A Human Factors Evaluation of a Container Cargo Inspection System

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1. Introduction

Recently, Korea Customs Service has installed container cargo inspection systems at several Korean ports in order to inspect an increasing number of containers imported from abroad. A container cargo inspection system, which is one of the advanced scientific developments, can inspect the contents of containers by X-ray without opening them. A total of eight container cargo inspection systems have been installed in Korea since 2002. In general, a container cargo inspection system has major components such as high energy X-ray generators, detectors, a transfer system, an image system, and an equipment operation system. Figure 1 shows the general arrangement of a container inspection system in a building.

Fig. 1. A drawing of a container cargo inspection system.

While a container truck is towed by a transfer system through a tunnel in the building, a set of horizontal and vertical X-ray generators and detectors produces an X-ray image of the container for an inspection.

In this paper, we describe our human factors evaluation of the user interface of the equipment operation system and many local control panels of a bi-directional fixed-type container inspection system. It is also discussed that human factors design and evaluation activities will be necessary for the enhancement of safety and usability of various equipment using or measuring radiation.

2. Evaluation methods

To evaluate the equipment operation system of the container cargo inspection system, human factors evaluation scope and methods were determined by considering three items ; evaluation object, evaluation method, and evaluation measure. In case of a physical object for the evaluation, a display structure of the software to operate the bi-directional fixed-type container inspection equipment and a control panel for the hardware were selected. As the evaluation measure, the usability of the operation software, design principals, and the suitability of the display constitution items were considered [1]. In addition, as the methodology to practically evaluate them, a document based evaluation and an expert evaluation by a working survey in the field were conducted.

The document evaluation is to evaluate the operation manual and documents describing the structure of the display by human factors standards. And also, the working survey is to identify the conditions in the fields by the results of the document based evaluation.

For an evaluation of human factors on the equipment operation software, setting up the criteria is required. In this study, NUREG-0700(Human System Interface Design Review Guideline, Rev.2) of USNRC was fundamentally applied for the suitability evaluation, and some guidelines were used for the evaluation of the usability and design principals. A checklist which was produced by human factors criteria was used, and review comments were recorded in a unique format.

3. Technical standards and guidelines

For the evaluation of the usability and design principals of the bi-directional fixed-type container inspection equipment, each measure was produced from the guidelines [2,3]. In case of the suitability, items that should be inspected were selected and modified on the basis of chapter 1, 2, 4 and 7 of NUREG-0700(Rev.2), USNRC [4], and then a display design checklist was made.

4. Results

4.1. Results of the display design

In the evaluation of the suitability on a display design, a total of 175 review items were checked. In that result, almost all of them were satisfied, but 21 items were partially satisfied and 19 items were not satisfied. This result is shown in Table 1.

Table 1. A result of suitability evaluation

Review items		Result			
Category	detail items	satisfied items	partially satisfied items	not satisfied items	not available
Information display	69	32	10	8	19
User-interface interaction and management	54	27	2	2	23
Alarm system	36	9	5	6	16
Soft control system	16	4	4	3	5
total	175	72	21	19	63

From the above result, a total of 40 review comments including usability and design principals were obtained.

In the result of the usability analysis, review comments as follows were produced.

In the middle of the process, when the self diagnosis button is pressed, the whole process is stopped and changed to a self diagnosis display. When the emergency stop button is pressed by an error of an operator, the inspection is stopped, but there are no signs for feedback to the field.

The form of the software window is the same as the one for the Windows Operating System of Microsoft as shown in Figure 2, so there is a possibility for it to be pressed by an operator's carelessness, but there are no fail-safe alternatives to avoid a pressing of it.

Fig. 2. General type of close button.

In the case that equipment operation software and other software are operated simultaneously in one computer, there are no alternatives to prevent the effects by the system environment or other software such as the failure of the Operating System and the automatic rebooting after the upgrade of the software.

There is a compatibility problem that the direction of the flow does not correspond with the direction of the image as shown in Figure 3.

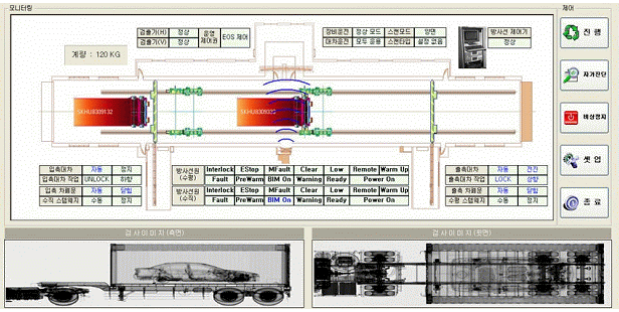

Fig. 3. A drawing of the manipulation display.

4.2. Results of the local control panel

In addition to the software design, an evaluation of the local control panel located in the field was conducted. In the result, a total of 25 review comments were obtained from the suitability evaluation.

Because the control room and the field are spatially separated, feedbacks about the result of manipulations and wrong operational conditions, which should be notified to each other, are necessary for its safety.

In the case of a selection switch, the marks to present each position are not indicated on the plates as shown in Figure 4, for that reason it is not easy to recognize the precision positions.

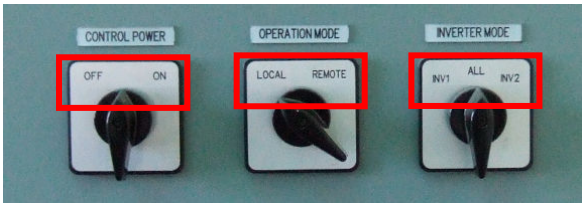

Fig. 4 Selection switches without position marks

In case that a work failure and an emergency situation such as the radiation leakage has occurred, there are no preparations to cope with these situations such as treatment methods, guide plates, and procedures.

5. Conclusion and discussion

As the result of a human factors evaluation on the display of the equipment operation system and the local panels of a bi-directional fixed-type container inspection system, a number of human factors deficiencies are found and corrective designs are proposed for an improvement of the safety and operability of the system. Because of these evaluation results, human factors evaluation has been performed continuously for container inspection systems by using this bi-directional fixed-type container inspection system.

There are many radiation measurement devices, X-ray inspection systems, and radiation-using medical equipment available. Such radiation-related equipment must have user interfaces through which operators can get information, make decisions, and control the system. As shown in this study, in order to maintain a higher safety level and usability, human factor engineering should be applied to the design and evaluation of radiation-related systems. For this purpose, well-established human factors application practices accumulated from the design and review of the main control rooms in nuclear power plants can be directly applicable.

REFERENCES

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