Appendix C
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Appendix C- Human Reliability Analysis

Approach

The quantification of human error for actions associated with spent fuel pool monitoring and operation presents some unique considerations that must be accounted for. As with any human reliability analysis a full understanding and description of the equipment, crew and structure, procedures, training, and work process is required. At present there is a wide potential variability in these elements from facility to facility. This makes it virtually impossible for one analysis to represent the entire spectrum of plants. The human reliability analysis performed for this project was developed for a representative sample of plants. Thus, it is believed to be applicable to the population of nuclear plants as a whole. Individual plants, however, may have specific characteristics that could serve to dramatically improve or degrade human performance relative to the population mean.

Two cases were defined for analysis based upon data collected by staff from the USNRC. We refer to these as a best case and a sensitivity case. The best case represents facilities where care has been taken in designing a complete system that includes appropriate instrumentation, procedures, well-qualified and trained staff, and work processes that assure that all potential tasks can be executed. The sensitivity case represents a facility where an incomplete system exists. There are no procedures, no training, and a staff that has not been trained. Work processes are left up to the staff and there is no assurance that all tasks can be executed. It is hoped that by having these two cases the risk significance represented by the planning and preparation required by the best case can be demonstrated.

In any instance of human performance there are three major contributors. First is that the operator(s) is aware of the situation and therefore is capable of responding. Second is that the operator can assess the situation and plan an appropriate response. Third is that the operator is able to implement the planned response. A number of factors referred to as performance shaping factors effect these steps and form the basis of understanding the probability of an operator being successful. This analysis selected human reliability analysis techniques that would allow taking these factors into consideration.

Methods

Three methods were applied in the human reliability analysis. How each technique was applied is briefly described below.

<u>The Technique for Human Error Prediction (THERP)</u>

The Technique for Human Error Prediction (THERP) was used to quantify six individual errors as identified in table C-1. These errors fall into three groupings, diagnosis errors, conducting a walkdown, and response to a fire.

HEP-DIAG-ALARM was drawn from Table 20-1 using items 5 and 6. Item 5 suggests 3E-3 for one hour and 3E-4 for one day. These items were selected to represent the potential for substantial recovery, due to the large time window, in the best case, and essential little or no recovery for the sensitivity case.

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HEP-DIAG-SFPLP1, and HEP-DIAG-SFPLP2 are combinations of a diagnosis value calculated using a SPAR worksheet and a value for a walkdown, modified for low dependency taken from THERP. The walkdown values including HEP-WLKDWN-DEPEN, HEP-WLFDWN-LOI, and HEP-WLKDWN-LSFPC were based upon the failure to carry out an inspection (Table 20-6, item 2), missing a step in a written procedure (Table 20-7, item 1), and misreading a measuring device (Table 20-10, item 1). For the best case we assumed at least three opportunities for recovery and arrived at a truncated HEP of 1E-5. For the sensitivity case we assumed complete dependence among the crews and used the sum of the three error rates giving 5E-3. We left the term in the equation for missing a step in the procedure to represent the potential failure to examine whatever indicators might be available to the operator on a walkdown. For the case of HEP-WLKDWN-DEPEN we assessed a low level of dependency using the THERP formula of (1 +19 x HEP)/20.

Response to a fire was calculated using Table 20-16. Normally this table is used for modifying a nominal error rate taken elsewhere from THERP. In this case, however, we assumed that in the situation where an operator is responding to and fighting a fire, that the operator will be under extremely high stress, performing a dynamic task, and in the best case will be experienced, and in the sensitivity case will not be experienced. Given this combination of factors, THERP suggests an error rate as opposed to a multiplier for a nominal error rate. The value for the best case is taken from item 7a (2.5E-1) and the value for the sensitivity case is taken from item 7b (5E-1).

Exponential Repair Model

An exponential repair model was applied to calculate the probability of failure associated with the repair of systems and components in this analysis. This method is described in the main body of the report. In the case where dependency existed with prior tasks a formula from THERP was used to assess the impact of that dependency. In all cases only the model for low dependency was used. That formula is (1 +19 x HEP)/ 20. The HEPs calculated using the repair model include HEP-COOL-REP-E, HEP-COOL-REP-L, HEP-FW-REP-DEPEN, HEP-FW-REP-DEPSW, HEP-FW-REP-NODEP, HEP-FW-REP-NODLG, and HEP-FW-REP-NODSM can be found in table C-1.

Simplified Plant Analysis Risk Human Error Analysis Method (SPAR HRA)

The SPAR HRA method was employed for all other HEPs. The worksheets for these calculations are included in this appendix. This method is fully documented in Revision of the 1994 ASP HRA Methodology INEEL/EXT-99-00041.

This method requires judgements to made regarding eight performance shaping factors which are used to select multipliers used to modify a base error rate for diagnosis, and action. Where applicable these values can then be modified for dependence. The performance shaping factors are:

1. Available Time
2. Stress
3. Complexity
4. Experience/Training
5. Procedures

6. Ergonomics
7. Fitness for Duty
8. Work Processes

Table C1 below shows the final results of the human reliability analysis. For each human error the method is listed as well as the value for the best case and sensitivity case.

Table C.1 Human Error Probabilities

Human Error Probability	Method	Best Case	Sensitivity Case
HEP-COOL-REP-E	Repair Model	1.8E-1	1.8E-1
HEP-COOL-REP-L	Inadequate time to perform	1	1
HEP-DIAG-ALARM	THERP	3E-4	3E-3
HEP-DIAG-LGLK	SPAR	4.E-4	5.E-1
HEP-DIAG-SFPLP1	SPAR	1E-6	5E-3
HEP-DIAG-SFPLP2	SPAR	2E-5	2.5E-2
HEP-FW-REP-DEPEN	Repair model/low dependency	5E-2	5E-2
HEP-FW-REP-DEPSW	Repair model/low dependency	7E-2	7E-2
HEP-FW-REP-NODEP	Repair model	1E-3	1E-3
HEP-FW-REP-NODLG	Repair model	9E-2	9E-2
HEP-FW-REP-NODSM	Repair model	7.5E-3	7.5E-3
HEP-FW-START	SPAR	1E-5	1.5E-1
HEP-FW-START-LOI	SPAR	1.25E-3	5E-1
HEP-FW-START-SW	SPAR	1E-3	3.8E-1
HEP-INV-OFFSITE	SPAR	5E-2	3.2E-1
HEP-INV-OFFSITE-LK	SPAR	5E-2	5E-1
HEP-INV-OFFST-SW	SPAR	8E-2	5E-1
HEP-LEAK-ISO	SPAR	1.5E-3	5E-1
HEP-MKUP-START	SPAR	2.5E-6	3E-4
HEP-MKUP-START-E	SPAR	2.5E-4	3E-1
HEP-MKUP-START-L	Inadequate time to perform	1	1
HEP-RECG-FW-LOI	SPAR	2E-4	5E-1
HEP-RECG-FWSTART	SPAR	2E-5	1E-1
HEP-RECG-FWST-SW	SPAR	1E-4	2.5E-1
HEP-RES-FIRE	THERP	2.5E-1	5E-1

HEP-SFP-STR-LP1	SPAR	5E-6	6E-3
HEP-SFP-STR-LP2	SPAR	5E-4	1.5E-2
HEP-WLKDWN-DEPEN	THERP	5E-2 (low dependency)	5E-1 (high depend
HEP-WLKDWN-LOI	THERP	1E-5	5E-3
HEP-WLKDWN-LSFPC	THERP	1E-5	5E-3

C.2 SPAR HRA Worksheets

The worksheets used to generate the results in Table C.1 are shown in the following pages.