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Rev. 0

Overview of "Red Oil" Frequency Analyses for F-Canyon (U)

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Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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DISCLAIMER

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Overview of "Red Oil" Frequency Analyses for F-Canyon (U)

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Approvals:

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1.0 INTRODUCTION

A very small potential exists in the Savannah River Site (SRS) separations operations for an uncontrolled reaction between tri-n-butyl phosphate (TBP) and nitric acid that could result in unacceptable damage to separations facilities and a significant release of radioactive materials.

The recent "red oil" (TBP and nitric acid) accident in Tomsk, Russia, resulted in considerable damage and radioactive release. Explosions have also occurred at SRS during the early years of operations. While the SRS separations facilities have operated without incident for many years, it is prudent to revisit the SRS defense-in-depth approach to preventing such an accident and to upgrade preventive procedures and hardware as appropriate.

2.0 SUMMARY

A detailed risk assessment was conducted for the F-Canyon facility. The analyses indicated that a runaway "red oil" reaction was extremely unlikely. However, the consequences of such an accident are severe enough that steps should be taken to make the frequency of the accident less than the credibility limit of 1 x 10^{-6}/yr. The steps include administrative changes, operational changes, and the addition of equipment. The added equipment includes level instrumentation, level alarms, and interlocks.

3.0 BACKGROUND

The basic chemistry of this reaction was studied extensively at SRS following the two early incidents. Recent experimental investigations were made at SRS and at Fauske Associates under SRS contract.

These investigations indicated the set of reactions known as a "red oil" reaction is exothermic with the reaction rate being a very strong increasing function of temperature. They also indicated the overall reaction rate and energy released is significantly enhanced in a closed system because of more energetic intermediate reactions and higher boiling points that result from the increase in constituent partial pressures.

Based on this information, the basic approach to preventing an uncontrolled reaction is to:

- Minimize the temperature of the TBP-nitric acid mixture, by ensuring the cooling mechanisms are capable of removing the heat being generated. The reaction will only runaway if the temperature exceeds some critical value (dependent upon the vessel), above which the rate of heat generation exceeds the rate of heat loss.

- Maximize the vessel vent areas to minimize constituent partial pressures in the vessel that could feedback to increase energy release rates and limit evaporative cooling. If the mixture is open to the atmosphere, evaporation of water, diluent, and nitric acid are efficient heat loss mechanisms which will limit the temperature of the mixture to the atmospheric pressure boiling point. Also, adequate venting allows the escape of reactants and intermediates from the reaction mixture, and limits the extent of the reaction. In contrast, a closed or inadequately vented system allows the pressure to increase as gaseous reaction products accumulate, which raises the boiling point, suppresses the heat loss due to evaporation, and retains partially reacted intermediates which can continue to react and generate heat.

- Limit the availability of highly concentrated nitric acid since the reaction rate and energy release increases with highly concentrated acid.
- Limit the mass of TBP present, when any of the above three items can not be satisfied. The total amount of heat generated and total amount of gases generated will be proportional to the amount of TBP that is reacted. With limited amounts of TBP, uncontrolled reactions can be accommodated with minimal consequences.

4.0 FREQUENCY METHODOLOGY

The fault tree analysis was performed in three steps. The first step was to look at the F-Canyon as an entirety and determine if "red oil" reactions are a potential danger, and if so, which equipment requires further analysis. The second step examined all vessels in F-Canyon which were not normally heated above about 80° C. The last step was to examine the F-Canyon evaporators. The evaporators are heated to a temperature high enough such that runaway "red oil" conditions are present if TBP is present in sufficient quantity. Human error analysis was used in all three of the steps and proved to be of great importance in the evaporator studies.

4.1 DETERMINATION OF NEED FOR ANALYSIS

An examination was made of the entire F-Canyon to determine where there was a potential concern for runaway "red oil" reactions. First, a "red oil" reaction requires that nitric acid be in contact with TBP. The vessels were then grouped into four general categories (Feed Tank, Sump Receipt Tank, Mixer Settler, and Evaporator) and a detailed analysis performed on a "worst case" vessel from each category.

This approach worked well for the first two categories, but the sources of TBP for each of the sump receipt tanks and evaporators were sufficiently different that it was necessary to construct a detailed fault tree for each sump receipt tank and each evaporator.

4.2 ANALYSIS OF UNHEATED VESSELS

The unheated vessels (Sump Receipt Tanks, Feed Tanks, and Mixer Settlers) were all combined in one study (Ref. 1, Appendix A). These vessels were combined due to their similarity in receiving TBP and mechanisms for overheating. All of these vessels are known to normally contain some TBP, and none are normally heated.

The detailed fault trees were first constructed to model the current state of operation using the assistance of knowledgeable facility operations personnel. If the calculated frequency of occurrence was more than 1 x 10^{-6}/yr, potential changes to the system were incorporated until the frequency dropped below this level. Once the 1 x 10^{-6}/yr goal had been reached, an elimination process was pursued to determine the minimum number of new components and controls necessary to keep the frequency below the goal. The controls and equipment remaining in the fault tree were designated as Safety Class Items to assure the desired protection.

4.3 ANALYSIS OF EVAPORATORS

Originally, due to the lack of experimental data , it was assumed in early evaporator fault trees that a "red oil" reaction could occur whenever TBP was exposed to temperatures exceeding 120° C or at temperatures above 80° C under certain conditions. Since evaporation of the solution is a very good mechanism for removing any excess heat from an uncontrolled reaction at temperatures below 120° C, the original fault trees modeled runaway reactions occurring during a) cool down, b) heating prior to boiling, and c) during excessive heating.

Experimental results (Ref. 2) now demonstrate that this reaction would not occur if an adequate aqueous layer is present and the temperature is less than 120° C. Since the vessels at SRS are open systems, a second set of fault trees was developed to determine the frequency of a "red oil" reaction due to overheating or due to evaporation of the aqueous layer. The presence of aqueous in the evaporator tanks allow credit to be taken for temperature interlocks. The temperature of the solution is limited by the boiling point of the aqueous solution, and the specific gravity of the solution increases as the aqueous is evaporated (Ref. 3).

After the earl·· incidents at SRS, defense-in-depth based on limiting the temperature and the amount of TI were successfully used to prevent any further incidents. After the Tomsk incident, restrictions on the use of highly concentrated nitric acid (a third measure) were implemented.

The second set of fault trees went through a similar process as that described above for the unheated tanks (Ref. 4, Appendix B). Once again new Safety Class controls were identified (Ref. 5, Appendix C).

4.4 HUMAN ERROR ANALYSIS

A human factors engineering review (Rev. 6, Appendix D) was performed for the accident scenario fault trees for runaway "red oil" reactions in the Savannah River Site (SRS) F-Canyon evaporators.

A total of five F-Canyon evaporators were modeled for potential "red oil" reaction concerns. The modeling for each evaporator was taken back to the point of initial release of organic material into the aqueous stream. Each step between the source and the evaporator was examined for methods of release of organic, methods for detection of organic in the aqueous stream, and reasons why the human error or equipment failure would go undetected.

Since the controls that serve to prevent an uncontrolled "red oil" reaction were operator intensive, a review of the human factors assumptions, error models and probabilities, and operator dependency was performed to ensure appropriate consideration of the contribution of operator actions. First, a qualitative task analysis was performed to support the human error modeling and quantification selections made by the fault tree analysts, for each of five F-Canyon evaporators.

To assure that all human errors were identified, each operating procedure involved was examined to assure clarity, accuracy, and required check-offs. With the help of operating personnel, the operator involved with each transfer or activity was identified. Careful consideration was given to the length of time involved in each action, time span between actions, number of operators involved in the action, and possible dependence between the actions. These dependencies could be the result of operators being closely associated, lack of communication between operators, or the same operator performing a series of actions. The heavy human involvement in this system made the careful identification of these interactions crucial to understanding the risk associated with the actions.

Consistency in human error modeling and frequency quantification was another area of concern. To aid in this process, the generic human error database (Ref. 7) was used to quantify all human errors. The fault tree structure for similar actions was compared and discrepancies were identified and resolved. Conservative values of human error probability were used throughout the modeling process to assure that the frequency of "red oil" reactions would not be underestimated.

5.0 RESULTS

The frequency of runaway "red oil" reactions, established by the detailed fault tree quantification, was in the incredible range of occurrence (i.e., $<$ 1E-06/year). To provide assurance of the reaction scenario's incredibility, a sensitivity study was performed. Each important function that could lead to a runaway reaction was evaluated to determine the sub-functions (either operator or equipment action) to which the fault tree frequency was most sensitive. An iterative process was employed to establish a minimum set of controls which would also be cost effective. Additional controls suggested by facility personnel were modeled in the fault tree and new top event frequencies were calculated. This iterative process continued until both the frequency and the set of controls were acceptable to analyst and facility personnel.

A minimum set of procedural controls and safety equipment which assure the incredibility of a runaway "red oil" reaction is:

- Agitators and cooling systems (where available) must be running during any transfer into a tank.

- Fluctuations in the specific gravity will be used as an indicator of the operation of the agitator.
- Verification of specific gravity of feed on the batch evaporators will be performed.
- Small volume evaporators will be operated as caustic evaporators.
- Waste from solvent recovery operations will be sent to a caustic evaporator.
- All sump receipt tanks require a dedicated head tank.
- There must be a 72 hour time spacing between the feeding of sump receipt tanks to the continuous evaporator.
- High and Low Level Alarms on solvent hold tank will be operable.
- High level interlock on solvent hold tank will be operable.
- Stabilization of Solvent extraction process will be performed before starting evaporators.

6.0 CONCLUSION

The frequency of red oil explosion in each F-Canyon evaporator is determined to be incredible by fault tree analysis. Runaway "red oil" reactions are unlikely to occur in the evaporators because very large amounts of TBP are needed to cause significant uncontrolled reactions in a well-vented system. Experimental analysis and consequence studies demonstrate that only reactions involving large quantities of TBP could result in unacceptable releases to the environment and public. "Red oil" reactions involving large quantities of TBP are prevented by maintaining administrative controls of solvent inventory, ensuring that the evaporator's temperature remains below 120° C, and ensuring that adequate aqueous layer is maintained in the evaporator to provide heat removal.

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APPENDIX A UNHEATED VESSEL ANALYSIS

Calculation Cover Sheet

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Title Fault Tree Analysis of Red Oil Reactions in the F-Canyon Evaporators (U)	Functional Classification NS Discipline Risk Analysis Group	Sheet 1 of 130

Preliminary	X Committed	Confirmed

Computer Program No. CAFTA+	Version 2.2c

Pupose and Objective

As requested by NMPD Safety Documentation, this Calc-Note determines the frequencies of runaway red oil reactions involving more than 3,000 lbs of TBP, in F-Canyon evaporators 8.5E, 7.6E, 7.7E, , and 9.3E. The dominant sequences leading to an explosion and top event frequency for each evaporator are determined by fault tree analysis.

Summary of Conclusion

Runaway red oil reactions involving more than 3,000 lbs of TBP in the evaporators are calculated to be incredible (<10E-6/yr). Incredibility is achieved by a combination of old and new controls involving: temperature, solvent inventory, and ensuring that aqueous is present during evaporation. The results of the analysis (i.e. incredibility) are contingent upon resolution of the open items listed in this calc-note.

Revision

Rev. No.	Revision Description
Rev. A	Initial Issue
Rev. B	Replaced pages 1-129

Sign Off

Rev. No.	Originator (Print) Sign/Date	Verification / Checking Method	Verifier /Checker (Print) Sign/Date	Manager (Print) Sign/Date
Rev. B	L. W. Christiansen C. R. Lux			D. A. Sharp

Classification

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OPEN ITEMS

Facility Commitments

The following is a list of commitments made by the facility (Ref. 18) that must be implemented in order for runaway red oil reactions to be incredible. These commitments must be implemented in order for the status of this calculation to be changed to "confirmed."

Equipment-Related

1 Low solvent hold tank (906, 14.7) level interlock and high level alarm will be installed or modified to ensure that solvent losses do not exceed 10,000 lbs of 30% TBP.

Operational Basis

2 Solvent wash waste will not be fed to the batch or continuous evaporators (the batch evaporator will be fed only the continuous evaporator bottoms). Solvent wash waste will be processed via caustic evaporation.

Procedural

The procedural open items listed below are referred to by number in the tabulation of human error events presented in Appendix C. Appendix C specifies which procedural open items require modification of existing procedures, and which require new procedures to be written.

3 Operator shall verify (via flow measurement) that steam is shut off (closing the steam block valve manually if needed) whenever temperature or level interlocks demand the steam valve to close.

4 The solvent hold tanks (14.7, 906) inventory will be administratively controlled to prevent losses in excess of 10,000 lbs of organic.

5 During start-up, evaporators will not be operated until levels in solvent hold tanks have stabilized (steady state).

6 Any actuation of the solvent hold tank's (906, 14.7) low level interlock, or discovery of large solvent losses, will require the evaporators to be shut down until accountability of the solvent inventory is performed.

7 Solvent hold tank operator (906, 14.7) will ensure that the solvent feed pump (to banks) is shut off if the low level interlock is demanded.

8 Operations will commit to emptying out the 8.7 and 8.3 feed tanks once every six months, such that three consecutive tank cleanings would have to be missed to build up 3,000 lbs of TBP (Ref. 19).

9 OMITTED

10 Administrative controls will be implemented to limit transfers from 17.5 to 8.7 (and from 7.3 to 8.3) to once per 72 hours to ensure that two full sump receipt tanks are not fed to the continuous evaporator feed tank in an evaporator cycle (Ref. 10).

11 Operators must verify that sp g in the batch evaporator is greater than 1.1 (matches that of the feed tank at the beginning of the batch) to ensure that an aqueous layer is present.

ASSUMPTIONS

Technical Bases

The following list contains details of system operation and characteristics used in the development of the fault tree. These items have formal documentation.

12 Tanks, c l ventilation, and the F-Canyon structure can withstand runaway red oil reactions involving less thar 000 lbs of TBP with minimal consequences (Ref. 1).

13 Experimental results indicate that a 1 ft aqueous layer will prevent red oil reaction for up to 9 feet of organic (Ref. 11).

14 There exist level and temperature interlocks for the continuous evaporators (Ref. 10).

15 There exist temperature interlocks for the batch evaporator (Ref. 10).

16 Each batch evaporator will process no more than 100 batches/yr (Ref. 10).

17 Because small amounts of the TBP in the evaporator will degrade within 72 hours, TBP can not accumulate in the evaporators unless a process upset has occurred (Ref. 10).

