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Arizona Nuclear Power Project

DOCUMENT NUMBER
13-NC-EC-200

TITLE/DESCRIPTION

Title: Human Reliability Analysis Calculation for Recovery of Essential Chillers following Flow Transmitter Isolation.

Description: The Probabilistic risk analysis uses a Human Cognitive Reliability (HCR) model for an HRA on recovery of a failure of ESS Chillers. The event assumed is similar to the event described in SPEER 88-01-007 except an accident situation is assumed.

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0	Initial Calculation	6-10-88	6-10-88	C.R. Strom 6/10/88	NA DWH 6-10-88	NA DWH 6-10-88

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D W Hennebe	6-9-88	HRA - Chiller Recovery Calc.	1 of 8
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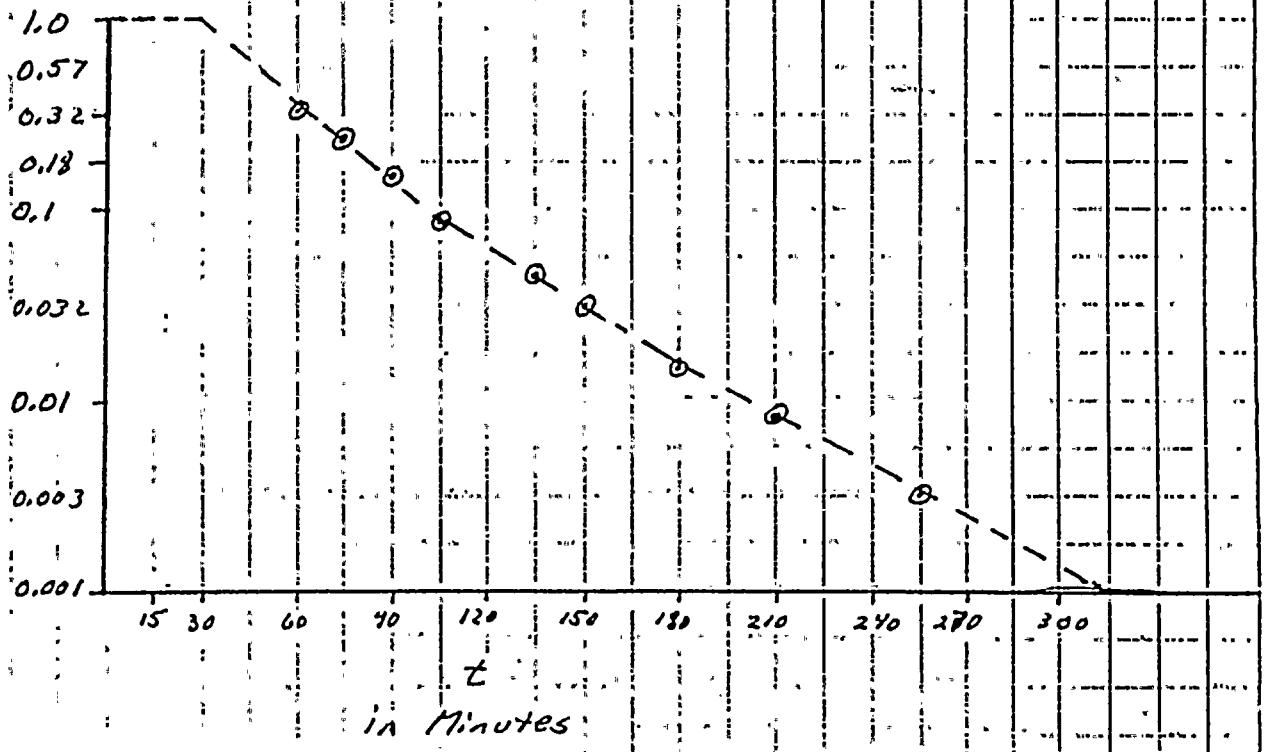
[illegible]	6-10-88		For EER 88-EC-018

1.0 Purpose: To Calculate the Human Reliability probability for recovery of the ESS Chiller following an incident as described in EER 88-EC-018 and SPEER 88-01-007.①

2.0 Summary: Using the HCR model② and assuming a 15 minute delay in operator recognition/response of the SESS alarm and high temperature room alarms, the following graph for operator failure to recover one chiller was calculated:



The results show that, during an emergency situation there is an 86 % Confidence that recovery of the ESS Chiller will occur within 90 Mins following an SESS alarm due to chiller failure.

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3.0 ASSUMPTIONS

3.1 Following a reactor trip or accident initiator there are approximately 25 to 50 control room alarms of which 10 to 15 require response by the operators.

3.2 With a failure of the ESS chillers, high temperature pump room alarms will sound within approximately 5 to 10 minutes of the pump starting.

3.3 The response time of 25 minutes for restoring the first ESS chiller as documented in SPEER 88-01-007 is assumed to be a median time for recovery under "optimal" conditions. 6-7-88

3.4 Although procedures are in place that would lead to chiller restoration, the actions performed are considered "knowledge" based since the procedures used are used as guides and not followed step by step. This is conservative since "rule" based actions (following procedures) are usually more reliable when considering longer time frames.

