Bringing up Youths to Become Engineers

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Abstract

As a Business Unit (BU) that has close contact with our customers on projects, we must meet customer requirements and secure the safety and high quality for construction. In so doing, the most important aspects are: "human resource management" and "transferring engineering knowledge and skills." We conduct complete engineering for construction of various diverse plant facilities. As a BU in charge of Construction Business, a training facility inside the premises of former Meiden Osaki Works (current ThinkPark Tower location) was used to provide education and training programs to our field engineers for the human resource development. Due to the urban redevelopment of Osaki area, our BU's training hub was since moved to near Meiden Numazu Works in Numazu City, Shizuoka Prefecture. In 2013, we established the Meiden Training Center in Ota City, Tokyo.

For the purposes of "human resource development" and "transferring engineering knowledge and skills," our construction BU thoroughly reviewed the education curriculum programs for new recruits and young workers with work experience up to four years. Under the new programs, we teach product knowledge necessary for plant engineering, the expertise of erection work, and on-site safety control. This education is closely linked with on-site project schedule management. We could produce tangible training results.

1 Preface

In the field of construction due to a decrease in construction investment, the average worker is becoming more senior while the population of young worker is decreasing. As a result, transferring engineering knowledge and skill to a different generation is becoming challenging. Our Plant Construction & Engineering Business Group ("PCEB" or the "Group") is in a similar situation. In the Japanese bubble economy period (from the middle of the 1980s to the beginning of the 1990s), the Company recruited many new employees, but from the latter half of the 1990s to recent years, we tended to recruit fewer new employees. The employees recruited during the bubble economy period are now core competent workers in their 40s. As such there are no current demographic problems. In ten years, however, the demographics will become problematic. To resolve this issue, from Fiscal 2012, we accelerate the hiring of mid-career employees. From Fiscal 2013, we increased the employment number of new graduates from senior high schools. In so doing, we tried to improve the balance of the various demographic ages. Fig. 1 shows demographics by age group in Fiscal 2014.

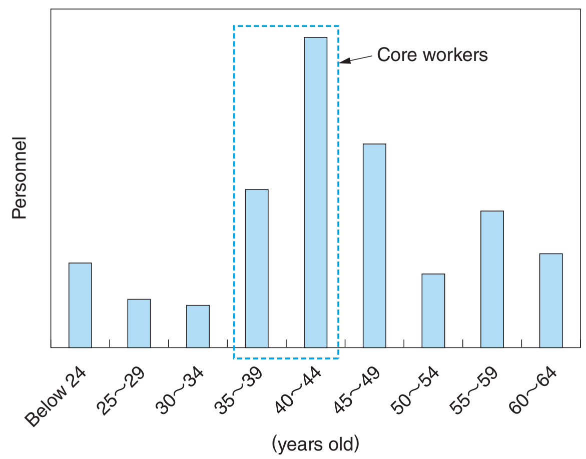


Fig. 1 Demographic by Age Group in Fiscal 2014

The demographic by age group is shown.

Recently, we began to accept trainees from Meiden Group firms in the Association of South East Asian Nations (ASEAN) area ("overseas trainees"). We are working on cultivating field engineers for overseas plant construction projects.

Under these circumstances, we founded the "PCEB Training Center" in Ota City, Tokyo in 2013 for the training of young workers, mid-career recruits and overseas trainees. This center was built for "human resource management" and "transferring engineering knowledge and skills." This paper introduces the training programs at the Training Center.

2 Educational Policy

Management of construction project works we conducted covers many fields ranging from social infrastructure facilities (in the fields of water processing, power, highways, broadcasting, railroads, etc.) to mission-critical power supply facilities of general industries. In addition, there are recent increasing cases of facility renovation projects where aged facilities are converted to new ones while main plant facilities continue working as usual. Our work has become increasingly difficult than previously.

In our conventional education programs, we conducted classroom courses in an office. Practical education was then conducted mainly at the project sites as On-the-Job Training (OJT). Recently, however, the rate of renovation work projects has increased and no failure is allowed since we must switch to a new facility while the main plant remains in operation. As a result, less-experienced younger workers are missing opportunities to work on such renovation work. According to allocated project work to such young workers, they are exposed to the various different level of experiences and no access to uniformed experiences. In order to realize "equal-footing educational quality and quantity" for younger workers, we changed the conventional education programs of conducting classroom lessons first, and then on-site OJT training at a later date. We offer class lessons first and then immediately perform practical hands-on experience education. We use the actual facilities located directly in the Center and the workers later use their knowledge acquired from classroom learning.