18 The probability of having 10,000 lbs of solvent in the sump receipt tanks (7.3 & 17.5) is 2.0E-3 (Ref. 3).

19 Process upsets occur at a frequency of 1/10 years (Ref. 10).

20 Operator actions are considered independent when they involve different tanks since the operati usually involve different operators and are not performed simultaneously. A review of human error pendencies and common causes was performed (Ref. 9), and the facility has agreed to operational a procedural changes that eliminate most of the dependencies between operators found during the initial human factors review (i.e. acidic evaporation of solvent wash waste streams will not be performed). A tabulation of the human error events for the continuous and batch evaporators is presented in Appendix C. This table specifies which operator actions are contingent upon open items. The tables are somewhat different than those listed in Reference 9 because of the previously mentioned facility commitments and because of logic changes to the trees subsequent to the initial review.

21 Temperature of concentrate in the de-entrainment column will increase and trigger the temperature interlock if there is a failure to supply feed to the evaporator. The temperature will increase due to an increase in the boiling point and sp g of the concentrate (Ref. 2).

22 There is sufficient time for the operator to shut off the steam block valve if a high solution temperature is detected (Ref. 10)

23 Cold streams are assumed to be sent he eva ator feed tanks 25% of the time (Ref. 10).

Experience-Related and General

The following assumptions are used in the fault tree and are assumed to be true, but do not have a formally documented technical basis:

24 Uncontrolled reactions do not generate sufficient heat to raise the evaporator contents over 120° C and to cause a red oil reaction. Most uncontrolled reactions lead to eructation of evaporator contents, and cause high delta-p's that lead to the steam being shut off. Since it is assumed that uncontrolled reactions can not lead to red oil reactions, these scenarios are not modeled.

25 Direct transfer errors to the evaporator feed tanks are not considered because direct solvent paths are assumed blocked off.

26 Continuous evaporator will not run more than a total of 4 days/month.

27 OMITTED

28 All TBP is assumed to "survive" the continuous evaporator and will be fed to the batch evaporator.

29 No credit is given to the batch evaporator temperature interlock whenever a very large amount of solvent (≥ 30,000 lbs) is fed because there may not be sufficient aqueous to prevent a runaway reaction even if the steam is shut down.

30 Process upsets can be detected and corrected in 12 hours.

31 Calibrations for instrumentation are performed every 6 months.

<u>Continuous Evaporator 9.3E (when different from 8.5E)</u>

32 Can receive excess TBP from 1A bank with credit for low level detection in 14.7 to catch a large loss of solvent (≥ 10,000 lbs). For losses involving ≥ 30,000 lbs, credit was given for detection via the low level alarm, since the full capacity of the tank is slightly less than 30,000 lbs and at least one full tank would have to be sent (Ref. 12).

33 Can receive excess TBP from 7.3 sump receipt tank. Transfers were assumed to be sent from 7.3 5% of the time, per cognizant engineer's estimate.

INTRODUCTION

A very small potential exists in the SRS separations operations for an uncontrolled reaction between tri-n-butyl phosphate (TBP) and nitric acid that could result in unacceptable damage to separations facilities and a significant release of radioactive materials.

The recent red oil (TBP and nitric acid) accident in Tomsk, Russia, resulted in considerable damage and radioactive release. Explosions have also occurred at SRS during the early years of operations. While the SRS separations facilities have operated without incident for many years, it is prudent to revisit the SRS defense in depth approach to preventing such an accident and to upgrade preventive procedures and hardware if appropriate.

A previous analysis (Ref. 16) was performed showing that the frequency of a runaway red oil reaction in the F-Canyon feed tanks, mixer-settlers and sump receipt tanks was incredible. This analysis presents the frequency of runaway red oil reactions in the F-Canyon evaporators.

Originally, due to the lack of experimental data, it was assumed in early evaporator fault trees that a red oil reaction could occur whenever TBP was exposed to temperatures exceeding 120° C or at temperatures above 80° C under certain conditions. Since evaporation of the solution is a very good mechanism for removing any excess heat from an uncontrolled reaction at temperatures below 120° C, the original fault trees modeled runaway reactions occurring during a) cool down b) heating prior to boiling and c) during excessive heating.

Experimental results demonstrate that this reaction would not occur if an aqueous layer (Ref. 1) is present unless the temperature exceeds 120° C. Since the vessels at SRS are open systems a second set of fault trees were developed to determine the frequency of a red oil reaction due to overheating or due to evaporation of the aqueous layer. The presence of aqueous in the evaporator tanks allow credit to be taken for temperature interlocks. The temperature of the solution is limited by the boiling point of the aqueous solution, and the sp g of the solution increases as aqueous is evaporated (Ref. 2).

INPUT

Basic data used to quantify the fault trees came from the following sources: WSRC-TR-93-262, "Savannah River Site Generic Data Base Development", WSRC-TR-83-581, "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities", Low Activity Waste (LAW) Study Guide (221-F Canyon), High Activity Waste (HAW) Study Guide (221-F Canyon), and estimates by F-Canyon and SRTC engineers/scientists (references 2,3,4,5). Complete sources for the basic events in the fault trees are listed in their corresponding "Basic Event and Type Code" reports, which are included in this Calc-Note. The basic event file also includes assumptions involving restoration and mission times used to calculate unavailabilities and unreliabilities of equipment.

ANALYTICAL METHODS AND COMPUTATIONS

Fault tree analysis was used to generate a logic model that generates "minimal" combinations (cutsets) of events that yield a runaway red oil reaction involving in excess of 3,000 lbs of TBP. The fault trees' logic structure was developed based on extensive discussions of a) canyon operations with F-Canyon engineers (D. Chostner, R. Eubanks (Ref. 10), S. Marek, and T. G. Campbell), and b) experimental results by SRTC (Ref. 1,11).

In order for a runaway red oil reaction of sufficient magnitude to compromise the F-Canyon containment to occur, it must involve at least 3,000 pounds of TBP. In addition, the organic must be heated to 120° C or above in the absence of an aqueous layer of at least one foot.

The fault trees model failures of the three main controls that prevent runaway red oil reaction: solvent inventory control, temperature control, and ensuring the presence of aqueous in the evaporator.

The analysis is conservative because the fault tree calculates the frequency of runaway reaction for 3,000 lbs (in the first two cases below), and for 10,000 lbs (in the last case). Reactions involving more than 3,000 pounds will happen with less frequency than those involving exactly 3,000 lbs because a large process upset is less likely than a small one, so the calculated frequency will conservatively bound the "actual" frequency.

The analysis does not take credit for items not committed to by the facility in the F-Canyon Basis for Interim Operation (BIO) (Ref. 18). If a non-safety class item performs a mitigative or preventative action, then no credit was taken for it in the analysis. However if the failure of an item (for example a pressure switch) could instigate a failure scenario, then its failure was accounted for in the fault trees.

Continuous Evaporators

- Excess TBP (≥ 3,000 lbs) is fed to the continuous evaporator and failure to regulate steam pressure to maintain a safe temperature. Credit is given to automatic shut down of steam by temperature interlocks. If the interlocks do not work, but the loss of control is detected by the temperature sensors or alarms, then credit is given to an operator for closing a steam block valve.

- Excess TBP (≥ 3,000 lbs) is fed to the continuous evaporator and failure to maintain an aqueous layer, and failure to shut down steam. Credit is given to automatic shut down of steam by level and temperature interlocks if the heating tubes begin to uncover. If the interlocks do not work, but failure is detected by the temperature or level sensors or alarms, then credit is given to an operator for closing a steam block valve. It is postulated that as long as the steam is shut off before all the aqueous is evaporated a runaway reaction is prevented. It should be noted that operators could be misled by the correct instrumentation signals (high level) to increase the steam flow and therefore remove the aqueous present.

- Excess TBP (≥ 10,000 lbs) is fed to the continuous evaporator and normal operation. 10,000 lbs of TBP represents enough organic so that any aqueous present will be displaced, so that no credit can be taken for cooling by an aqueous layer. Credit is given to automatic shut down of steam by the temperature interlock. It should be noted that, due to the large amount of TBP and small amount of aqueous in this scenario, a rapid response is necessary.

Batch Evaporators

- Excess TBP (≥ 3,000 lbs) is fed to the batch evaporator and failure to regulate steam pressure to maintain a safe temperature. Credit is given to automatic shut down of steam by the temperature interlocks. If the interlocks do not work, but the loss of control is detected (by the temperature sensors or alarms), then credit is given to an operator for closing a steam block valve.

- Excess TBP (≥ 3,000 lbs) is fed to the batch evaporator and failure to maintain an aqueous layer by overcooking the feed. Credit is given to automatic shut down of steam by the temperature interlock (due to an increase in boiling point).

- Excess TBP (≥ 10,000) is fed to the batch evaporator from the continuous evaporator bottoms tank during normal operation. Credit is given to verification that the sp g in the batch evaporator matches that of the evaporator feed tank at the beginning of the batch.

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The following table shows the sources of TBP for each evaporator and mechanisms for detecting its presence.

Evaporator **Continuous**	Source of TBP	Detection
8.5E	Solvent Extraction Bank 2A Solvent Extraction Bank 2 (cold streams operations) Sump Receipt Tank 17.5 *	Organic high level alarm in tank 06 Organic low level alarm in tank 06
9.3E	Solvent Extraction Bank 1A Sump Receipt Tank 7.3 Tank 12.6, 1C Bank (cold streams operations)	Organic high level alarm in tank 14.7 Organic low level alarm in tank 14.7

*B-Line (via tank 9.7), this event was judged incredible because: a) no further processing of B-Line material is planned b) would have to transfer organic up to B-Line unnoticed then back down to canyon again

Evaporator **Batch**	Source of TBP	Detection
7.6E	8.5 Bottoms Tank (see above 8.5E)	Verification of matching sp g between 7.6E and 7.8 prior to evaporation
7.7E	8.5 Bottoms Tank (see above 8.5E)	Verification of matching sp g between 7.7E and 7.8 prior to evaporation

The fault trees underwent extensive revisions and the open items represent the list of requirements needed to prevent an unacceptable runaway red oil reaction frequency. The list below shows some of the additional controls that were considered:

- High and low sp g alarms for the evaporators
- Monitoring of feed flow rate into continuous evaporators
- Improved sampling & additional sampling requirements
- Improved decanting procedures
- High organic level alarms on decanters

Reference 17 presents a scoping calculation detailing the frequency of uncontrolled red oil reactions in F-Canyon if these additional features/controls are implemented. These controls cause a reduction in frequency of approximately two orders of magnitude less than those presented in the Results section.

RESULTS

The frequency of evaporator explosion due to red oil reaction is listed in the following table for each of the evaporators analyzed. The final sets of fault trees and resulting cutsets are included in Appendices D, E and F.

Evaporator	Operation	Frequency (/yr)
Continuous		
8.5E	Continuous Mode	2E-7
9.3E	Continuous Mode	2E-7
Batch		
7.6E	Batch (8.5E Bottoms Only)	4E-7
7.7E	Batch (8.5E Bottoms Only)	4E-7

CONCLUSION

The frequency of red oil explosion in each F-Canyon evaporator is determined to be incredible by fault tree analysis. These results are contingent upon the facility implementation of the identified open items. Runaway red oil reactions are unlikely to occur in the evaporators because very large amounts of TBP are needed to cause significant uncontrolled reactions in a well-vented system. Experimental analysis and consequence studies demonstrate that only reactions involving more than 3,000 lbs of TBP could result in unacceptable releases to the environment and public. These red oil reactions are prevented by maintaining administrative controls of solvent inventory, ensuring that the evaporator's temperature remains below 120° C, and ensuring that one foot of aqueous is maintained in the evaporator to provide adequate heat removal.

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10. D. F. Chostner and R. A. L. Eubanks, "Existing Parameters to Mitigate TBP Reaction in 221-F (U)", NMP-EFA-94-0289. Westinghouse Savannah River Company. October 14, 1994.

11. J. R. Smith and W. S. Cavin, "Isothermal Heat Measurements of TBP-Nitric Acid Solutions", WSRC-TR-94-0540. Westinghouse Savannah River Co. December 16, 1994.

12. V. M. Martinez, "F-Canyon Vessels Capacities (U)", NMP-EFA-94-0054. Westinghouse Savannah River Co. February 17, 1994.

13. High Activity Waste (HAW) Study Guide (221-F Canyon). Training Course NSATSYWE. Westinghouse Savannah River Co.

14. R. A. L. Eubanks, "906 Operator Independence (U)", NMP-EFA-94-0309. Westinghouse Savannah River Co. November 21, 1994.

15. H. A. Ford, "Common Cause Parameters Using the Multiple Greek Letter Method-Work Performed by Los Alamos National Laboratory for WSRC (U)", WSRC-TR-92-470. Westinghouse Savannah River Co. June 21, 1993.

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16. C. R. Lux, L. W. Christiansen, K. M. Marshall, T. L. Slaven, "Frequency Determination for Runaway TBP/Nitric Acid Reactions in Support of the F-Canyon BIO (U)." S-CLC-F-00100. Westinghouse Savannah River Co. June 21, 1994.

17. E. V. Browne, L. W. Christiansen, C. R. Lux, "Scoping Study of Red Oil Reactions in F-Canyon Evaporators (U)." S-CLC-F-00146. Westinghouse Savannah River Co. January, 1995.

18. F-Canyon Basis for Interim Operation (U). WSRC-RP-93-1215.

19. Inter-Office Memorandum from R. A. L. Eubanks, "Solvent Additions (U)", Westinghouse Savannah River Co. March 8, 1995.

ATTACHMENTS AND APPENDICES

APPENDIX A - MEMORANDA

Calculation No. S-CLC-F-00140
Sheet No. 14 of 130
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INTER-OFFICE MEMORANDUM
Savannah River Site

26-Aug-1994 02:53pm EST

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASRS2)
Dept: NMPD Safety Documentation
Tel : 2-3319

Boiling Points of Various Evaporator Solutions

I have found some good information on vapor-liquid equilibrium and boiling points in DPSOP 250, "200 Areas Process Guidebook". Using this information, I have made some calculations to prove our assumption that the temperature interlock will be reached before all of the aqueous in an evaporator could be boiled away. In these calculations I assumed the temperature interlock was set at 118 C, although I'm sure we could set the interlock lower without adversely impacting operations.

