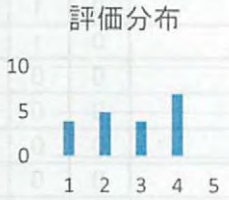
P1	1	0	0	0	0	1
P2	0	1	0	0	0	2
P3	0	0	0	0	1	5
P4	0	0	0	1	0	4
P5	0	0	0	0	0	0
P6	0	0	0	0	1	5
P7	0	0	0	1	0	4
P8	0	0	0	1	0	4
P9	0	0	0	1	0	4
P10	0	0	0	1	0	4
P11	0	0	0	1	0	4
P12	0	0	0	1	0	4
P13	1	0	0	0	0	1
P14	0	0	0	0	1	5
P15	0	0	1	0	0	3
P16	0	0	0	1	0	4
P17	0	0	0	1	0	4
P18	1	0	0	0	0	1
P19	0	0	1	0	0	3
P20	1	0	0	0	0	1
Score Distribution	4	1	2	9	3	



total of P	19
sum of S	63
average	3.3158
STDEVP	1.5256

(7) Fault Calculation

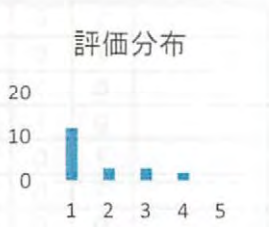
P1	1	0	0	0	0	1
P2	1	0	0	0	0	1
P3	0	1	0	0	0	2
P4	0	0	0	1	0	4
P5	0	0	0	1	0	4
P6	0	0	1	0	0	3
P7	0	0	0	1	0	4
P8	0	0	1	0	0	3
P9	0	0	1	0	0	3
P10	0	1	0	0	0	2
P11	0	0	1	0	0	3
P12	0	0	0	1	0	4
P13	1	0	0	0	0	1
P14	0	0	0	1	0	4
P15	1	0	0	0	0	1
P16	0	0	0	1	0	4
P17	0	1	0	0	0	2
P18	0	1	0	0	0	2
P19	0	1	0	0	0	2
P20	0	0	0	1	0	4
Score Distribution	4	5	4	7	0	



total of P	20
sum of S	54
average	2.7
STDEVP	1.1446

(8) Have you experienced Relay Setting?

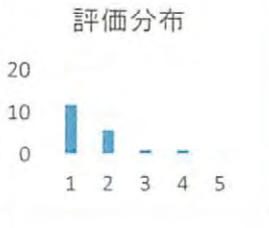
P1	1	0	0	0	0	1
P2	1	0	0	0	0	1
P3	0	0	0	1	0	4
P4	0	1	0	0	0	2
P5	1	0	0	0	0	1
P6	1	0	0	0	0	1
P7	0	0	0	1	0	4
P8	0	1	0	0	0	2
P9	1	0	0	0	0	1
P10	0	0	1	0	0	3
P11	1	0	0	0	0	1
P12	1	0	0	0	0	1
P13	1	0	0	0	0	1
P14	0	0	1	0	0	3
P15	0	1	0	0	0	2
P16	1	0	0	0	0	1
P17	0	0	1	0	0	3
P18	1	0	0	0	0	1
P19	1	0	0	0	0	1
P20	1	0	0	0	0	1
Score Distribution	12	3	3	2	0	



total of P	20
sum of S	35
average	1.75
STDEVP	1.0428

(9) Have you experienced Relay Testing? (Commissioning test and scheduled test)

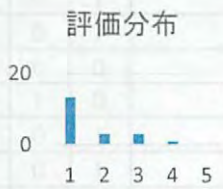
P1	1	0	0	0	0	1
P2	1	0	0	0	0	1
P3	0	1	0	0	0	2
P4	0	1	0	0	0	2
P5	1	0	0	0	0	1
P6	1	0	0	0	0	1
P7	0	1	0	0	0	2
P8	0	1	0	0	0	2
P9	1	0	0	0	0	1
P10	0	1	0	0	0	2
P11	1	0	0	0	0	1
P12	1	0	0	0	0	1
P13	1	0	0	0	0	1
P14	0	0	0	1	0	4
P15	0	1	0	0	0	2
P16	1	0	0	0	0	1
P17	0	0	1	0	0	3
P18	1	0	0	0	0	1
P19	1	0	0	0	0	1
P20	1	0	0	0	0	1
Score Distribution	12	6	1	1	0	



total of P	20
sum of S	31
average	1.55
STDEVP	0.8047

(10) Relay Setting (How to calculate the setting value, time coordination and sensitivity coordination)

P1	1	0	0	0	0	1
P2	1	0	0	0	0	1
P3	0	1	0	0	0	2
P4	0	1	0	0	0	2
P5	1	0	0	0	0	1
P6	1	0	0	0	0	1
P7	0	0	1	0	0	3
P8	1	0	0	0	0	1
P9	1	0	0	0	0	1
P10	0	0	1	0	0	3
P11	0	0	1	0	0	3
P12	1	0	0	0	0	1
P13	1	0	0	0	0	1
P14	0	0	0	1	0	4
P15	1	0	0	0	0	1
P16	1	0	0	0	0	1
P17	0	1	0	0	0	2
P18	1	0	0	0	0	1
P19	1	0	0	0	0	1
P20	1	0	0	0	0	1
Score Distribution	13	3	3	1	0	



total of P	20
sum of S	32
average	1.6
STDEVP	0.9165