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Experimental Investigation of the Essential Information in the Part of Remarks of Operation Manual to Support Novice Plant Operators

Takashi Matsubara*, Akio Gofuku**
Taro Sugihara***

** Graduate School of Natural Science and Technology, Okayama University, 3-1-1, Tsushima-Naka, Kita-ku, Okayama, 700-8530, Japan (Tel: +81-086-251-8022; e-mail: pm255ahm@s.okayama-u.ac.jp)*
*** Graduate School of Natural Science and Technology, Okayama University, (e-mail: gofuku-a@ okayama-u.ac.jp)*
**** Graduate School of Natural Science and Technology, Okayama University, (e-mail: t-sugihara@okayama-u.ac.jp)*

Abstract: Operation manuals are used to support plant operators in order to reduce human errors and to ensure the quality of operation independent on the skill of operators. However, there are some troubles happened by the causes of problems in operation manuals. The authors analyzed the reported trouble cases happened in petroleum and nuclear industries due to the problems in operation manuals. The analyses revealed that most of the trouble cases were caused by insufficient information in the part of remarks in operation manuals. This means that novice operators need some more information in addition to that of operation purpose and goal, operation step names, the order of operation steps, and concrete operation actions. This study investigates experimentally the influence of insufficient information in the part of remarks on the performance of novice plant operators using an artificial and semi-scaled boiler type power generating plant. Several categories of information described in the part of remarks are identified. Then, two types of operation manuals are prepared. The one describes all information in the part of remarks. Another type has some missing information that may support operators. The experimental results show that the usage of the operation manuals describing all information has much effect to decrease operation risk and the rate of omitting an operation action. However, the operation time to complete a task becomes longer. The results also suggest that sufficient description of the information has little effect on the understanding of operations.

Keywords: Operation manual, Information, Novice plant operator, Power generating plant, Experimental study

1. INTRODUCTION

In the operation and maintenance of large scaled engineering plants such as nuclear power plants, oil refinery plants, and so on, various types of manuals are used. The purposes of using manuals are to complete operation and maintenance tasks independent of the skill level of staffs and to decrease human errors that may happen in the tasks. The manuals are specified and revised by some steps from creation to usage stages[Matsubara2012a]. For example, operators use operation manuals to perform safe and stable operation of plants. However, trouble cases including accidents sometimes happen caused by the problems of operation manuals.

There are extensive works for the computerization of operation procedures in normal and emergency plant situations[Niwa1994, Niwa2002, Zhou2014], automatic creation of operation procedures[Lee2004, Abe2011] and the guidelines of evaluation of them[Sakuda2015]. These studies mainly focus on the process of creation or usage of operation procedure but do not consider the relations between creators of operation manuals and operators.

The authors analysed the trouble cases reported in Web-base databases of NUCIA[JNSI2016] for Japanese nuclear power plants and PEC-Safer[JPEC2016] for Japanese petroleum plants in order to investigate the problematic factors of manuals that cause trouble cases[Matsubara2012a, Matsubara2012b]. These studies identified some patterns of the problems in operation and maintenance manuals for frequent trouble cases. The authors also examined the direction of the measures for the identified problem patterns[Matsubara2012b]. One of main results of these studies is that trouble cases happened by the problematic factor of manuals such that “necessary information is missing for an operation/maintenance task”.

Especially, there are many trouble cases in doing operation and maintenance tasks of plants that only some of necessary information is served in the part of remarks in manuals. The supplementary information including the instruction of confirmation of an operation/maintenance is usually described in the part. The information is considered to be useful for, especially, novice operators and maintenance workers. Therefore, the creators of manuals should pay

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careful consideration in selecting and describing the information to be included in the part.

This study aims at clarifying the relations between the type and amount of information served in the part of remarks in operation manuals and the operation performance of operators in beginner's skill level. For this purpose, this study conducts an experiment to observe the operation performance by changing the amount of information described in the part of remarks in operation manuals. This study treats two operation tasks for a semi-scale model boiler-type power-generating plant. Two types of operation manuals are used in the experiment. The first one describes all information necessary to operate the plant. The other type of operation manuals has some missing information in the part of remarks.

