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SHEAN (SIMPLIFIED HUMAN ERROR ANALYSIS CODE) AND AUTOMATED THERP

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One of the most widely used human error analysis tools is THERP (Technique for Human Error Rate Prediction). Unfortunately, this tool has the following disadvantages:

1) The analyst should have a background in human factors. Two problems arise from this: Few facilities have human factors experts available, and those that do, often use them as "fill in". That is, a probabilistic risk assessment (PRA) analyst models the overall events and the human factors expert determines the human failure rates. This creates an error-prone interface between the two analysts due to the myriad of assumptions not explicitly developed in the logic model or text (e.g., communication between any two individuals is never perfect, especially where the disciplines differ so greatly and new ground may be covered by the analysis).

2) THERP is a complicated, detailed technique. This gives rise to two related problems: The analysis itself is very time consuming, and results between different analysts tend to be very inconsistent, mostly due to differences in the detailed assumptions. For instance, in the benchmark exercises conducted by the European Joint Research Centre, 11 teams working on the same facility derived results with THERP that differed by almost four orders of magnitude on the first pass.[1] (Clarification of assumptions subsequently tightened this range greatly, but emphasized the need for such clarification early in the analysis).

The Nuclear Regulatory Commission, realizing these drawbacks, commissioned Dr. Swain, the author of THERP, to create a simpler, more consistent tool for deriving human error rates. That effort produced the Accident Sequence Evaluation Program Human Reliability Analysis Procedure (ASEP), which is more conservative than THERP, but a valuable screening tool.

ASEP involves answering simple questions about the scenario in question, and then looking up the appropriate human error rate in the indicated table (THERP also uses look-up tables, but four times as many).

The advantages of ASEP are that human factors expertise is not required, and the training to use the method is minimal.

Although not originally envisioned by Dr. Swain, the ASEP approach actually begs to be computerized. That WINCO did, calling the code SHEAN, for Simplified Human Error ANalysis. The code was done in TURBO Basic for IBM or IBM-compatible MS-DOS, for fast execution. WINCO is now in the process of comparing this code against THERP for various scenarios.

The SHEAN code produces a series of menus that walk the analyst through each human error evaluation. Because our facilities span 40 years of construction, the state of human factors design differs greatly. For this reason, a human factors team was brought in to evaluate the basic HEP (human error probability) for each of WINCO's major facilities. The basic HEPs varied between 0.01 and 0.05. Figure 1 illustrates how the user is requested to name the human error scenario he's about to work on, the scope of the analysis (screening or

detailed), and the building in which the scenario occurs. A basic HEP is then automatically assigned.

To continue the analysis, the analyst answers questions about recovery factors to adjust the basic HEP for that facility to the specific HEP for each scenario within that facility (see figure 2). In parenthesis after each question below is the maximum HEP reduction factor allowed and the error factor ("EF") that determines the uncertainty. These factors are not simply multiplied together when several of these questions have "yes" answers (that's why this analysis must be table-driven):

1) Are alarms or compelling signals present after commission of the error? (If "yes," the specific HEP for this scenario is negligible). In figure 2, the user answered "no."

2) Is an operability test done after the error? (0.01, EF=2).

3) Is some form of self-checking involved (two workers, or a single worker using a written checklist at a different time or place)? (0.1, EF=2). Note that a single worker can only approach this degree of reliability if a checklist is used at a different time or place than the original task (a checklist is defined as a permanent document that has the user's signature along with the system condition noted).

4) Is either a once-a-shift or daily check of component status conducted using a written checklist after error commission and prior to accident initiation? (0.1, EF=2). If this regular checklist function is not performed before the accident can take place, this question must be answered negatively.

5) Does supervision sign off that the action was correctly done? (0.1, EF=1).

If common cause is involved, the following must be determined (see figure 3):

1) How many components are involved (between 1 and 5)? In the unlikely case that more components are involved, the THERP approach will have to be used.

2) Are the components in series or parallel? (A multiplier of two to five for series applications. In other words, for each subsequent human action required, the total error rate increases).

3) If the configuration is in parallel, is the level of dependence zero, "halfway" or complete? (0.025 to 0.00025, EF=5 to 8).