Under normal operating conditions, a continuous evaporator runs with a boiling sp g of 1.25, and makes overheads with about 6% nitric acid. For this condition, the vapor-liquid equilibrium chart in DPSOP 250 gives a sodium nitrate concentration of 25% (about 3.7M) and 20% nitric acid (about 4.0M), with a boiling point of 112 C, which is consistent with our experience. Concentrating this solution to a boiling point of 118 C gives a final sodium nitrate concentration of 33% and nitric acid concentration of 23%. The sp g would be about 1.33 (boiling). The volume reduction to reach this point is only about 30%.

If you assume that the evaporator bottoms have no solids (very unusual), only nitric acid, then to make 6% nitric acid overheads would require the bottoms to be about 32% nitric acid, with a boiling point of about 106 C. To reach a boiling point of 118 C, the evaporator bottoms must be concentrated to about 56% nitric acid. My calculations indicate a volume reduction in this case of about 75%, which is probably somewhat larger than actual because of the conservative assumptions I made about the amount of nitric acid lost to the overheads.

In my opinion, expected operating conditions are closer to the first example, with the second example being more of a worse case. In both of the examples, however, the temperature interlock of 118 C would be reached and the evaporator shut down well before all of the aqueous is gone. As I mentioned earlier, the interlock probably can be lowered to at least 115 C, thus providing even more margin.

Although the above calculations were primarily done with the continous waste evaporators (9.3E and 8.5E) in mind, the same conclusions can be expected with the batch evaporators, especially when they are being used for acid stripping concentrated bottoms. As for 17.7E, you can concentrate uranyl nitrate to a boiling point of 118 C also, but the U concentration (wt%) would have to be increased from about 30% (1.5 sp g) to about 75% (sp g of over 2.2). I find it hard to believe that the evaporator would continue to operate under these conditions. The temperature interlock on 17.7E could be lowered substantially, however, probably to about 110 C.

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INTER-OFFICE MEMORANDUM
Savannah River Site

03-Jun-1994 04:30pm EDT

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASRS2)
Dept: NPSR
Tel: 2-3319

Probability for Accumulation of TBP in Canyon Sumps

Process solvent is expected to be received in canyon sump receipt tanks from time to time due to overflows and leaks from canyon tanks and piping. Procedures require that accumulated solvent be removed from receipt tanks before amounts (about 3000 pounds of TBP) are reached that could be a concern from a "red oil" reaction standpoint. The only way an amount can be received that is large enough to be of concern is from a single sump transfer. Experience indicates that the frequency of receiving such a large mass of organic material unexpectedly into a canyon vessel is very low. Myself, Ronnye Eubanks, and Dave Chostner conservatively estimate that a receipt of solvent, containing more than 3000 pounds of TBP, can be expected in the sump receipt tanks less than once every five years. This value is considered conservative because loss of such a large volume would be detected during operations. Actions other than transfer to sump receipt would be expected in these situations. Also, in our collective experience in the canyons (more than 40 years) we can recall of no occasion when such a large volume of organic material was received into a sump receipt tank from a leak, spill, or transfer error. Please incorporate this value (once in 5 years for receipt of large volumes of solvent in sump receipt) into the sump receipt tank fault trees for "red oil".

Distribution:

To: Lance W. Christiansen
(CHRISTIANSEN-LW-L0489 @A1@SLSRP1)

CC: ONELIO M. EBRA-LIMA (EBRALIMA-OM-T5452 @A1@SLSRP1)
CC: Ray Lux (LUX-CR-T7244 @A1@SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 AT A1 AT SASRS2)
CC: David F. Chostner
(CHOSTNER-DF-03090 AT A1 AT SASRS2)
CC: Ronnye A. L. Eubanks
(EUBANKS-RA-06258 AT A1 AT SASRS2)
CC: Sandra H. Marek (MAREK-SH-07923 AT A1 AT SASRS2)

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INTER-OFFICE MEMORANDUM
Savannah River Site

30-Aug-1994 02:25pm EST

To: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)

CC: Thomas G. Campbell (CAMPBELL-TG-05094 @A1@SASR52)

From: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLS.P1
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : 52539

RE: Mixing Studies

Neguib estimates the experimental work will be complete by the end of September. He anticipates data analysis and documentation will require approximately 2 months. Therefore, we should have correlation(s) for the canyon tanks by the end of November.

INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 08:15am EST

To: See Below

From: Neguib M. Hassan (HASSAN-NM-L2267 AT A1 AT SASR52)
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : x5-5765

RE: Good News About Mixing Tests

This may be a worse case, but in the next few runs we will reduce the liquid level in small increments and establish a mixing pattern. We know thus far that just below the second impeller (approximately 12 inches of liquid in our tank or about 5.3 feet scaled canyon tank-8' x 11') no organic is detectable in the current sampling procedure.

Distribution:

To: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52)

CC: DON F. PADDLEFORD
(PADDLEFORD-DF-H0010 AT A1 AT SLSRP1)
CC: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLSRP1)
CC: Lee Hyder (HYDER-ML-T3258 AT A1 AT SLSRP1)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT A1 AT SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 @A1QSASRS2)
CC: Ray Lux (LUX-CR-T7244 AT A1 AT SLSRP1)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)
CC: Thomas G. Campbell (CAMPBELL-TG-05094 @A1@SASRS2)
CC: David F. Chostner (CHOSTNER-DF-03090 @A1@SASRS2)
CC: Charlene B. Cochran (COCHRAN-CB-06921 @A1@SASRS2)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT A1 AT SLSRP1)
CC: Jim Knight (KNIGHT-JR-T3559 AT A1 AT SLSRP1)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT A1 AT SLSRP1)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @A1@SASRS2)
CC: Major C. Thompson (THOMPSON-MC-T3324 @A1@SASRS2)

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INTER-OFFICE MEMORANDU-
Savannah River Site

22-Jul-1994 08:23am EST

To:See Below

From: Tracy 5. Rudisill
(RUDISILL-TS-T6876 AT Al AT SLSRPl
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : 52539

RE: Good News About Mixing Tests

When the tank is full, two agitator blades are used to mix the tank. This doubles the mixing power and is apparently enough to form a dispersion which reaches the dip tube at the bottom of the tank. In Neguib's previous work, the liquid level was just below the bottom of the top agitator.

There will also be a very low liquid level where the mixing quality would permit the detection of large amounts of organic. At this point, a single agitator would provide enough power to disperse the organic phase. Intermediate levels seem to be the problem.

Distribution:

To: Charlene B. Cochran
(COCHRAN-CB-06921 AT Al AT SASRS2)
To: Thomas G. Campbell (CAMPBELL-TG-05094 @Al@SASR52)

CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl)
CC: Lee Hyder (HYDER-ML-T3258 AT Al AT SLSRPl)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT Al AT SLSRPl)
CC: William E. Harris (HARRIS-WE-05596 @Al@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT Al AT SLSRPl)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT Al AT SLSRPl)
CC: David F. Chostner (CHOSTNER-DF-03090 @AlQSASR52)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT Al AT SLSRPl)
CC: Jim Knight (KNIGHT-JR-T3559 AT Al AT SLSRPl)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT Al AT SLSRPl)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @AlQSASR52)
CC: Major C. Thompson (THOMPSON-MC-T3324 @Al@SASRS2)

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INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 11:02am EST

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT Al AT SASR52
Dept: NMPD Safety Documentation
Tel : 2-3319

RE: Good News About Mixing Tests

I've got to make one more comment on this subject.

If covering the top set of agitator blades is what is important for sampling organic, then a tank certainly does not have to be "full". In canyon tanks, both sets of agitator blades are covered by the time the tank is about half full. In 8x11 and 10x11 tanks, there is four feet between the bottom of the lower set of blades and the bottom of the upper set of blades. The bottom set of blades is within about six inches of the bottom of the tank. Therefore both sets of blades should be covered before the tank contains five feet of solution. In bicell tanks, which are 15 feet high, there is six feet from bottom to bottom of the agitator blades. Again, the upper set of blades are covered by the time the tank is about half full.

From what Neguib said in his message, I'm not sure your test equipment is scaled correctly. He said the upper impeller is uncovered at 5'3" of liquid level. In an actual canyon 8x11 tank, the upper set of agitator blades would be covered by at least 3 inches of solution at that level.

Distribution:

To: Tracy 5. Rudisill
(RUDISILL-TS-T6876 AT Al AT SLSRPl)

CC: Charlene B. Cochran
(COCHRAN-CB-06921 AT Al AT SASRS2)
CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl)
CC: Lee Hyder (HYDER-ML-T3258 AT Al AT SLSRPl)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT Al AT SLSRPl)
CC: William E Harris (HARRIS-WE-05596 QA1@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT Al AT SLSRPl)
CC: ONELIO M EBRA-LIMA
(EBRALIMA-OM-T5452 AT Al AT SLSRPl)
CC: David F Chostner (CHOSTNER-DF-03090 @A1@SASRS2)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT Al AT SLSRPl)
CC: Jim Knight (KNIGHT-JR-T3559 AT Al AT SLSRPl)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT Al AT SLSRPl)
CC: Neguib M Hassan (HASSAN-NM-L2267 QA1@SASRS2)
CC: Major C Thomp~on (THOMPSON-MC-T3324 @A1@SASR52)

INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 11:40am EST

To: See Below

From: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl Dept: WESTINGHOUSE STAFF
Tel :45420

RE: Good News About Mixing Tests

I guess I meant---filled above upper stirrer blades--- instead of full. Apparently this would only be half full according to T. Campbell's response. You may well be right that full could represent a bad situation too?? I don't know whether the scale tests covered this "full" depth or not.

Don

Distribution:

To: Charlene B. Cochran
(COCHRAN-CB-06921 AT Al AT SASRS2)

CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl)
CC: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT Al AT SLSRPl)
CC: Lee Hyder (HYDER-ML-T3258 AT Al AT SLSRPl)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT Al AT SLSRPl)
CC: William E. Harris (HARRIS-WE-05596 @Al@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT Al AT SLSRPl)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT Al AT SLSRPl)
CC: Thomas G. Campbell (CAMPBELL-TG-05094 @Al@SASRS2)
CC: David F. Chostner (CHOSTNER-DF-03090 @Al@SASRS2)
CC: Charlene B. Cochran (COCHRAN-CB-06921 @Al@SASRS2)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT Al AT SLSRPl)
CC: Jim Knight (~NIGHT-JR-T3559 AT Al AT SLSRPl)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT Al AT SLSRPl)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @Al@SASR52)
CC: Major C. Thompson (THOMPSON-MC-T3324 @Al@SASRS2)

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INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 12:30pm EST

To: See Below

From: Neguib M. Hassan (HASSAN-NM-L2267 AT A1 AT SASR52)
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : x5-5765

RE: Good News About Mixing Tests

The second impeller in our small tank is currently located 14 inches from the bottom of the tank and it can be moved up/down. In the prelimenary test runs, we collected data at 6, 8 and 12 inches with one set of impeller and found that no organic is detectable at the 12 inch level even when the initial concentration of organic was 8% volume. In the current runs, we raised the liquid level above the second impeller to see the effect. As I mentioned we can locate the second impeller at any point in the shaft and repeat an experiment. Thanks for the information

Distribution:

To: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52)

CC: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLSRP1)
CC: Charlene B. Cochran
(COCHRAN-CB-06921 AT A1 AT SASRS2)
CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HO010 AT A1 AT SLSRP1)
CC: Lee Hyder (HYDER-ML-T3258 AT A1 AT SLSRP1)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT A1 AT SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 @A1@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT A1 AT SLSRP1)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)
CC: David F Chostner (CHOSTNER-DF-03090 @A1@SASR52)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT A1 AT SLSRP1)
CC: Jim Knight (KNIGHT-JR-T3559 AT A1 AT SLSRP1)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT A1 AT SLSRP1)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @A1@SASRS2)
CC: Major C. Thompson (THOMPSON-MC-T3324 @A1@SASR52)

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INTER-OFFICE MEMORANDUM
Savannah River Site

30-Aug-1994 03:35pm EST

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52)
Dept: NMPD Safety Documentation
Tel : 2-3319

See Attached

It looks like it will be a long time before we have anything conclusive on O/A sampling reliability from SRTC. As Dave has suggested, an in-canyon test is still probably our best bet to get useful information anytime soon.

Diatribution:

To: Andrew P. Mock (MOCK-AP-L0498 AT A1 AT SASR52)
To: Charlene B. Cochran
(COCHRAN-CB-06921 AT A1 AT SASRS2)
To: Renee H. Spires (SPIRES-RH-06630 AT A1 AT SASRS2)
To: David F. Chostner
(CHOSTNER-DF-03090 AT A1 AT SASR52)
To: Ray Lux (LUX-CR-T7244 QA1QSLSRP1)
To: Eric V. Browne (BROWNE-EV-Y8089 QA1QSLSRP1)
To: J. Stuart Evans (EVANS-JS-07266 AT A1 AT SASRS2)

INTER-OFFICE MEMORANDUM
Savannah River Site

04-Aug-199408:26am FDT

To: Eric V. Browne (BROWNE-EV-Y8089 eAlQSLSRPl)

CC: Charlene B. Cochran
(COCHRAN-CB-06921 AT Al AT SASRS2)
CC: Ronnye A. L. Eubanks
(EUBANKS-RA-06258 AT Al AT SASRS2)
CC: David F. Chostner
(CHOSTNER-DF-03090 AT Al AT SASRS2)

From: Sandra H. Marek (MAREK-SH-07923 AT Al AT SASRS2)
Dept: NMPD/SEP TECH.
Tel : 9524199

8 5 Evaporator Information

Attached is the information you reque~ted for 8.5E. Bryan, one of our STE's, reviewed some blueprints to perform the calculations and verified/corrected the numbers I gave you off the top of my head on Tuesday. I'll call you later today to discuss these numbers and some of your other assumptions.

INTER-OFFICE MEMORANDUM
Savannah River Site

03-Aug-1994 05:28am EDT

To: Sandra H. Marek (MAREK-SH-07923 AT A1 AT SASRS2)

From: Bryan K. Altringer
(ALTRINGER-BK-Y5558 AT A1 AT SASRS2
Dept: SEP TECH
Tel : 952-2153

<u>Info you requested (U)</u>

OK...
By now you should have found the four prints I left you. Hope they are helpful. Sorry about the poor quality of the one showing the trays.

