

Study Committee B3 Substations and Electrical Installations Paper B3_10734_2022

Knowledge Transfer of Substation Engineering and Experiences in Japan

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Motivation

- In order to sustain and develop power infrastructure business with the changing environment, issues such as effective method of transferring knowledge and experience to the next generation.

Method/Approach

- Identifying and classifying technologies that need to be transferred and examine which methods are optimal to transfer knowledge.
- Skill record system in order to grasp and improve skill level of substations engineering.
- Training curriculum with MR (Mixed Reality) technology to realize efficient and effective training.
- Close data linkage of design information by converting drawings to 3DCAD.
- Digitalization of facility-related information

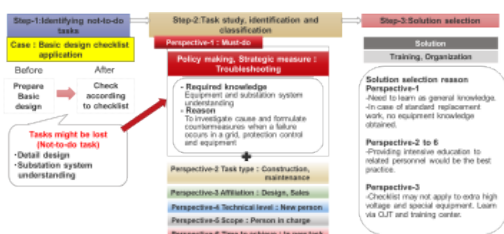


Figure 2 Example of initiative in terms of efficiency, and knowledge preservation and upgrade

- Through this practice, by clarifying the review process of identification and classification on lost knowledge caused by job streamline, variations of review process caused by human can be prevented, and knowledge transfer can be realized effectively and efficiently.

Approach Examples

EXTRACTION AND EVALUATION OF NECESSARY KNOWLEDGE AND EXPERIENCE BY JAPANESE POWER COMPANIES

CASE1- Efficiency, and Knowledge Preservation and Upgrade

- At the stage of deploying measures related to business process improvement and efficiency throughout the company, following steps are being implemented to achieve efficiency, and knowledge preservation and upgrading.
- Step-1: Identifying not-to-do jobs
Identify jobs that were carried out by "People" in the past, and no longer be carried out due to improvements and streamlining.
- Step-2: Job study, identification and classification of required knowledge to transfer.
- Step-3: Solution selection
Using technical classification result in this step, examine the optimal knowledge transfer method (Training, OJT (On the Job Training), License, etc.).

CASE2- Skill Record System Utilization

- In order to grasp and improve skill level of substations engineering, and to systematically and continuously secure the number of personnel with skills required by the organization.
- Skills for substation design and maintenance are classified into 6 categories for each job type, where detailed skills are defined for each job type. Skill levels are defined to 5 levels.

Table 1 Job type skill and Skill levels classification

Job type skills (Design job) (6 categories)	Skill levels classification (5 levels)
Understanding of internal and external engineering standard.	Basic: Ability to perform basic job under supervision.
Basic and detail design.	Application: Ability to perform basic job by himself and irregular job with points guidance.
Construction preparation permit application.	Specialty: Ability to perform and coach irregular job.
Progress management, quality control.	Complex: Possess high expertise, able to perform and coach complicated job.
Completion inspection and substation handing over.	Ultimate: Possess high expertise, able to perform and coach, and provide optimal and improved solution.
Treatment and actions to accidents and failure.	-



Figure 1 Job classifications

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- For each person, skill evaluation is performed from the perspective of the individual and its supervisor.
- Provide opportunities for self-awareness, encourage self-development, and reflect it in the training plan for improvement in order to acquire the required skill level.
- Each business sets the ideal organization structure, such as the number of personnel at the required skill level to execute business operations, and then formulates and implement annual training plans, in order to secure the required technical personnel.

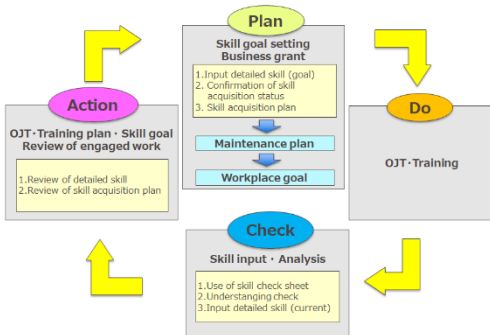
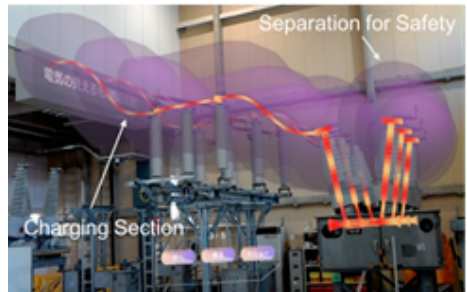
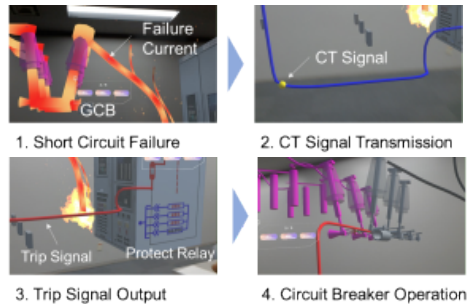


Figure 3 PDCA cycle of Skill Record System utilization



Safety separation distance of an exposed energized electric circuit. It is easier to understanding and could greatly improve safety education effectiveness.