A problem we have encountered in past human error analyses was the audit trail or record of all decisions made during the assignment of human error probabilities. Such a record enforces consistency over the course of the analysis, recording and justifying each determination. Upon request, the computer code prints out the name, median value, upper and lower bound, and error factor for each HEP derived, and the answer given for all the questions above (see figure 4).

The results given by the SHEAN code are conservative (or pessimistic). This is a natural outcome of a method so simple and generic, but it allows the method to be used by PRA analysts with minimum training. For this reason, WINCO uses SHEAN as a screening analysis. Some of the values produced by the screening analysis may be so conservative that they unrealistically affect the overall system failure rate. In such cases, WINCO requests a THERP expert to reanalyze these high values, deriving more realistic values using the more complex technique.

To aid the THERP expert, WINCO has computerized the THERP tables, incorporating recovery values discussed in the text of the accompanying document,[2] but not included in the tables. The tables and resultant search routine (see figure 5) have also been abbreviated, eliminating the time-dependent performance-shaping factor (high-stress, short-time post-accident activities). Time-dependent post-accident activities are almost never encountered in WINCO's processing environment where prevention is the primary defense.

As an additional aid to the human factors analyst, this same code contains expert opinion (Delphi) distribution determination and evaluation techniques described in Reference 2. These can be used where on-site experts or data present better HEPs than those derived from THERP.

Currently, WINCO is exercising both THERP and SHEAN codes, comparing results, and looking for pitfalls leading to nonconservatisms. Thus, in the near future, the "one/two punch" of SHEAN and THERP computer codes will offer increased flexibility to our human factors analysis effort, eliminating many analyst interfaces, reducing training needs and allowing our THERP experts to be used more effectively.

References:

1. A. Poucet, "Insights from the Benchmark Exercises and impact on Methodological Development," Reliability Engineering and System Safety 31 (1991) 65-90.

2. A. D. Swain, and Guttmann, H. E., Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, USNRC, NUREG/CR-1278, August 1983.

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           ----  ICPP-ASEP QUESTIONAIRE  ----

Type HEP Name Desired:  By-pass Vlv Mispositnd

Screening/Detailed Analysis Desired:  d

Human Factors (HF) adjustment for *By-pass Vlv Mispositnd*

     CPP AREA FACILITY
---------------------------
     -------- ( 601 )
     FSB ---- ( 603 )       — SPACE-BAR   to select facility...
     NWCF --- ( 659 )
     FAST --- ( 666 )            then
     FPR ---- ( 691 )
     Other - Facility       — ENTER (CR) to record selection...
     New Construction


{ F1 (function key)  to redo page --- ESC  to MENUs & DOS }
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Figure 1: Computer Screen #1 -- Human Factors Adjustment

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   Recovery Factors (RF) adjustment for *By-pass Vlv Mispositnd*
---------------------------------------------------------------------

1. Are there ALARMS (compelling signals) present? {Y/N}  N

2. Is an OPERABILITY TEST performed after error committed? {Y/N}  y

3. Are TWO workers involved in HEP Name OR does a single worker
   check job using a written CHECKLIST at a DIFFERENT
   TIME/PLACE? {Y/N}  y

4. Is there a SHIFTLY or DAILY CHECK of component status using a
   written CHECKLIST? {Y/N}  N

5. Does a SUPERVISOR SIGN-OFF that the action was correctly
   done? {Y/N}  N



                        (Press P to redo page)
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Figure 2: Computer Screen #2 -- Recovery Factors

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---- HEP MODIFICATION for MULTIPLE-COMPONENT SYSTEMS ----

Are there multiple-components or systems where your HEP Name
is implicated? {Y/N}   y

Select number of multiple-components or systems: {2,3,4,5}   4

Is your HEP Name in Series or Parallel as related to
components/systems? {S/P}   P

In the parallel configuration is there: {Z,H,C}    HD
    Z (ZD) == not      dependent    on    HEP    Name    neighbor(s)
    H (HD) == about 'halfway' dependent on HEP Name neighbor(s)
    C (CD) == completely  dependent   on   HEP   Name   neighbor(s)

{ Press R to Redo page -- Press other keys when asked -- ESC to MENUs & DOS }
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Figure 3: Computer Screen #3 -- Multiple Component Dependencies

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                    ----  ICPP-PRA  SUMMARY  ----