3.5 Stress factors considered in the analysis shall be calculated assuming an accident situation and the failure of the ESS chillers could cause a potential emergency.

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4.0 Input Data:

4.1 HCR Model:

The HCR model was developed by NUS and is presented in document NUS-4531.②

The probability of operator non-response is given by equation 3-1 as

$$P(t) = \exp\left(\frac{t/T_{1/2} - C_{\gamma i}}{C_{\eta i}}\right)^{\beta_i}$$

where,

$T_{1/2}$ = median time taken by crew for the performance of a task

β_i = The shape parameter of the HCR Model

$C_{\gamma i}$ = a dimensionless time delay parameter of the HCR model correlation. This represents the minimal time as a fraction of $T_{1/2}$ below which the operators can't respond.

$C_{\eta i}$ = The demensionless's scale parameter of the HCR model.

Using Equation 3-2

$T_{1/2} = T_{1/2}^{*} \prod_j (1 + K_j)$ where K_j's are influence factors for stress, operator experience and quality of operator/plant experience

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4.2 Data

$T_{1/2}$ = 25 Mins ; Spar 88-01-007

From Table 3-4

Adjusted $T_{1/2}$ = 25 Mins * (1 + 0.28)

= 32 Mins

this assumes K_1 = 0.00 ; Average knowlege & Training

K_2 = 0.28 ; Situation of potential emergency

K_3 = 0.00 ; Quality of operator / plant interface is good.

From Table 3-2

β_i = 0.8
$C\gamma_i$ = 0.5
C_{β_i} = 0.791

} For knowledge Based actions

4.3 Resulting Formula

The resulting Formula using the above data is:

$$P(t) = \exp - \left(\frac{t/32 \text{ mins} - 0.5}{0.791} \right)^{0.8}$$

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5.0 Calculation and Results:

5.1 Time Delay:

Per SWAIN, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," (1) For each abnormal event add 10 minute constants for time delay to derive HEPs (PS 12-18). The Handbook also recomends approximately 1 minute for each action in the CR as a response time. Using 15 annunciators following the trip to respond to, a delay of 15 minutes is assumed. If several alarms, e.g. high room temperature alarms, are coincident, this time delay would probably be less.

5.2 Calculation of P(t)

Adjusting the formula in 4.3 for a 15 min time delay gives:

$$P(t) = \exp - \left(\frac{\frac{t-15}{32} - 0.5}{0.791} \right)^{0.8}$$

This yields the following results:

t	P(t)
60 Mins	0.328
75 Mins	0.211
105 Mins	0.095
135 Mins	0.045
195 Mins	0.012
210 Mins	8.4×10^{-3}
240 255 Mins DWH 6-9-88	3.3×10^{-3}
90 Mins	0.14

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5.3 Comparison with other Results

It is felt that the complexity of the event and actions required can not be accurately Modeled by SWAIN/O, as most HRA results for the PRNGSPRA. However, if screening values are used by combining results from 12-2 (Table 12-2) and 12-3 the results are as follows:

t	P(E)	
10 Mins	1.0	
20 Mins	0.55	(Note: no recovery)
30 Mins	0.125	(Note: Recovery)
40 Mins	0.035	"
70 Mins	0.026	"
1510 Mins	0.025	"

These Results are for Role Based actions and not Knowledge Based and are thus low for screening Values. They do however point out that actions in the longer than 1 Hour time frame are highly likely to succeed and thus the HCR model is comparable.

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5.4 Uncertainty in the Analysis

The calculation for HCR above is using Knowledge Based results. If Rule base HR results are calculated using:

$P_i = 0.9$
$C_{Yi} = 0.6$
$C_{Zi} = 0.601$

the following results are calculated:

$$P(t) = \exp - \left(\frac{\frac{t-15}{32} - 0.6}{0.601} \right)^{0.9}$$ DWH 6-9-88

t	Rule P(t)	Knowledge P(t)prev
60 Mins	~~0.203~~ 0.272 DWH 6-9-88	0.328
90 Mins	~~0.082~~ 0.0737 DWH 6-9-88	0.14
135 Mins	0.012	0.045
210 Mins	3.2×10^{-4}	3.3×10^{-3}

Thus at longer time periods, the results of 5.2 show deviation on the conservative side by up to a factor of 10. At 90 Mins the results are conservative by ~ a factor of 2.

SWAIN® Approximates the error factors above as:

$P(E) > 0.1$		$EF = 5.0$
$0.1 \geq P(E) > 0.001$		$EF = 10.0$
$P(E) < 0.001$		$EF = 30.0$

The ~~DR~~ DWH 6-9-88 Results above agree with this range of EFs since larger deviations occur at lower probabilities.

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DW Hennecke	6-7-88	HRA Calculation	8 of 8
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6.0 References

1) A.D. SWAIN, H.E. Guttman, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications", NUREG/CR-1278, Aug. 1983

2) G.W. Hannaman, "Human Cognitive Reliability Model for PRA Analysis," NUS-4531, Dec. 1984

3) "Essential Chilled Water System Rendered Inoperable Due to Isolation of Flow Transmitters on Both Loops," SPEER-86-01-007, June 1988