1. The overflow wier is at 96.7", or 15,360 lb water

2. Typical steam rates for 8.5E are 13,500 lb/hr to 16,500 lb/hr (or 15,000+/-1500 lb/hr). It's unusual to see it run outside this range. I normally assume 15,000 lb/hr as the normal rate.

3. Time to lose 1 ft level....this is a fun one.

Assumptions: 15,000 lb/hr steam 90% efficiency (0.9 lb evap per lb steam) initial liquid level at wier height, 96.7" sp gr at 1.0 (this made it easier for me)

Calculations:
Feed rate = (15,000 lb/hr)(0.9) = 13,500 lb/hr
Final liquid level = 96.7" - 12" = 84.7"
Final pounds = ~11,634 lb (per calib chart)

Pounds depletion = 15,360 lb - 11,634 lb
= 3726 lb

Time = (3726 lb)/(13,500 lb/hr) = 0.26 hr
= 16.56 minutes (How 'bout those sig figs!)

NOTE: You know as well as I do how the lb/in varies so much in a continuous evaporator. Ultimately, this calculation is only one of many possibilities for the evaporator...

4. The typical length of a run:

Assumptions:
Full 8.7 at 146,797 lb water
Heel of 36,000 lb water
Typical run rate = 13,500 lb/hr feed

Time = (146,797 lb - 36,000 lb)/(13,500 lb/hr)
8.2 hr

If you count startup and shutdown heating and cooling times (while the evaporator above 80 deqrees C), Ronnve mav have been able to stretch it to 16 hours. I do not believe we could have gotten 16 hours on feed.

5. How far down 'till we uncover the tube bundle? A quickie roundabout calculation based on the prints lead~ me to believe that we could go down as far as 1.5 ft below wier level before uncovering tubes. Unfortunately, this number sounds funny to me. Check it out.

6. Distance between the bottom of the de-entrainment column and the bottoms of the reboiler looks to be about 4.5 feet based on the prints. You can check it out yourself.

I didn't have time to look into any of the instrumentation stuff. I saw the alarm light you saw for the "low hat flow," but that's all I saw.

Havefun...

INTER-OFFICE MEMORANDUM
Savannah River Site

08-Mar-1995 10:31am EST

To: Thomas G. Campbell
(CAMPBELL-TG-O5094 AT A1 AT SASRS2)
To: Ray Lux (LUX-CR-T7244 @A1@SLSRP1)

CC: Dave H Ecklund
(ECKLUND-DH-L1695 AT A1 AT SASRS2)
CC: David F. Chostner
(CHOSTNER-DF-O3090 AT A1 AT SASRS2)

From: Ronnye A. L. Eubanks (EUBANKS-RA-O6258 AT A1 AT SASRS2 fi
Dept: SEP TECH/NMPD
Tel : 2-4074

Solvent additions (U)

Years ago I summarized the amount of solvent added to each cycle. The data I used was from Maurice Meadows records from 1970-1985. This is what I came up with:

Average solvent (n-Paraffin plus TBP) added to:

1st Cycle - 30,500 pounds/year
2nd Pu - 13,200 pounds/year
2nd U - 18,700 pounds/year

Average pounds of solvent/MTU processed through 1st cycle:

1st Cycle - 28 pounds/MTU
2nd Pu - 13 pounds/MTU
2nd U - 17 pounds/MTU

On average the n-paraffin and TBP addition was at 30 vol% TBP. I assumed the TBP lost to solubility in the aqueous was about equal to the evaporation rate of the n-paraffin. Solvent lost to entrainment (or oops) would have been at approximately 30 vol% TBP.

Tom, I hope this is what you told me Ray needed. If not, I will try again.

Ronnye

APPENDIX B - DIAGRAMS

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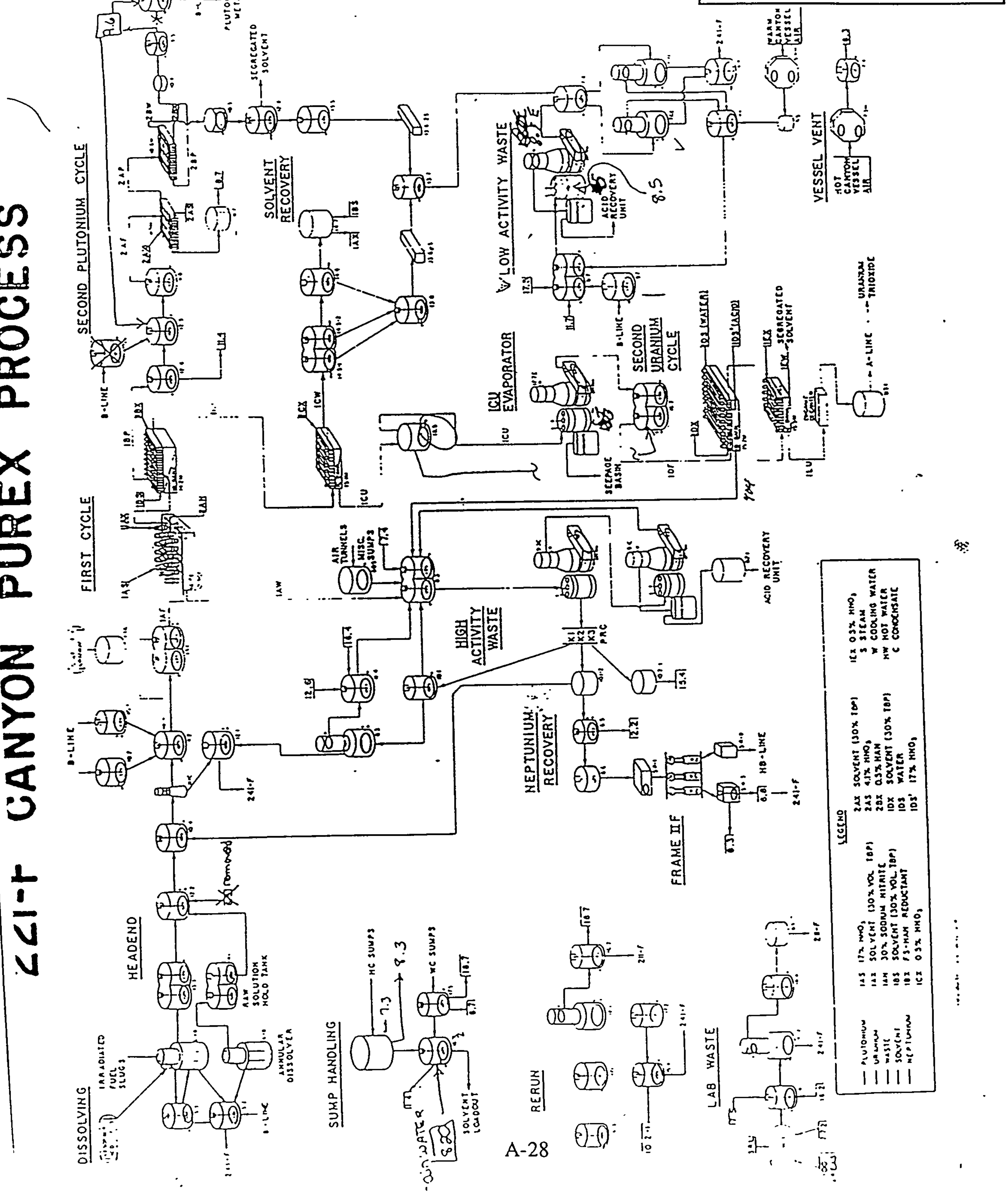

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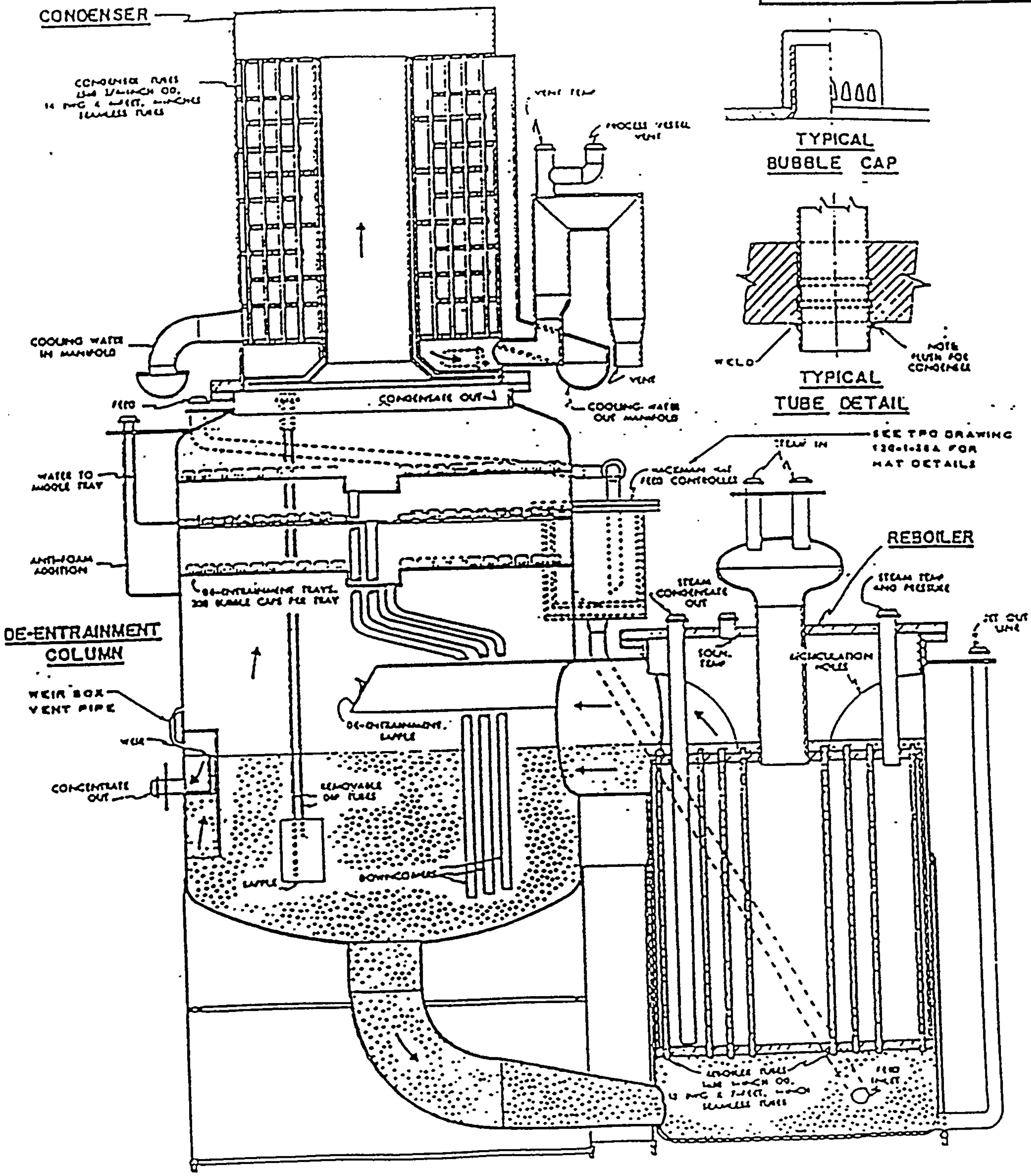

Schematic of Continuous Evaporator

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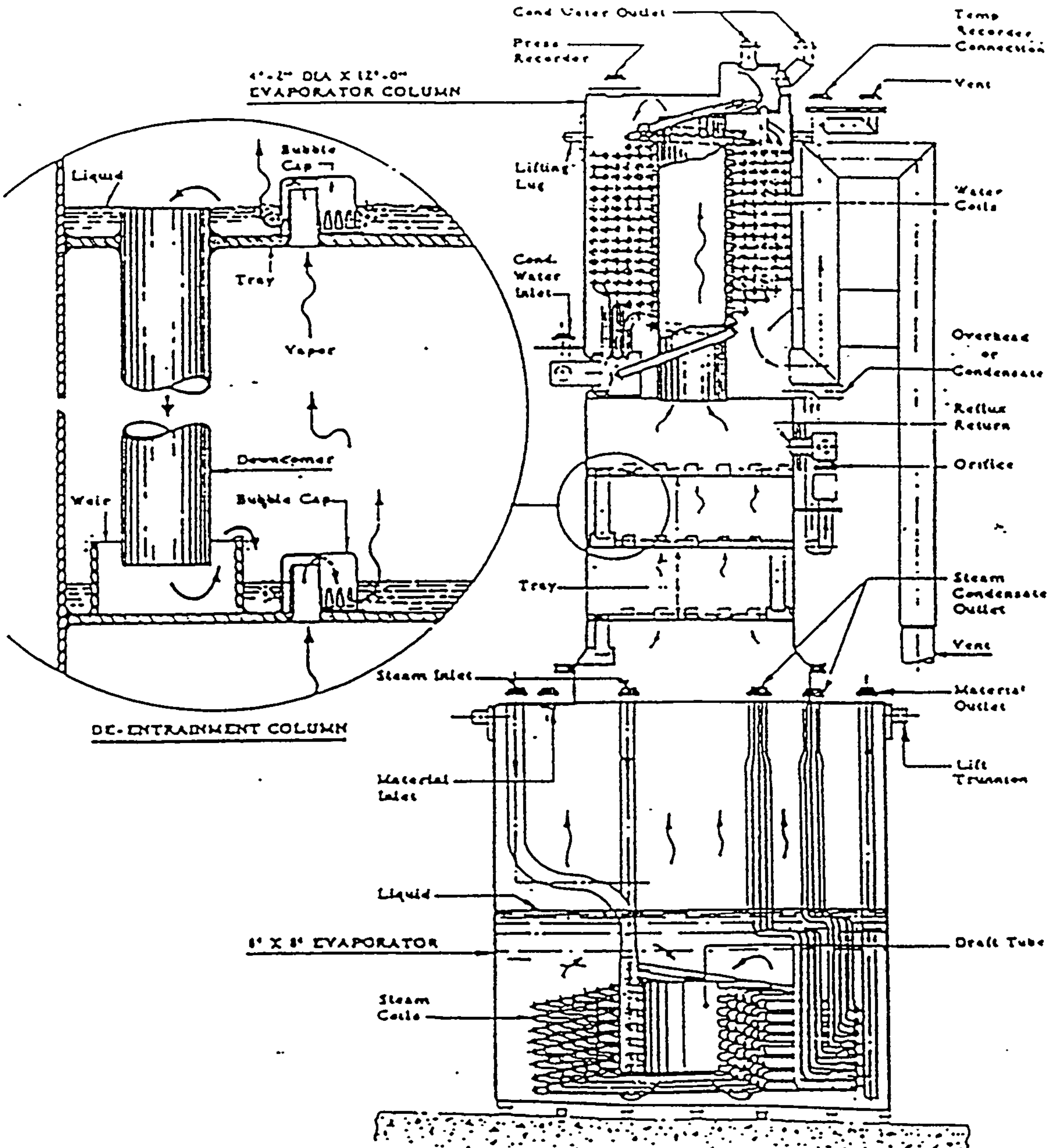

Standard Coil Batch Evaporator and Column

APPENDIX C - TABULATION OF HUMAN ERROR EVENTS

The following Appendix contains a tabulation of the human error events for the evaporators considered (8.5E, 9.3E and 7.6E-7.7E). It gives the event names and descriptions of the human error events, as well as information on the probability of human error (Ref. 7). It also contains information on applicable procedures, and actions/equipment involved in the event where necessary.