At the newly founded Training Center, trainees are required not only to acquire engineering knowledge but also become adept to think on his or her feet by tinkering the actual facility on simulated training. They learn through experience that cover "what should be checked and what we should pay attention to," "assess how and what is a serious situation," "where and why dangers exist." In so doing, they increase their level of awareness on these matters. From examples of cases of past failures, trainees can experience "failures" that are never allowed on actual project sites.

3 Educational Plan

As described previously, "human resource management" and "transferring engineering knowledge and skills to another generation" are our primary pressing needs. According to our educational plan, a trainee shall complete all periodical technical training courses at the Training Center within four years while accumulating actual work experience and earning the clearances of required national qualifications specified in the program schedule (acquisition of licensed qualification for engineer in five years at the minimum). We factored such elements into the program plan. The educational program is designed so that each trainee learns the technical skills necessary for becoming field engineers. For the acquisition of national qualifications in Japan, we drew up plans to get technical training qualifications, safety and health qualifications, and internal certificate qualifications. This plan is based on a year-by-year qualification acquisition plan. It is a systematic education plan and **Fig. 2** shows a one-year (schedule) cycle for the execution of hands-on experiences in the training programs.

4 Outline of the Training Center

Fig. 3 shows the hands-on experiences training facilities at the Training Center. These facilities are outlined below. In order to increase the effectiveness of education, the facility space was designed to accommodate a maximum of ten trainees at a time for the training course.

(1) First floor (124.2m^2)

Facility equipment: High-voltage power incoming equipment, high- voltage power receiving and distribution facilities, operation equipment, remote monitoring and control equipment

(2) Second floor (79.14m^2)

A Room for classroom learning: Accommodates 20 people

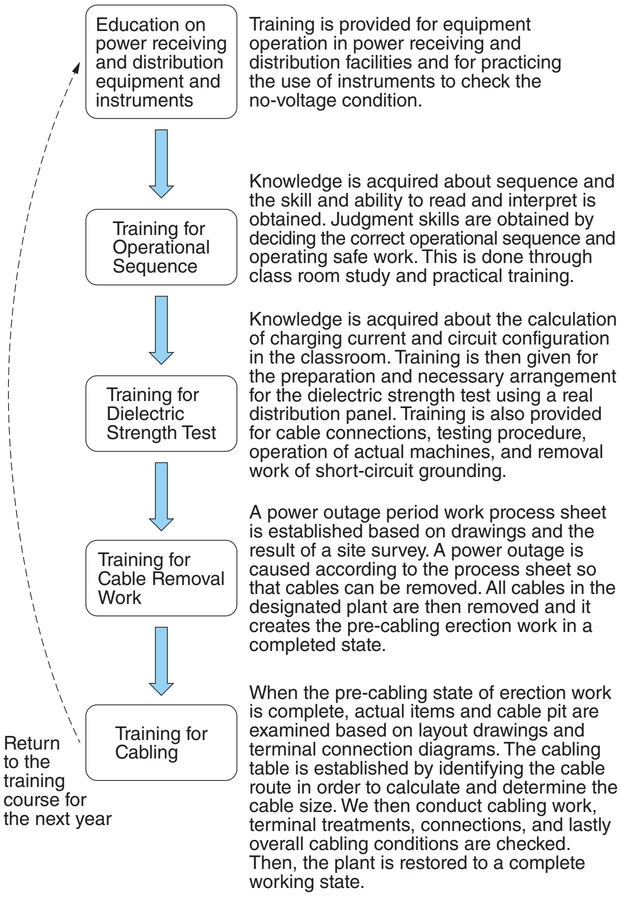


Fig. 2 One-Year (Schedule) Cycle for Execution of Hans-on Experiences in the Training Programs

The one-year (schedule) cycle for practical education is shown.

5 Year-by-Year Educational Plan and the Contents of Practical Education

In the first year of the annual practical education, each OJT trainee is required to understand how the plant works before entering the project site and acquire the necessary knowledge to protect oneself against dangers for safety. Until the second to fourth year training program, more practical education needed for field engineers is provided. Table 1 shows the year-by-year educational program and the main education contents at the Training Center. The specific practical courses are introduced below.

