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Verbal Communication in the APR1400 Advanced Control Room

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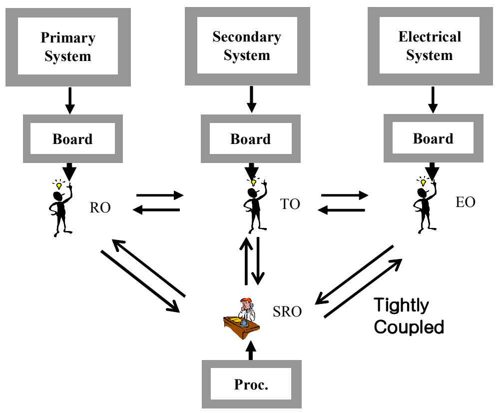
1. Introduction

This paper introduces the characteristics of communication in advanced main control rooms (MCRs) and some observations from a case study performed for APR1400 MCR. In advanced MCRs, operators need not maintain the same communication patterns as they do in conventional ones. For example, a senior reactor operator (SRO) does not have to rely on board operators for information acquisition and can get any information from his/her own workstation. This situation may also bring about new problems in MCRs such as lack of shared situation awareness and collaboration between MCR operators. To cope with these problems, the APR1400 MCR adapts several approaches in design and training for encouraging operators to communicate with each other. This paper introduces the possible changes of communication patterns and the countermeasures in design and training. Some findings from an integrated system validation for Shin Kori Units 3&4 are also presented.

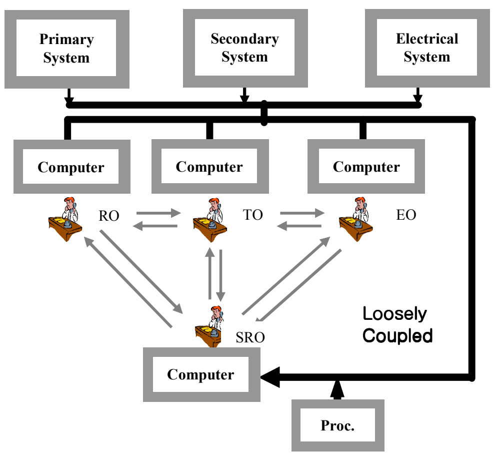
2. Characteristics of Communication Pattern in Advanced MCRs

Figure 1 shows the comparison of communication patterns in conventional and advanced MCRs. In conventional MCRs, to perform an operating procedure, SRO should completely depend on the information acquired from board operators through verbal communications. Similarly, each operator, i.e., reactor operator (RO), turbine operator (TO), and electrical system operator (EO), also uses verbal communications to get the information about systems which other operators are responsible for, if he/she does not move to the control boards. Therefore, it can be said that the dependency of information on other operators is very high in the conventional MCRs. On the contrary, in advanced MCRs, operators have their own workstations. Through display devices, they can access any information about other operator's system as well as his/her systems. Therefore, SRO needs not acquire the information from board operators verbally and can even perform the operating procedure by himself without any help from them. Board operators need not to play a role of information provider any longer and the higher level of information could be exchanged between operators.

In the advanced MCR, the necessity of communication between operators is reduced compared with in conventional ones. The lack of communication may cause new problems from the perspective of human factors. The main problem results from the lack of shared situation awareness. For a crew to maintain complete situation awareness, operators should share the perception of the elements in the environment within a volume of time and space (Level 1 SA), the comprehension of their meaning (Level 2 SA) and the projection of their status in the near future (Level 3 SA) [1]. As a pessimistic case, board operators may not recognize which procedure is now being performed by SRO if there is no notification from the SRO about procedure execution. Then, if the situation in which the board operator's intervention is required happens, the board operator may not be able to mitigate abnormal situations appropriately. Therefore, a certain level of verbal communication should also be maintained in the advanced MCRs.



(a) Conventional MCR



(b) Advanced MCR

Figure 1. Comparison of communication patterns

3. Countermeasures for the lack of communications

In APR1400 MCR, the approaches to encouraging the communication between operators are considered in terms of human-system interface (HSI) design and training. The first concept of design is a large display panel (LDP). The LDP continuously displays spatially dedicated information that provides the status of the plant's critical safety functions, plant operation mode, key operating parameters, major alarms, trend displays, etc. The operating staffs in MCR are always able to maintain the system in safe operating condition and share the plant status by utilizing the continuously and quickly comprehensible information.

The other design concept is the key step of computerized procedure system (CPS). Because CPS shows to SROs all plant data required to resolve procedural step logic, the inherent communication needed on paper-based procedure do not longer exist on CPS use. APR1400 CPS has introduced the concept of key step which was originally established in COMPRO system [2]. In the key steps, the SRO must communicate with the board operators and contrast the information provided by system with the information provided by the board operators from the 1E instrumentation.

The last concept is the synchronization meeting stressed by the training. A good level of communication between crew members allows them to maintain a good situation awareness, and to handle the transients in an effective way. This is supported by the synchronisation meetings between the members of the operating crews, which are very useful, as well as the introduction of critical steps concept, that guarantees a minimum level of communication.

4. A Case Study: Human Factors Engineering Validation

As a case study, the communication patterns in the human factors engineering validation were investigated. Three crews from OPR1000 plants participated in the validation. Each crew took 1 week of training program and carried out four scenarios of emergency situations in the APR1400 mockup during 1 week after the training course. In the training, the communication pattern in advanced MCR, that is, high level of information exchange, was explained briefly. This paper provides some qualitative observations related to the communications.

2.1 Relation to SRO's Confidence on Operation

It seemed that the communication patterns are related to the SRO's confidence or experience on operation. In the validation, one crew of which SRO has less experience than other two crews maintained the same communication pattern as they do in their conventional control room.

2.2 Relation between Communication and Workload

The less communication in the execution of emergency operating procedure may cause SRO's higher workload. There was one crew of which SRO executed the emergency operating procedure mainly by himself and acquired a little of important information from board operators. The SRO mentioned that the workload in the advanced MCR is higher than in the conventional one because he should proceed the procedure and gather the information at the same time. However, the other board operators of the crew said that their workload was reduced. The other two crews which showed different communication patterns provided the opposite opinions about workload.

2.3 Proceduralization of Verbal Protocol

Even if the HSI design for APR1400 is well-established, relatively little attention has been paid to the verbal protocol. In the conventional MCR, board operators should respond to the SRO's request loudly and inform SRO of every operational activities (in Korean, "복명복창"). Although the low level of information exchange is not necessary in the advanced MCR, the well-defined communication patterns should be also developed for operator training and real operation.

5. Conclusions

This paper presented the characteristics of advanced MCR related to verbal communication and some interesting findings from a human factors engineering validation. The findings are based on qualitative observations. To support the qualitative observations, it is necessary to perform the statistical analysis about human performance like NASA-TLX for workload. In addition, the study on proceduralization of communication patterns, i.e., defining verbal protocol, should be also performed.

REFERENCES

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[2] Tecnatom, s. a., Consultancy on licensing issues for SKN 3,4 computerized based procedures, 7182-INF-01, 2004