Preliminary Analysis of Task Types and Error Types Involved in Human-related Unplanned Reactor Trip Events

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1. Introduction

As the number of the unplanned reactor trip due to human erroneous actions increases, interest in reducing such unplanned reactor trip events has been recently drawn. During the year of 2002 ~ 2006, unplanned reactor trip events due to human error take 23 % of all unplanned reactor trips, and more recently during 2005 ~ 2006 it increased to amount to 40 %.

As an initial effort for analysing vulnerabilities related to the tasks and environments during plant normal operations, the human-related unplanned reactor trip events that happened during 1986 ~ 2006 have been analysed preliminarily in view of task types and error types.

2. Data

The data used for analysis was from the KINS OPIS (Operational Performance Information System) [1]. The total number of the human related unplanned reactor trip events that happened during 1986 ~ 2006 amounts to 119, of which the events caused by the primary system take 30 % and the events caused by the secondary system does 70 %. Table 1 categorizes the human-related unplanned reactor trip events by causes of reactor trip, i.e., human, mechanical, I&C, electrical. Even though the event is classified as a non-human cause, human factors can be involved as a contributory factor.

Table 1. Overview of human-related unplanned reactor trips by cause categories

Cause of reactor trip	# of events related to the primary system	# of events related to the secondary system	# of events by cause category
Human	29	62	91
Mechanical	2	10	12
I&C	4	6	10
Electrical	1	5	6
Sum	36 (30 %)	83 (70 %)	119 (100 %)

3. Results

2.1 Analysis of Task Type

Task types are classified according to (1) the type of work activities: test, maintenance, calibration, and operation, (2) the type of work preparedness, i.e. a pre-planned task or a requested task. Accordingly, task type is classified as follows:

- planned test
- planned maintenance
- planned calibration
- planned operation
- corrective maintenance
- corrective calibration
- response to a trouble
- design/implementation/manufacturing/installation

For the 119 events, task types involved in each event were analyzed and summarized in Table 2. According to the classification of tasks for all the events, the contribution to the number of the unplanned reactor trip is in the following order: planned test (21 %), planned operation (19 %), corrective maintenance (16 %), response to a trouble (15 %), and so on. According to the classification of tasks for the events related to the primary system, the order of contribution is as follows: planned test (30 %), corrective maintenance (14 %), planned maintenance (14 %), planned calibration (14 %), and so on. And, according to the classification of tasks for the events related to the secondary system, the order of contribution is a little different as follows: planned operation (23 %), response to a trouble (18 %), planned test (17 %), corrective maintenance (17 %), and so on.

Table 2. Analysis of task types involved in the human-related unplanned reactor trip events

Task type	# of events related to the primary system	# of events related to the secondary system	Total # of events by task type
planned test	11 (30 %)	14 (17 %)	25 (21 %)
planned operation	4 (11 %)	19 (23 %)	23 (19 %)
corrective maintenance	5 (14 %)	14 (17 %)	19 (16 %)
response to a trouble	3 (8 %)	15 (18 %)	18 (15 %)
planned maintenance	5 (14 %)	10 (12 %)	15 (13 %)
planned calibration	5 (14 %)	3 (4 %)	8 (7 %)
design/implement/ installation	1 (3 %)	5 (6 %)	6 (5 %)
corrective calibration	2 (5 %)	0 (0 %)	2 (2 %)

type not clear (N/C)	1 (3 %)	3 (4 %)	4 (3 %)
Sum	37 (100 %)	83 (100 %)	120 (100 %)

2.2 Analysis of Error Types

Cognitive function failures and error modes involved in the human-related unplanned reactor trip events were analyzed. The basic model of human cognition is used for definition of cognitive function failure and error modes [2]. According to the analysis of cognitive function failures, planning function (42 %), execution function (26 %), and observation function (19 %) take much portion of all the events. And, according to the analysis of error modes, error modes such as control failure (22 %), omission (17 %), wrong object (16 %), and wrong action (16 %) appear frequently when performing normal tasks in nuclear power plants. Table 3 and Table 4 show detailed results of the analysis.

Table 3. Analysis of cognitive function failures involved in the human-related unplanned reactor trip events

Cognitive function failure	# of events related to the primary system (%)	# of events related to the secondary system (%)	Total # by cognitive function failure (%)
observation failure	8 (21 %)	16 (18 %)	24 (19 %)
interpretation failure	5 (13 %)	6 (7 %)	11 (9 %)
planning failure	16 (42 %)	37 (42 %)	53 (42 %)
execution failure	6 (16 %)	27 (31 %)	33 (26 %)
lapse (memory failure)	2 (5 %)	1 (1 %)	3 (2 %)
unclear	1 (3 %)	1 (1 %)	2 (2 %)
Sum	38 (100 %)	88 (100 %)	126 (100 %)

Table 4. Analysis of error modes involved in the human-related unplanned reactor trip events

Error mode	# of events related to the primary system (%)	# of events related to the secondary system (%)	Total # by error mode (%)
control failure	3 (8 %)	25 (40 %)	28 (22 %)
omission	12 (32 %)	10 (16 %)	22 (17 %)
wrong object	8 (22 %)	13 (21 %)	21 (16 %)
wrong action	8 (22 %)	13 (21 %)	21 (16 %)
inadequate	2 (5 %)	7 (11 %)	9 (7 %)
too fast	0 (0 %)	5 (8 %)	5 (4 %)
too little	0 (0 %)	5 (8 %)	5 (4 %)
too late	1 (3 %)	3 (5 %)	4 (3 %)
miscalibration	3 (8 %)	1 (2 %)	4 (3 %)
wrong input	2 (5 %)	1 (2 %)	3 (2 %)
too early	1 (3 %)	2 (3 %)	3 (2 %)
too much	0 (0 %)	1 (2 %)	1 (1 %)
reversal	0 (0 %)	1 (2 %)	1 (1 %)
unclear	0 (0 %)	1 (2 %)	1 (1 %)
Sum	40 (100 %)	88 (100 %)	128 (100 %)

3. Conclusion

As an initial effort for analysing vulnerabilities related to the tasks and environments during plant normal operations, the human-related unplanned reactor trip events that happened during 1986 ~ 2006 have been analysed preliminarily in view of task types and error types. According to task types, it showed somewhat different results between the events related to the primary system and the secondary system. And, according to the analysis of cognitive function failures, planning function (42 %) showed a major contributor to the unplanned reactor trip.

REFERENCES

[1] http://opis.kins.re.kr.
[2] E. Hollnagel, Cognitive Reliability and Error Analysis Method (CREAM), 1998.