5.1 Education for Power Receiving and Distribution Facilities and Instruments (First Year Program)

For new recruits and those who are unfamiliar with an actual plant, one of the facilities difficult to grasp is a power receiving and distribution facility. Through classroom learning, the trainees learn various symbols of equipment and their mechanical functions. This is done by comparing a single line connection diagram or multi-line connection diagram with an actual distribution panel. In so doing, they will learn “what are power receiving and distri-

(a) Distribution panel

(b) 6kV voltage step-up facility

Fig. 3 Hands-on Experiences Training Facilities at the Training Center

Practical training facilities are shown.

Table 1 **Year-by-Year Educational Program and the Main Education Contents at the Training Center**

The table below shows the year-by-year educational program at each year level and the contents of the core education at the Training Center.

	Classroom learning	Practical training	Internal qualification	External qualification	Safety education
First year program	Electrical basics Theory and calculation	Basics of substation facilities Use of instruments Basics of sequence/Dielectric strength test Making terminal board layout diagram	Optical cable termination	First-class electric works specialist Second-class electric works operation and management engineer (written test)	Safe installation cycle LV electrical handling education HV/special-HV electrical products handling education
Second year program	Calculation for cable selection Calculation for cable-rack selection Calculation for cable-duct selection Seismic calculation Making cable installation list	Cable installation and termination Cable connections Checking cable connections		Second-class electric works operation and management engineer (written test/field test) (Second-class electrical work engineer) Slinging training course Anoxic・hydrogen sulfide・dangerous work manager	Work injury prevention training
Third year program	How to read drawings Sequence diagram reading and training Making termination diagrams Making power outage period work procedure sheet ※Procedure sheets are produced after understanding drawings and operation. Power outage period work is then carried out and cables are removed.	Sequence test Equipment operation Cable check and site survey Partial removal of cables in the state of partial power outage Removal of cables under total power outage	Low voltage termination work certification	Third-class electric chief engineer Second-class electric work operation and management engineer (written test/field test) Organic solvent works manager Asbestos works manager	Risk assessment education (Education for foreman)
Fourth year program	Calculation of charging current and quantity of reactors Dielectric strength test theory Making dielectric strength test procedure sheet	Recognition of tester construction and circuit configuration and training for connections and actual operation Dielectric strength test/voltage detection/grounding discharge	Dielectric strength testing technical license certification	Third-class electric chief engineer Scaffold check engineer training Special education for dioxins	Foreman education Electrical works supervisor

Fig. 4 **Practical Training Using an Electroscope**

A view of practical training using an electroscope is shown.

bution facilities?" and "why they are necessary?" In the practical training course, trainees will learn external appearances of equipment, construction, operation, and how to operate them by operating real machines. They will learn the movement and operation method of power receiving and transmission facilities through hands-on experience of "seeing and handling" such matters difficult to understand through only textbooks. They learn what should be noted at the project site as well as the basic principle of each instrument and how to use it so that they can manage equipment and machines correctly. This training is provided focusing mostly on electroscopes and circuit testers needed for protection from electrical accidents and to secure their safety. Fig. 4 shows a view of practical training using an electroscope and Table 2 shows an example of measurement training.

5.2 Training for Cabling Work (Second Year Program)

Through lecture, the trainees learn how to choose and calculate cable sizes, a method how to make a cable installation list, and how to figure cable interconnection with reading and interpreting

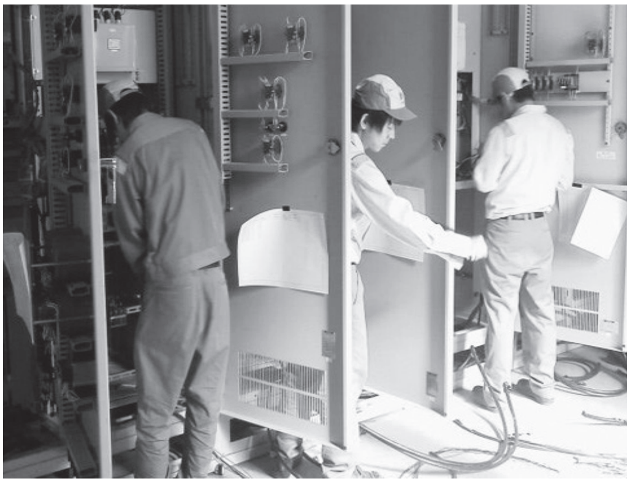
Table 2 Example of Measurement Training (Handling of Electroscope)

An example of measurement with a low-voltage electroscope is shown. Voltage check is possible even with low-voltage rubber gloves. If gripped incorrectly, however, DC voltage cannot be properly detected.