      Your HEP Name     : By-pass Vlv Mispositnd

      Your PRA Level    : DETAILED   for   New Construction

      Your HFs          : Overall CPP Qualification  Rating is GOOD
                             with  a  Multiplicative Factor of 0.67

      Your RFs          : ALARMS not present
                          OPERABILITY test effective
                          Two workers OR one with written CHECKLIST
                          No PERIODIC CHECK with written CHECKLIST
                          COMMON CAUSE considered under Dependencies
                          No SUPERVISOR SIGN-OFF that action correctly done

      Your Dependencies: 4 components/systems are in PARALLEL with HD

      Your HEP Value    :   2E-05
           EF  Value    :   10
           UB  Value    :   2E-04
           LB  Value    :   1E-05

{ F1 for new HEP Name -- ESC to Menus & DOS -- ENTER (CR) for new HEP Name }
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Figure 4: Computer Screen #4 -- Audit Trail

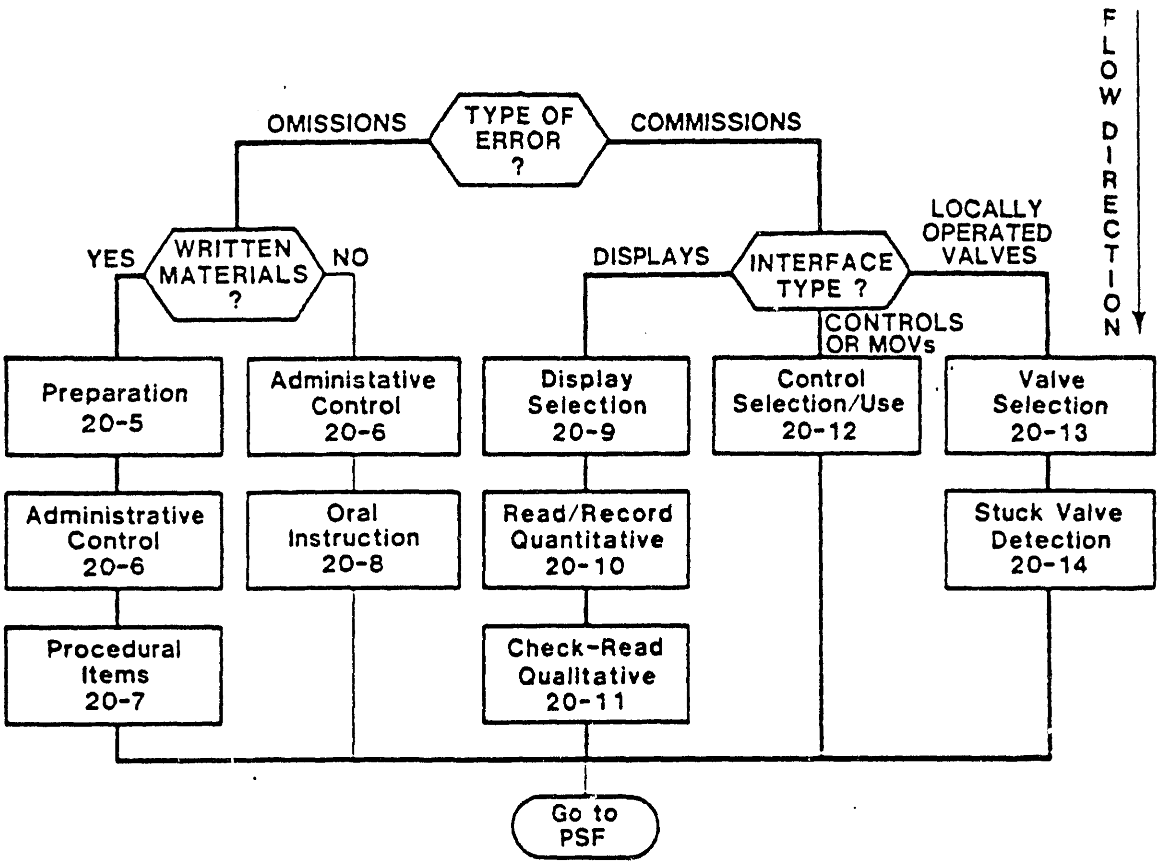

Figure 5: Nominal HEP Selection Flowchart for Automated THERP Code

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