Figure 5 Projection of the separation for safety

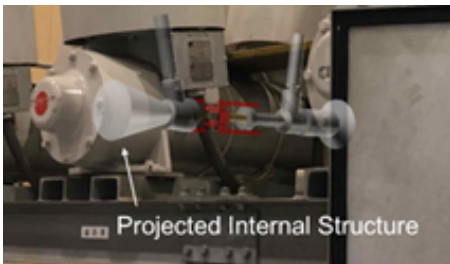


Visualize control input/output instantaneous signal which is not possibly seen in actual, it is expected to greatly help understanding of relays operation sequences.

Figure 6 Short circuit failure removal flow

CASE3- Succession of technologies using MR technology

- Regarding to the problem of talent shortage in knowledge transfer and coaching, training curriculum with MR (Mixed Reality) technology is being reviewed to realize efficient and effective training.
- MR technology can make virtual 3D model appear in the real space by mounting HMD (Head Mount Display) to the head.



Visualize the internal structure of a sealed equipment by superimposing. Engineers are able to observe the internal structure and helps to understand easier.

Figure 4 Internal structure projection of GCB

ENGINEERING VISUALIZATION APPROACH BY SUBSTATION EQUIPMENT MANUFACTURER

CASE1- Close data linkage of design information by converting drawings to 3DCAD

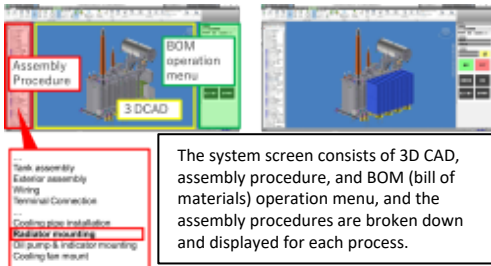
- With the shift to utilizing 3DCAD drawings, we are promoting a shift from manufacturing in which each worker read and understand the drawings to manufacturing in which workers can understand the work description by looking at the "Digitalized assembly instructions"

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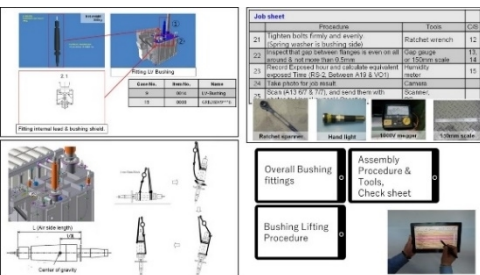
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- The 3DCAD system allows workers to visually check the structure of the product. [Figure 7]
- By digitizing the check sheet, the operator can easily confirm and record the tools required for the work, the work criteria, and all the results after assembly. [Figure 8]
- Human error during assembly work can be prevented with the automated work recording and monitoring system. [Figure 9]
- By utilizing 3D animation display, virtual training is possible when actual product is not available. Also, it could be utilized as a tool to assist OJT. [Figure 10]



The system screen consists of 3D CAD, assembly procedure, and BOM (bill of materials) operation menu, and the assembly procedures are broken down and displayed for each process.

Figure 7 Digital work procedure for transformer



Detail assembly procedure, tools and check sheet are shown in the tablet.

Figure 8 Digital work procedure for transformer



The work instructions are for one work and one process using 3D animation. Work records are recorded in real time as digital data. In addition, an automated judgement function is available.

Figure 9 Assembly navigation system for GIS



Figure 10 OJT coaching utilizing assembly navigation system

CASE2- Digitalization of facility-related information (inspection, repair, accident reports, etc.)

- Document retrieval system that applies AI technology (data mining technology) [Figure 11]
- By making it possible to reuse knowledge, empirical knowledge, etc. buried in various documents, which were conventionally accumulated on paper, as structured digitized information, similar events in the past can be easily retrieved in a short time using data mining technology.
- As a result, when a new event is discovered through scheduled inspection, repair, or accident response, it is possible to reach similar events in the past without relying on experienced person, and to use insight to deal with the event.

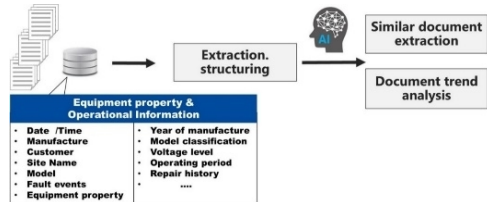


Figure 11 Concept of documents retrieval system

- Search for information related to a subject form the database

Conclusion

- To transfer knowledge to the next generations, it is crucial to consider improvement and optimization after carefully clarifying what job to entrust to individual and reviewing conventional OJT concept while considering "People" "Process" "Technology" balance.
- Correct knowledge transfer is important to contribute to future generations' substation business growth and technology level advancement after careful consideration of how the business has been developed, what problems are being confronted now, and how it will develop and operate in the future.