TASK #	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
	Items A-D are not explicitly modeled in the fault tree. They are commitments the facility must implement in order for the assumptions in the analysis to remain valid										
A	open item 4		The solvent hold tanks (14.7, 906) inventory will be administratively controlled to prevent losses in excess of 10,000 lbs of organic.							(new procedure/requirement).	
B	open item 5		During start-up, evaporators will not be operated until levels in solvent hold tanks have stabilized (steady state).							(new procedure/requirement).	
C	open item 6		Any actuation of the solvent hold tank's (906, 14.7) low level interlock, or discovery of large solvent losses, will require the evaporators to be shut down until accountability of the solvent inventory is performed.							(new procedure/requirement).	
D	open item 7		Solvent hold tank operator (906, 14.7) will ensure that the solvent feed pump (to banks) is shut off if the low level interlock is demanded.							(new procedure/requirement).	
		NEW BRANCH EVENTS SPECIFIC TO THIS TREE									

TASK #	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
	ALL COMMITMENTS FOR THE BATCH EVAPORATOR ARE APPLICABLE TO THE CONTINUOUS EVAPORATOR										
3	ok	OPRCELE-MCNA	Calibration error- Level instrument is calibrated to give a high signal	(8.5E level it can't be too far off because the evap overflows at a known level.)	E&I techn with Operations check	x-mitter & recorder (WZ-19)			0.005	W-770005 (x-mitter); W-798003 (recorder)	
7	ok	OPRGCETEMCNA# consider change to OPRGCETEIRNA#	Evaporator temperature sensor is out of calibration		E&I techn with Operations check	Molytek			consider p=0.01; else 0.005	Molytek	Molytek may be a non-calibratable IPI; event may need to be re-modeled (as a programming data entry error p=0.01).
12	No HRA performed Open Item 15	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch		Rerun operator					No procedure exist (tranfer 17.5 to 8.7) Must include step restricting to only one transfer every 72 hours	Ensures that two full tanks of sump receipt material are not transferred during one evaporator cycle.
14	No HRA performed Open Item 8	OPR87EM1ACNA#	operator fails to feed remaining tank contents at end of 1st interval- clean out						1.0 til added (then p=0.005)	New Procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
15	No HRA performed Open Item 8	OPR87EM2ACNA#	operator fails to feed remaining tank contents at end of 2nd interval- clean out						1.0 til added (then p=0.005)	New Procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic

TASK #	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
16	No HRA performed Open Item 8	OPR87EM3ACNA#	operator fails to feed remaining tank contents at end of 3rd interval- clean out						1.0 til added (then p=0.005)	New Procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
18	OMITTED										
20	Open Item 3	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level alarm (close block valve)	alarm acknowledgement, verify no steam flow	LAW operator and Bldg operator				0.01		
26	Open Item 1 setpoints	OPRTK906ACNA# change to OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	acknowledge alarm; shutdown process	OF-CR operator; 2nd Pu cycle operator	Outside facilities; CCR	OF-CR occupied at all times	N[illegible] [illegible] setpoints need to be fixed for both LOW-LEVEL and LOW LOW-LEVEL alarms	0.5 until fixed (then p=0.01)	SOP 211-F-1221 Steps 5.5.1 (LOW), 5.6.1 (LOW LOW-LVL)	(Pump cavitation stops transfer) If no response from Canyon Supervisor, OF will shutdown process within 15 min. (avoid pump cavitation). Credit (0.5) given because of training & alert for pump cavitation
27	ok	OPR906LEMCNA#	Calibration error - level instrument is calibrated to give a false reading		single E&I tech ; Op check	Outside facilities	at tank 906		0.005		This could/would be a relative amount instead of an absolute
54	Open Items 4,5	OPRLV906ACNA#	Operator overfills tank 906 (Level procedurally controlled)	implies an inventory control at regular intervals at various points in the cycle	2nd Pu cycle operator and OF Operator	CCR and Outside Facil. CR			re-modeled with various HEPs	this event needs to be further developed & modified to include (events to the right):	the first response (2nd Pu cycle operator shuts down cycle); LAW operator shuts down evaporator; and maybe Solvent Recovery operator troubleshooting if Solvent recovery cycle is involved

TASK #	COMMITMENT	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
	Items A-D are not explicitly modeled in the fault tree. They are commitments the facility must implement in order for the assumptions in the analysis to remain valid.										
A	open item 4		The solvent hold tanks (14.7, 906) inventory will be administratively controlled to prevent losses in excess of 10,000 lbs of organic.							(new procedure/requirement).	
B	open item 5		During start-up, evaporators will not be operated until levels in solvent hold tanks have stabilized (steady state).							(new procedure/requirement).	
C	open item 6		Any actuation of the solvent hold tank's (906, 14.7) low level interlock, or discovery of large solvent losses, will re quire the evaporators to be shut down until accountability of the solvent inventory is performed.							(new procedure/requirement).	
D	open item 7		Solvent hold tank operator (906, 14.7) will ensure that the solvent feed pump (to banks) is shut off if the low level interlock is demanded.							(new procedure/requirement).	
1	ok	OPR147LEMCNA#	Calibration error - Level instrument is calibrated to give a false reading -14.7		E&I technician	transmitter; recorder			0.005	SOP W-794001 (transmitter); W-798003 (recorder)	

TASK #	COMMITMENT	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	BEP	PROCEDURE	NOTES
2	open item 1 setpoints	OPRRA147ACNA# change to OPRRA147CSNA#. name changed to DOPRA147CSNA# (dependent event) in part of tree (dep. on OPRTK147ACNA#)	Operator fails to respond to level in tank 14.7		solvent recovery operator, CCR		annun tile and orange status light for "14.7 Lo Level" WS-23) (WT-1A)		0.02 (0.15 for dependent) assuming procedure is written, otherwise 0.5	NO ARP exists (there were & may still be operator aids on the panel boards that indicate wgt ftr when pump loses prime)	
18	no HRA performed, open item 8	OPR83EM1ACNA#	operator fails to feed tank contents after 1st interval- clean tank						1 until added (then p=0.005)	New procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
19	no HRA performed, open item 8	OPR83EM2ACNA#	operator fails to feed tank contents after 2nd interval- clean tank						1 until added (then p=0.005)	New procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
20	no HRA performed, open item 8	OPR83EM3ACNA#	operator fails to feed tank contents after 3rd interval- clean tank						1 until added (then p=0.005)	New procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
25	no HRA performed, open item 10	OPRQ7.3-ACNA#	second consecutive transfer containing TBP from tank 7.3 is fed to same batch		HAW				0.005	SOP 221-F-40790 should be modified or new procedure written to prohibit 2 transfers within 72 hours	
26	OMITTED										
27	open items 3	OPRQBLOCDENA#	operator fails to respond to 9.3E temp, level alarms (close block valve)	alarm acknowledgement, verify no steam flow	HAW				0.01		
28	ok	OPRQCBTEIRNA#	Evaporator temperature sensor is out of calibration		E&I	Molytek			0.01	Molytek	

TASK #	COMMITMENT	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
31	ok	OPRQELE-MCNA#	Calibration error-Level instrument is calibrated to give a high signal		E&I Tech. with operations check				0.005	W-770005 (x-mitter); W-798003 (recorder);	
35	open items 4,5	OPRTK147ACNA#	operator overfills tank 14.7 (level procedurally controlled)	implies an inventory control at regular intervals at various points in the cycle	HAW				0.005	new procedure	

TASK#	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
	Items A-D are not explicitly modeled in the fault tree. They are commitments the facility must implement in order for the assumptions in the analysis to remain valid.										
A	open item 4		The solvent hold tanks (14.7, 906) inventory will be administratively controlled to prevent losses in excess of 10,000 lbs of organic.							(new procedure/requirement).	
B	open item 5		During start-up, evaporators will not be operated until levels in solvent hold tanks have stabilized (steady state).							(new procedure/requirement).	
C	open item 6		Any actuation of the solvent hold tank's (906, 14.7) low level interlock, or discovery of large solvent losses, will require the evaporators to be shut down until accountability of the solvent inventory is performed.							(new procedure/requirement).	
D	open item 7		Solvent hold tank operator (906, 14.7) will ensure that the solvent feed pump (to banks) is shut off if the low level interlock is demanded.							(new procedure/requirement).	

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TASK#	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
2	Open Item 3	OPRBBLOCCSNA# \change to OPRBBLOCDENA#	Operator fails to respond to 7.6E temp. alarm (close block valve)	alarm acknowledgement; intiates "221-F-ARP-WX-10-1"; CRO asks Bldg Op to initiate SOP; (may not need to close this BV every time)	LAW operator & Bldg operator	alarm/ annunciator tile (WX-10-1); manual 3 inch valve in piping corridor; don't dress out	alarm/ red light in CCR "OSR 7.6E HI POT TEMP"; in field - rising vlv stem & no position labels; "righty-tighty"; "DIAGNOSIS would include looking at steam flow indicator to see that steam has stopped"	Awareness of what needs to be done; fail to close all the way; CCR Op fails to call Bldg Op when he should have	change to p=0.01	SOP-221-F-40811 Step 4.4; then SOP 221-F-20050 Step 4.2.2;) ADD steam flow diagnosis criterion TO THESE PROCEDURES)	fails to shut off steam; Interlock has to have failed- he needs to diagnose this (should get "OSR 7.6E HI POT TEMP" alarm)
3	ok	OPRGBETEMCNA#	Tank Temperature sensor is miscalibrated	whole temp loop cal; yields false low	single E&I tech; ops checks the functionality	sensor in 7.6 tank in Warm Canyon; transmitter on 2nd Level, recorder in CCR			0.005	for Molytek	to check- look for "100C" boiling- can tell if cal is "off"
5	Open Item 11	OPRG7.8-DEHA# change to OPRG7.8-ACHA#	Operator fails to assure SPG is within range	reading spg at tank 7.8 during decanting procedure; he expects & looks for the "break"	LAW operator; SUPVPERM keylock to jet to transfer	CCR panel	spg meter; graph recorder; conversion from % to sp gr required; equation below recorder	fails to recognize the break	1.0 until added, then p=0.05	NO procedure currently for this decanting	procedure to include info on "looking for the spg break"
26	Open Item 1 setpoints	OPRTK906ACNA# change to OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	acknowledge alarm; shutdown process	OF-CR operator; 2nd Pu cycle operator	Outside facilities; CCR	OF-CR occupied at all times	NOTES containing setpoints need to be fixed for both LOW-LEVEL and LOW LOW-LEVEL alarms	0.5 until fixed (then p=0.01)	SOP 211-F-1221 Steps 5.5.1 (LOW), 5.6.1 (LOW LOW-LVL)	(Pump cavitation stops transfer) If no response from Canyon Supervisor, OF will shutdown process within 15 min. (avoid pump cavitation). Credit (0.5) given because of training & alert for pump cavitation
27	ok	OPR906LEMCNA#	Calibration error - level instrument is calibrated to give a false reading		single E&I tech ; Op check	Outside facilities	at tank 906		0.005		This could/would be a relative amount instead of an absolute

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TASK#	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
54	Open Items 4, 5	OPRLV906ACNA#	Operator fills tank 906 (Level procedurally controlled)	implies an inventory control at regular intervals at various points in the cycle	2nd Pu cycle operator and OF Operator	CCR and Outside Facil. CR			re-modeled with various HEPs	this event needs to be further developed & modified to include (events to the right):	the first response (2nd Pu cycle operator shuts down cycle); LAW operator shuts down evaporator; and maybe Solvent Recovery operator troubleshooting if Solvent recovery cycle is involved
61	OMITTED										
62	No HRA performed Open Item 8	OPR87EM1ACNA#	operator fails to feed tank contents after 1st interval-clean tank						1.0 til added (then p=0.005)	New procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
63	No HRA performed Open Item 8	OPR87EM2ACNA#	operator fails to feed tank contents after 2nd interval-clean tank						1.0 til added (then p=0.005)	New procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic
9	No HRA performed Open Item 8	OPR87EM3ACNA#	operator fails to feed tank contents after 3rd interval-clean tank						1.0 til added (then p=0.005)	New procedure required to clean (empty out) feed tank periodically to prevent accumulation of organic	prevents accumulation of organic

TASK#	COMMITMENTS	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT	FEEDBACK/ INDICATION	ERRORS	HEP	PROCEDURE	NOTES
11	No HRA performed Open Item 10	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch		Rerun operator					No procedure exists (transfer 17.5 to 8.7) Must include step restricting to only one transfer every 72 hours	Ensures that two full tanks of sump receipt material are not transferred during one evaporator cycle.

APPENDIX D - 8.5E EVAPORATOR FAULT TREE AND DATA

The following abbreviations appear on the fault tree print out and in the basic event file for the fault tree:

FR=Failure Rate

a:= assumption

COG= cognizant engineer estimate/information

TRUNC= Truncation limit of cutset evaluator

The Beta Factor method used to estimate common cause alarm failure is explained in Reference 15.

NOTE: Events in this tree with a probability of "1E-32" are incredible. They do not contribute to the top event frequency and were included only to show that they had been considered. The number "1E-32" was used because it is the smallest number CAFTA is capable of handling.