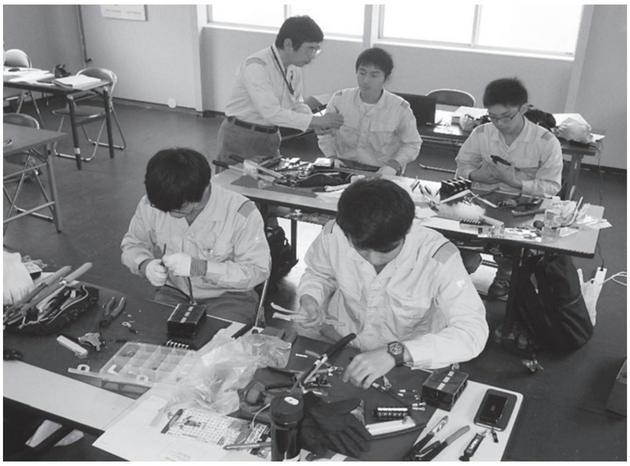
Date & time	15th July 2014	Temper ature℃	29	Humidity %	55	Weather	Fine	Examiner	○○○○

Source class	Line class (phase)	Bare hand		Work gloves		Rubber gloves		Place: Training Center
		Wrong grip	Correct grip	Wrong grip	Correct grip	Wrong grip	Correct grip	Electroscope spec.
AC100V ungrounded	U	×	○	×	×	×	×	DC50～600V AC50～600V
	V	×	○	×	○	○	×	
DC100V ungrounded	P	×	×	×	×	×	×	
	N	×	×	×	×	×	×	
AC100V grounded	U	○	○	○	○	○	○	
	V	×	×	×	×	×	×	
DC100V grounded	P	×	○	×	○	×	○	
	N	×	×	×	×	×	×	

With voltage: ○ Without voltage: ×
Blocks in [blue] indicate that the electroscope does not work though there is voltage.
Dangerous (possibility of human error).
Blocks in [grey] indicate that Operation is unstable, suggesting lack of reliability.



(a) Training for cable connections



(b) Training for low-voltage cable termination

Fig. 5 Training for Cabling Work

A view of training for cabling work is shown.

drawings of equipment. In the practical training, they try to do cabling work, terminations, connections, and continuity checks according to their designed documents. In so doing, they learn the method of cable procedure, cabling method, and quality control method. Fig. 5 shows a view of training for cabling work.

5.3 Training for Operational Sequence (Third Year Program)

In classroom learning, the trainees learn how to read and interpret manufacturing drawings for a factory such as elementary wiring diagrams. This training will enable trainees to understand block diagrams and sequence diagrams. In practical training, they experience a sequence test. In so doing, they learn the operational principle of equipment and the contents of testing work by operating the equipment. In the course of this training, they will recognize “where is danger zone?” and come to think about “what it takes to secure safety for people working there and plant facilities.” Fig. 6 shows a flow diagram of the sequence training.

5.4 Training for Cable Removal Work (Third Year Program)

In the classroom, trainees produce the power outage period work process sheet based on

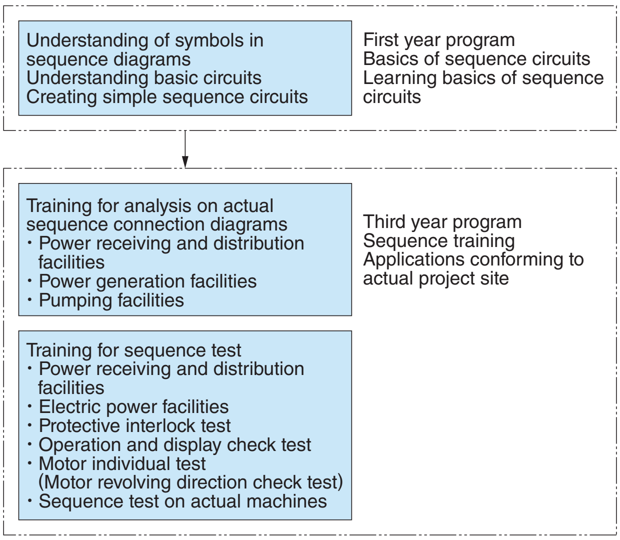


Fig. 6 Flow Diagram of the Sequence Training

A flow diagram of training for sequence circuits is shown.

sequence diagrams by examining the range of influenced area from a power outage. They learn how to remove cables safely and efficiently. In practical training, they learn how to secure safety by conducting a designated operation and performing a required treatment based on the power outage period work process sheet. There have been many failure cases of cabal removal work in the past. For this reason, work for cable disconnection and removal work is carried out according to our internal rules and regulations. Trainees are trained to strictly observe the rules so that they can gain mastery through personal hands-on experiences. Fig. 7 shows a view of training for cable removal work.