In this paper, types of information included in operation manuals are analysed in Section 2. Then, Section 3 describes the working hypothesis of the experiment, experimental set up, and operation manuals prepared. The experimental results are described and discussed in Section 4. Finally, the finding of this study and future works are described in Conclusions.

2. TYPES OF INFORMATION INCLUDED IN OPERATION MANUALS

2.1 Types of information in operation manuals

Based on our experiences of describing some operation manuals for real plants and our analyses of the description of operation manuals obtained from the Web sites[CNIC2016, JNSI2016, JPEC2016] and literatures[Kaibo1998, JISHA2011], an operation manual is composed of similar groups of information such as title of operation manual, operation steps, remarks, etc. although some differences exist in the layout and representation of information depending on companies and plant types. By considering the analyses results, the format of the operation manuals used in this study is determined as shown in Fig. 1.

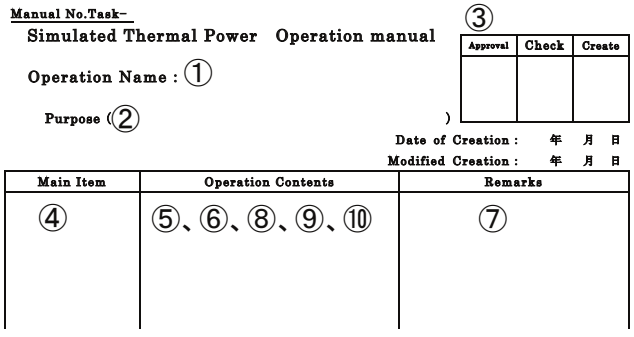

Fig.1 Example of format of operation manual.

In the figure, the parts (1) to (10) include the following information:

(1) Title of the operation manual,
(2) Operational purpose,
(3) Authors and corresponding persons,
(4) Name of operation,
(5) Contents of a series of operation steps,
(6) Operation steps such as the contents of concrete operation steps, their order, and the effects of operation steps,
(7) Remarks (Supplementary information necessary for operation steps directly and indirectly such as expected plant conditions after the operation, target values of operation, notes for each operation step, supplementary data and information, checklist useful for the operation, etc.,
(8) Emergency response procedure for the case of happening a trouble in taking the operation,
(9) Highlighting symbols/characters of important points, and
(10) Explanation of operation(s) that can be taken in parallel.

In the parts mentioned above, the emergency response procedure (Part (8)) can be considered as a returning operation procedure at the time of making an operation error.

2.2 Types of information included in the part of remarks

The authors analysed that the information described in the part of remarks can be divided into several categories such as detailed explanation of operation steps, advices of the timing of a valve operation, quantitative values of control goals, and so on.[Matsubara2012b] In the creation of operation manuals, authors of operation manuals decide if specific information of these types should be included in the part of remarks considering the skill level of operators and usability of operation manuals in the field. From this viewpoint, it is helpful to have a guideline for the necessary information and the place to describe it by relating with the skill level and capability of operators for creating a high-quality operation manual to navigate safe and concrete operations.

The relation between the types of information described in the part of remarks of operation manuals and the intention of their authors are considered. As the results, the types of information described in the part of remarks are categorized into six categories as shown in Table 1 by referring the experiences of creating operation manuals by one of authors, the operation manuals obtained from Web sites[CNIC2016, JNSI2016, JPEC2016], and literatures[Kaibo1998, JISHA2011]. The six categories are grouped into two groups from the viewpoint if the information is related with the operation directly or indirectly.

Table 1 Categories of information described in the part of remarks of operation manuals

No.	Group	Category
1a	Direct relevance with operation	Conditions that should be satisfied before taking an operation
1b		Responsive operations when different plant behaviour from the expected one is observed
1c		Operation when an emergency situation happens
2a	Indirect relevance with operation	Additional explanation of an operation step
2b		Instructions to confirm an operation before and/or after taking the operation and expected plant conditions after taking an operation
2c		Advices and/or notices in taking an operation (Ex.: "Change slowly of valve opening.")