Fault Tree (Page 41)

Gate/Event Cross Reference (Page 57)

Cutset Report (Page 58)

Basic Event Data (Page 68)

Type Code Data (Page 70)

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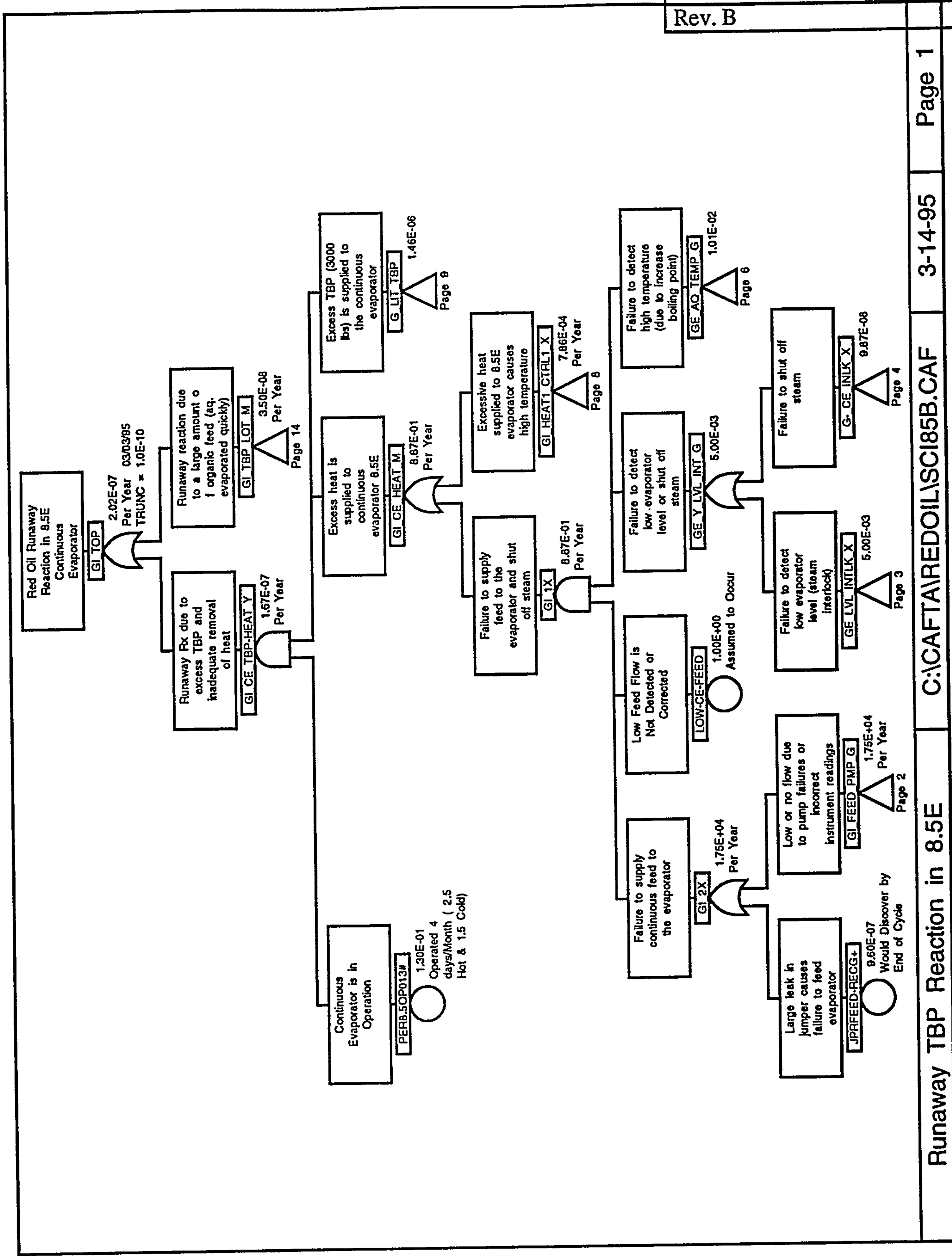

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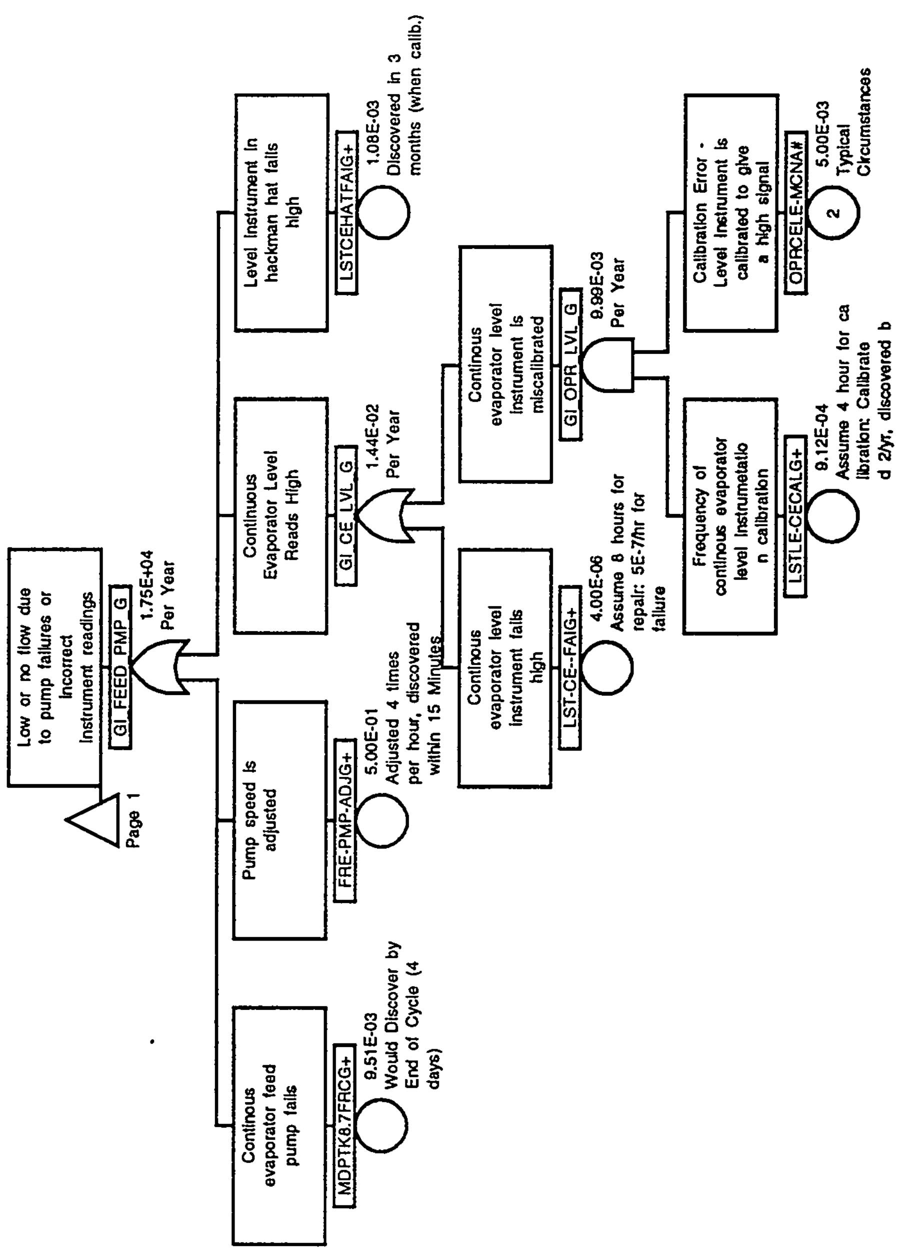

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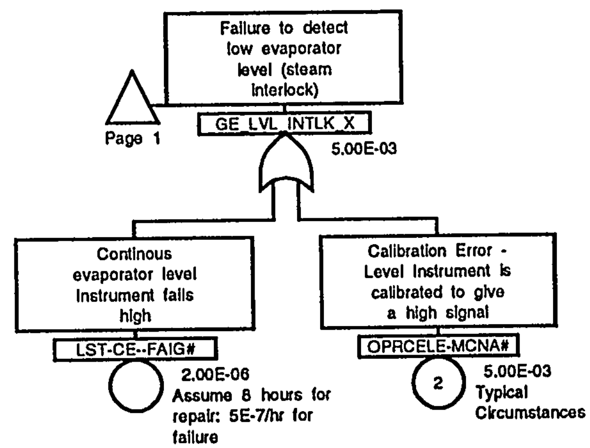

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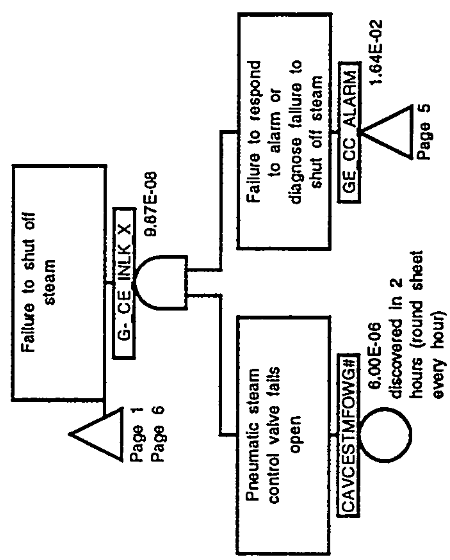

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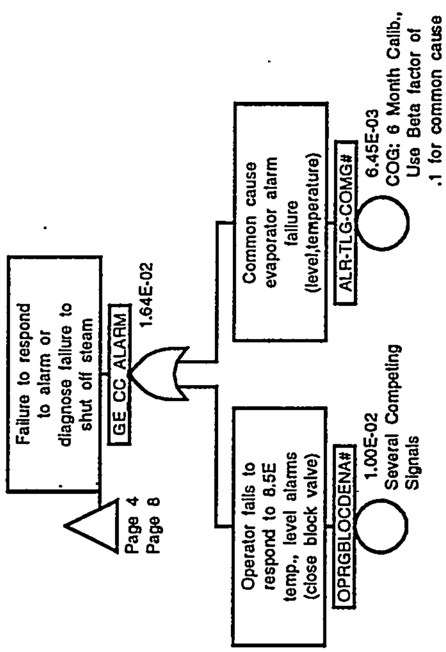

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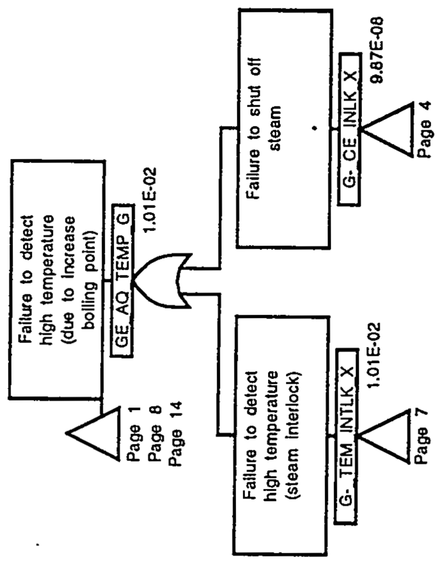

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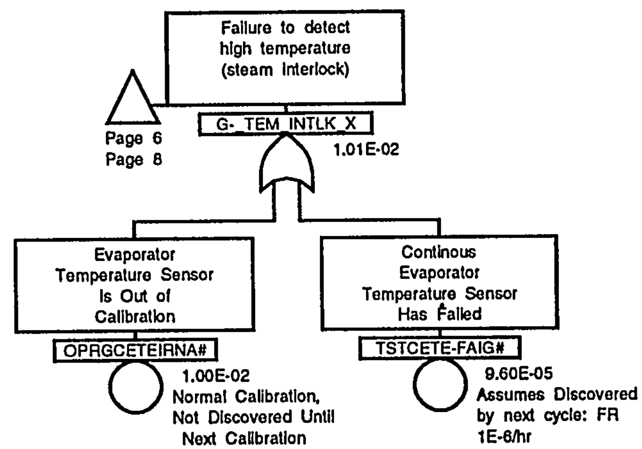

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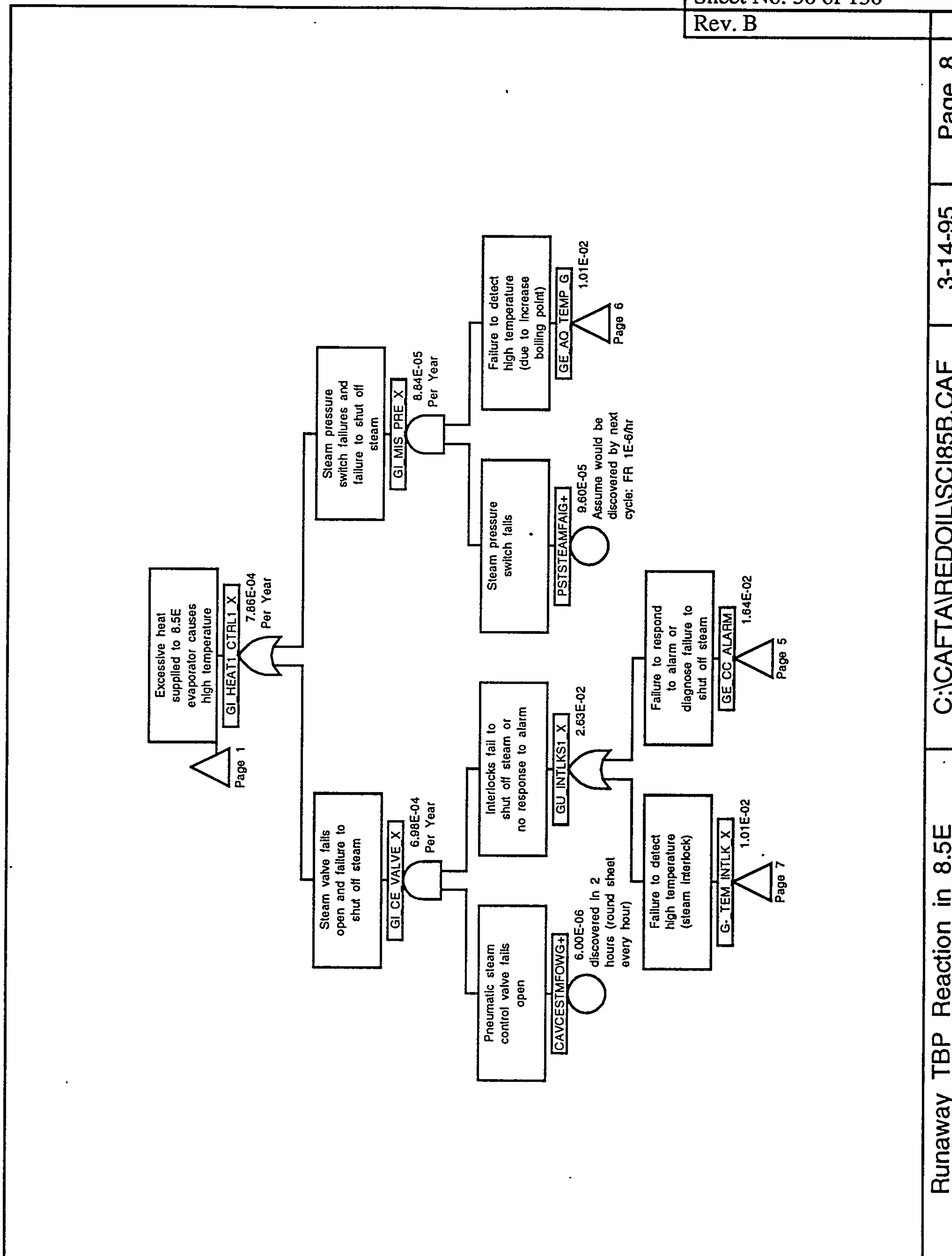