5.5 Training for Dielectric Strength Test (Fourth Year Program)

In classroom, the trainees study how to calculate the charging current necessary when making a dielectric strength test. They also learn the method of calculation for determining the quantity of reactors and capacities of testers and power sources, and how to draw up the test procedure plan. In practical training, they learn a work flow by using actual testers and high-voltage panels. They learn a configuration of dielectric strength test circuit, necessary safety treatments (safety organization, short-circuit conductor, voltage detection, and grounding), and testing (using a maximum voltage). Still more, they check and compare the actual internal structure of an actual tester with tester's circuit diagram. In so doing, they learn the likely faulty points and how to check and repair them. Fig. 8 shows a view of training for dielectric strength test.

5.6 Safety Education (First to Fourth Year Program)

Safety education is provided in tandem with practical training. In addition to classroom learning prior to practical training, the trainees learn various activities based on safe working cycles such as the drafting of worker lists as conducted at each project site, education for new comers to the project site, drafting work instructions, morning briefings, risk prediction program, inspection check lists, afternoon briefing, safety patrol, and leave checks. Fig. 9 shows a view of the risk prediction program.

5.7 Education of Internal License Qualifying Lectures (First to Fourth Year Program)

To secure safety and quality, we designated "Termination Work for High Voltage Cables," "Connection Work for Optical Fiber Cables," and "Dielectric Strength Test Work" as special processes

Fig. 7 Training for Cable Removal Work

A view of training for cable removal work is shown.

Fig. 8 Training for Dielectric Strength Test

A view of training for dielectric strength testing is shown.

Fig. 9 View of Risk Prediction Program

A view of risk prediction program is shown.

Table 3 Contents of Internal License Qualifying Lectures

The contents of internal license qualifying lectures are shown.

Name of qualification	Contents of practical training
Low-voltage termination work qualifying lectures	Basic policy of the Group, Management of tools, Torque control for screw tightening, Introduction of defect examples, Activities for the prevention of reoccurrence of defects Classroom learning: written test Practical training: 2 types of terminations (Control and power circuits)
High-voltage termination work qualifying lectures	High-voltage termination theory, Explanation for working contents, Introduction of examples of defects, Explanation for ISO Special Processes Classroom learning: written test Practical training: 1 type of termination (6kV CV-3C-38sq.)
Dielectric strength test license qualifying lectures	Explanation for electrical facility engineering basics, Testing procedures, testing material check, Acceptance test, Test circuit configuration, Charging current, Various calculation for reactors and so on, Introduction of defect examples, Explanation for ISO Special Processes Classroom learning: written test Practical training: test circuit configuration
Optical fiber cable connection work lectures	Optical fiber cable outlines, Explanation for connection method, Connection training, Loss measurement, IO-Link III outlines, Assembling connectors

work. Inclusive of “Termination Work for Low Voltage Cables,” we use the Internal License System. To qualify, a person who meets the specified qualification requirements can attend a series of internal license qualifying lecture series and only those who persons that have passed each qualification test are allowed to perform the designated work. To perform quality control as a manager, a very important position, except for “Termination Work for High Voltage Cables” requiring acquisition of qualification from an external public organization in Japan, we designed a system for the acquisition of such qualifications in tandem with the track records of previously received practical training courses. Table 3 shows the contents of internal license qualifying lectures.

6 Postscript

The project sites we managed are the most vital facilities in public, infrastructure, and industrial fields. In order to offer safe and reliable construction work to customers, we have to sustain good engineering levels, draw up work execution procedure plans, and build a solid organization to implement such tasks. This is our duty and mission.

With trends of the times and changes in social environment, the required engineering and technical level are subject to change. The required quality of the field engineers is, however, unchanged. As cited in our basic policy of the medium term management plan, we aim to be an engineering company group trusted by our customers as a supplier of reliable products and services contributing to society at home and abroad. Going forward, we strive to improve our education programs which is effective in realizing “human resource development” and “transferring engineering knowledge and skills.”