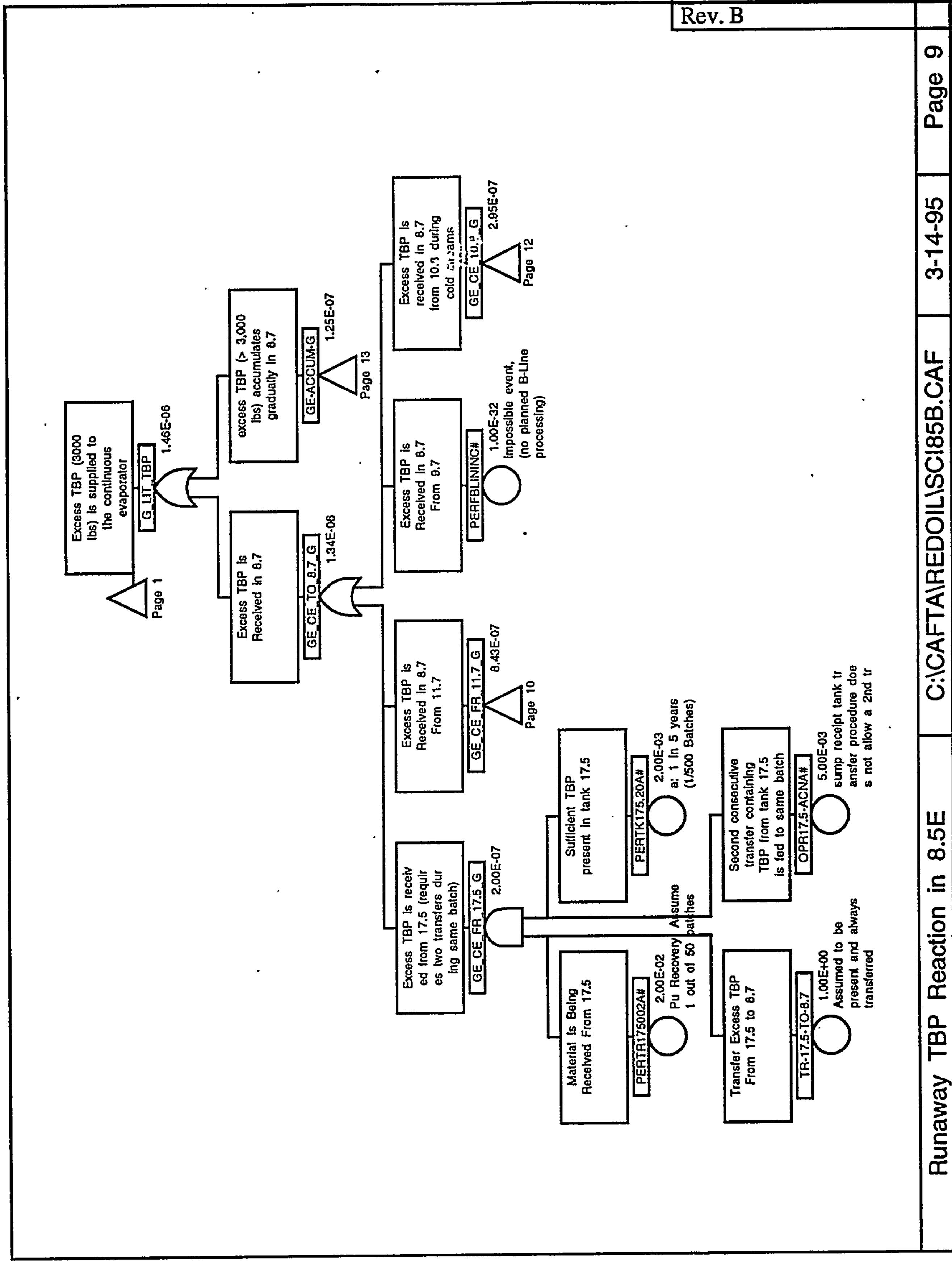
Excess TBP (3000 lbs) is supplied to the continuous evaporator
G_LIT_TBP
1.46E-06
Page 1
Excess TBP is Received in 8.7
GE_CE_TO_8.7_G
1.34E-06
excess TBP (> 3,000 lbs) accumulates gradually in 8.7
GE-ACCUM-G
1.25E-07
Page 13
Excess TBP is received in 8.7
2.95E-07
Page 12
Excess TBP is Received in 8.7 From 9.7
PERFBLININC#
1.00E-32
Impossible event, (no planned B-Line processing)
Excess TBP is Received in 8.7 From 11.7
GE_CE_FR_11.7_G
8.43E-07
Page 10
Excess TBP is receiv ed from 17.5 (requir es two transfers dur ing same batch)
GE_CE_FR_17.5_G
2.00E-07
Sufficient TBP present in tank 17.5
PERTK175.20A#
2.00E-03
a: 1 in 5 years (1/500 Batches)
Second consecutive transfer containing TBP from tank 17.5 is fed to same batch
OPR17.5-ACNA#
5.00E-03
sump receipt tank tr ansfer procedure doe s not allow a 2nd tr
Material is Being Received From 17.5
PERTR175002A#
2.00E-02
Pu Recovery Assume 1 out of 50 batches
Transfer Excess TBP From 17.5 to 8.7
TR-17.5-TO-8.7
1.00E+00
Assumed to be present and always transferred
Runaway TBP Reaction in 8.5E
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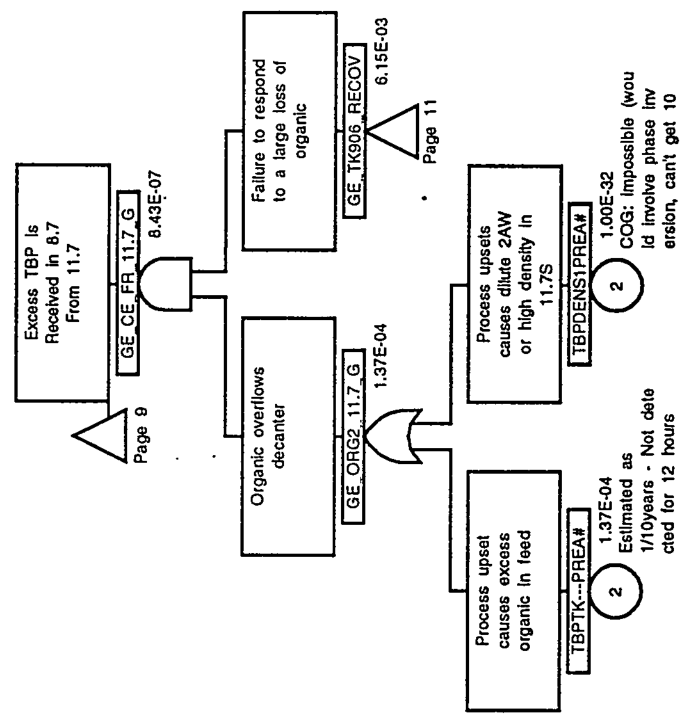

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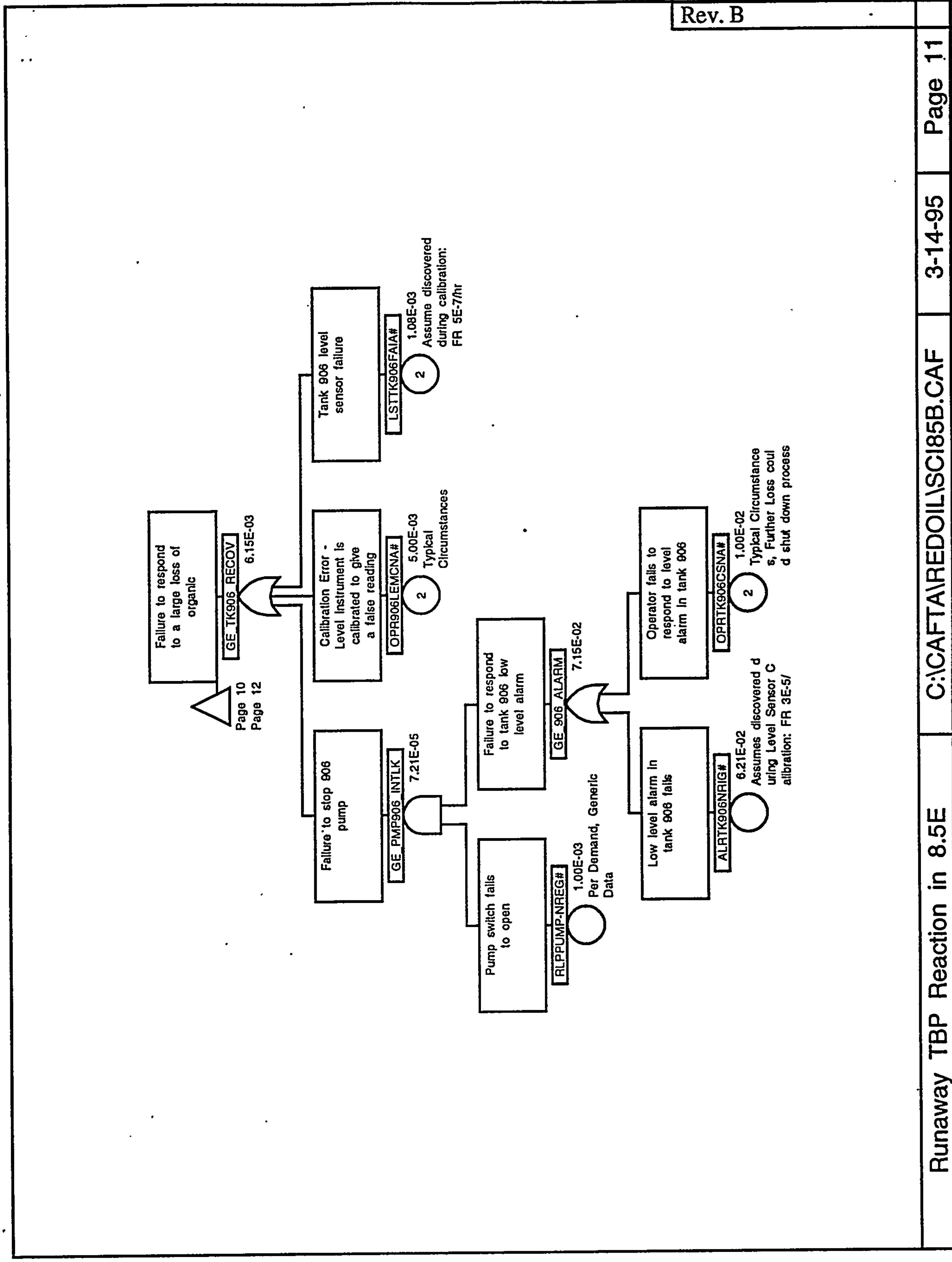

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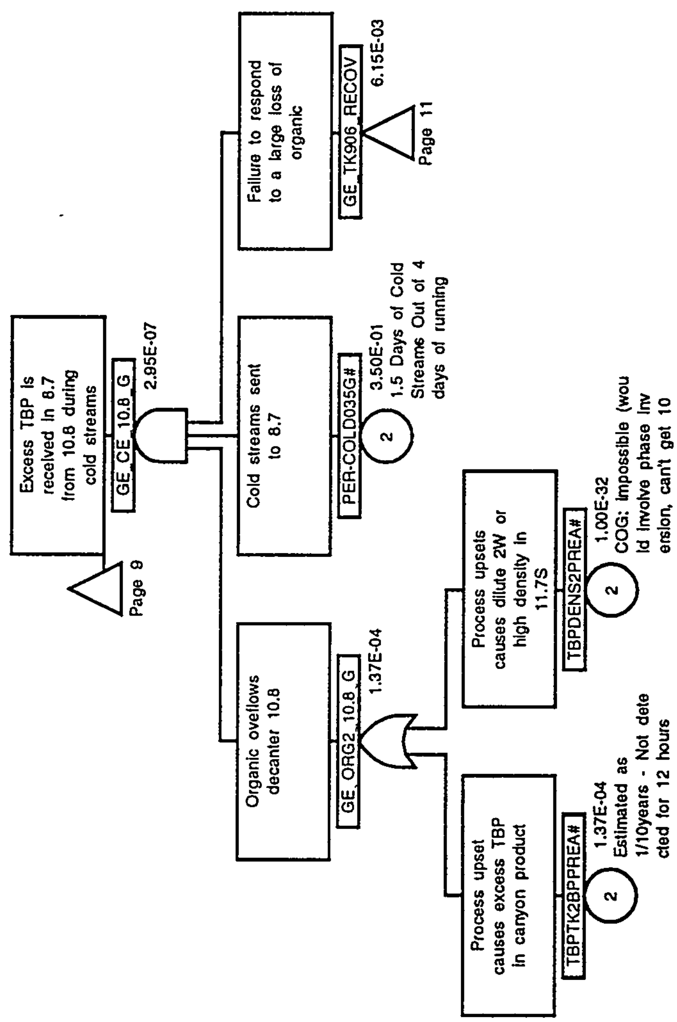

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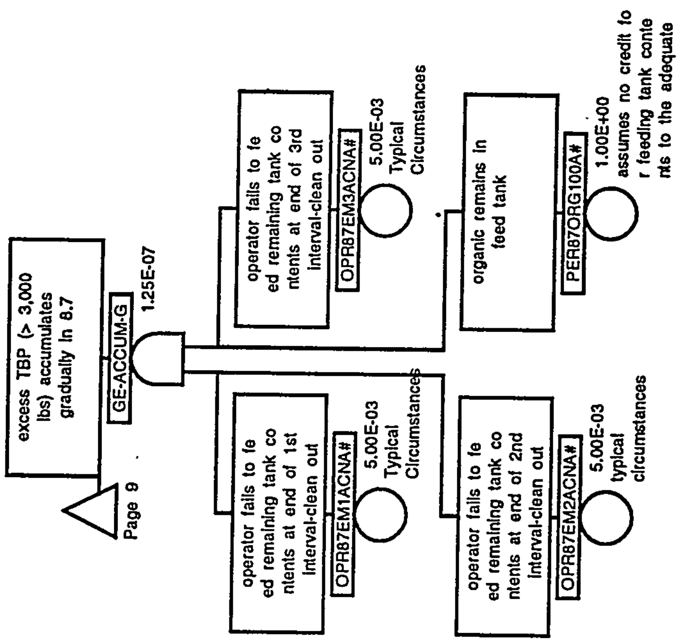

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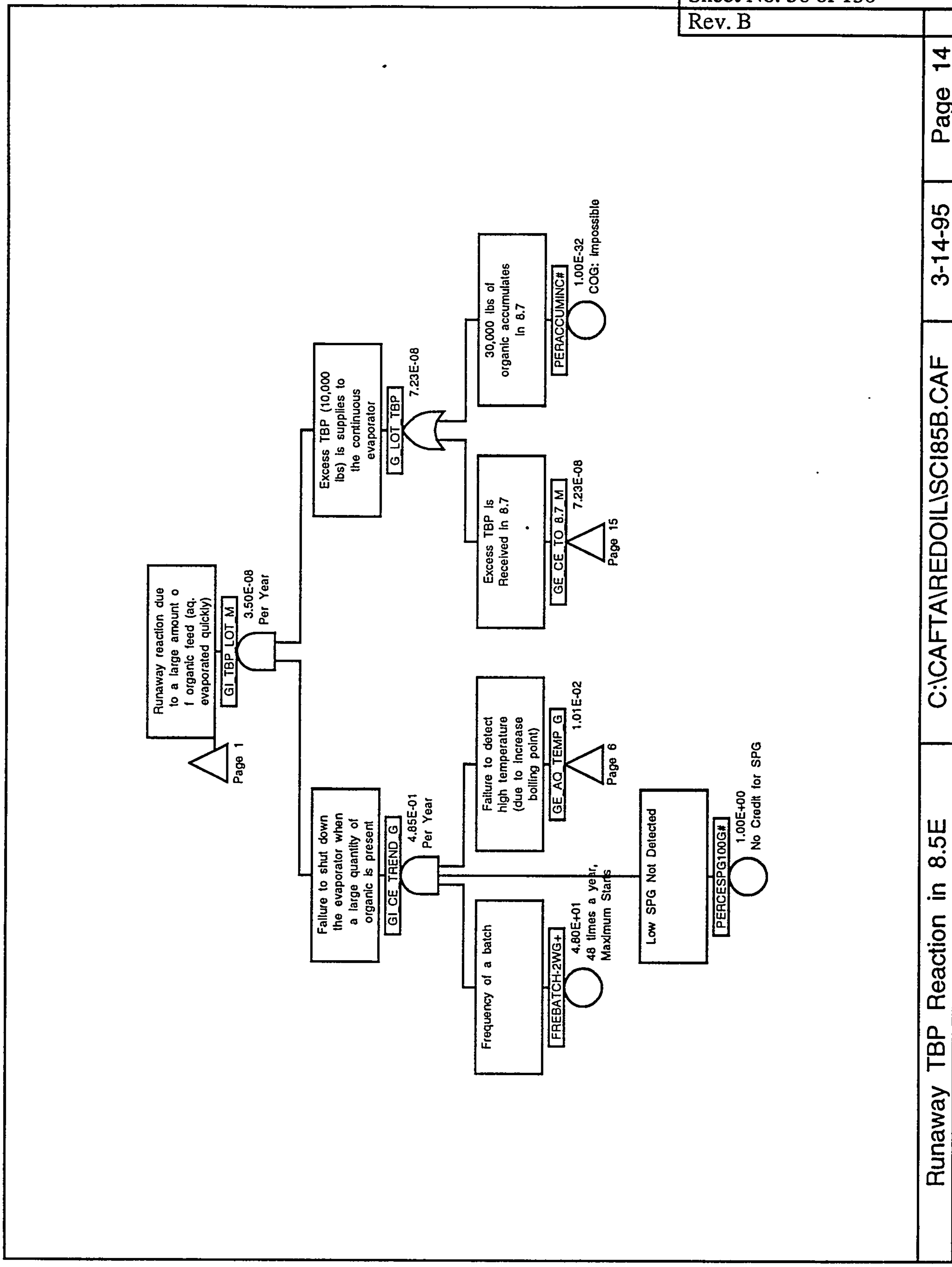
Runaway reaction due to a large amount o f organic feed (aq. evaporated quickly)
GI_TBP_LOT_M
3.50E-08 Per Year
Page 1
Excess TBP (10,000 lbs) is supplies to the continuous evaporator
G_LOT_TBP
7.23E-08
30,000 lbs of organic accumulates in 8.7
PERACCUMINC#
1.00E-32
COG: Impossible
Excess TBP is Received in 8.7
GE_CE_TO_8.7_M
7.23E-08
Page 15
Failure to shut down the evaporator when a large quantity of organic is present
GI_CE_TREND_G
4.85E-01 Per Year
Failure to detect high temperature (due to increase boiling point)
GE_AQ_TEMP_G
1.01E-02
Page 6
Low SPG Not Detected
PERCESPG100G#
1.00E+00
No Credit for SPG
Frequency of a batch
FREBATCH-2WG+
4.80E+01
48 times a year, Maximum Starts
Runaway TBP Reaction in 8.5E
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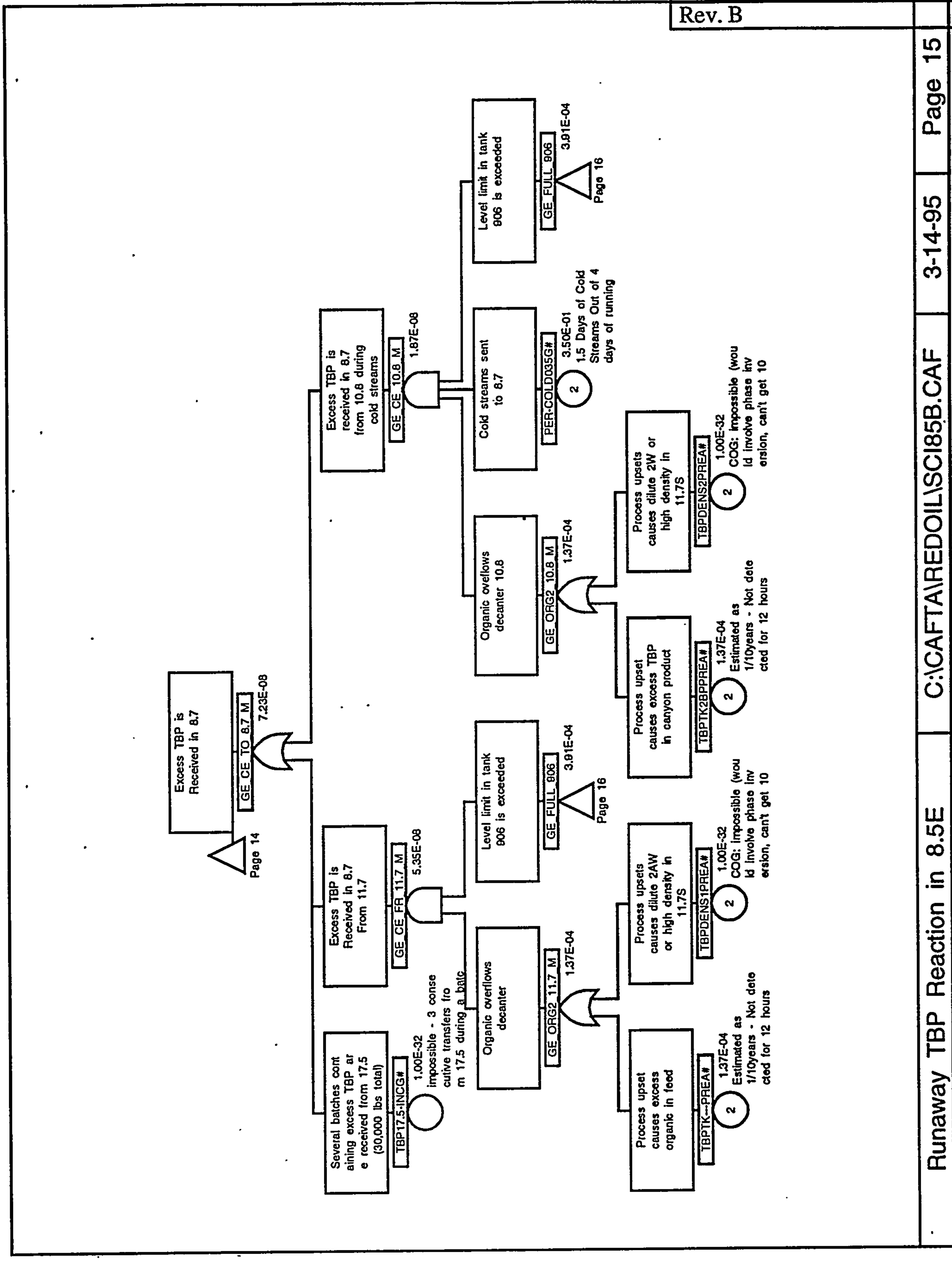

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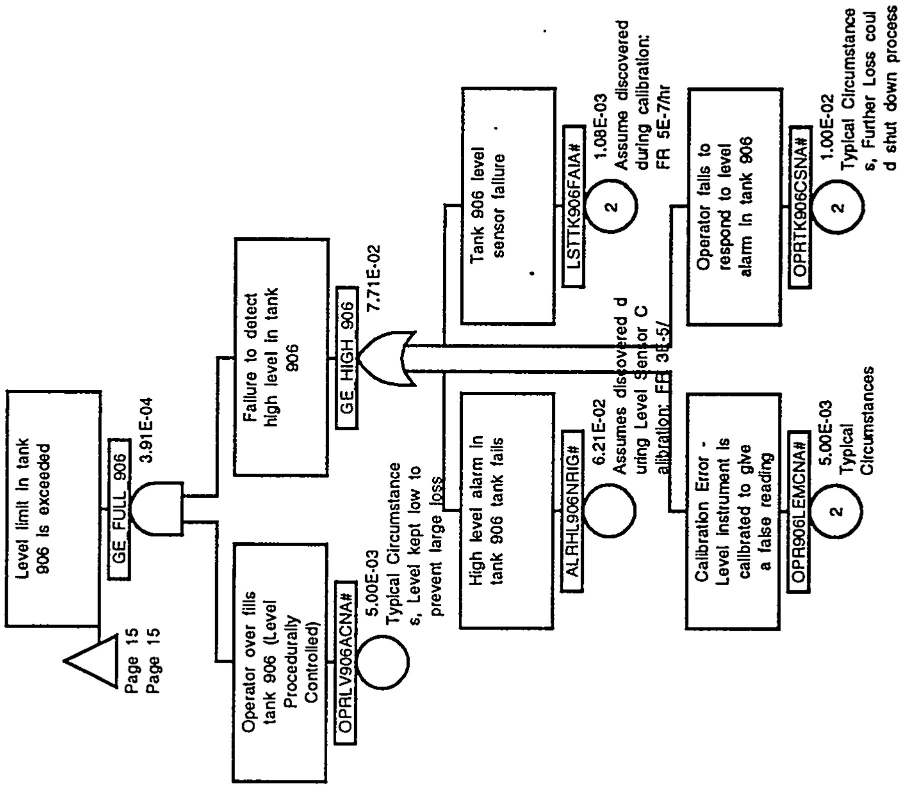

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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
ALR-TLG-COMG#	5		GE_LVL_INTLK_X	3		MDPTK8.7FRCG+	2				
ALRHL906NRIG#	16		GE_ORG2_10.8_G	12		OPR17.5-ACNA#	9				
ALRTK906NRIG#	11		GE_ORG2_10.8_M	15		OPR87EM1ACNA#	13				
CAVCESTMFOWG#	4		GE_ORG2_11.7_G	10		OPR87EM2ACNA#	13				
CAVCESTMFOWG+	8		GE_ORG2_11.7_M	15		OPR87EM3ACNA#	13				
FRE-PMP-ADJG+	2		GE_PMP906_INTLK	11		OPR906LEMCNA#	11				
FREBATCH-2WG+	14		GE_TK906_RECOV	10		OPR906LEMCNA#	16				
G-_CE_INLK_X	1		GE_TK906_RECOV	11		OPRCELE-MCNA#	2				
G-_CE_INLK_X	4		GE_TK906_RECOV	12		OPRCELE-MCNA#	3				
G-_CE_INLK_X	6		GE_Y_LVL_INT_G	1		OPRGBLOCDENA#	5				
G-_TEM_INTLK_X	6		GI_1X	1		OPRGCETEIRNA#	7				
G-_TEM_INTLK_X	7		GI_2X	1		OPRLV906ACNA#	16				
G-_TEM_INTLK_X	8		GI_CE_HEAT_M	1		OPRTK906CSNA#	11				
GE-ACCUM-G	9		GI_CE_LVL_G	2		OPRTK906CSNA#	16				
GE-ACCUM-G	13		GI_CE_TBP-HEAT_Y	1		PER-COLD035G#	12				
GE_906_ALARM	11		GI_CE_TREND_G	14		PER-COLD035G#	15				
GE_AQ_TEMP_G	1		GI_CE_VALVE_X	8		PER8.5OP013#	1				
GE_AQ_TEMP_G	6		GI_FEED_PMP_G	1		PER87ORG100A#	13				
GE_AQ_TEMP_G	8		GI_FEED_PMP_G	2		PERACCUMINC#	14				
GE_AQ_TEMP_G	14		GI_HEAT1_CTRL1_X	1		PERCESPG100G#	14				
GE_CC_ALARM	4		GI_HEAT1_CTRL1_X	8		PERFBLININC#	9				
GE_CC_ALARM	5		GI_MIS_PRE_X	8		PERTK175.20A#	9				
GE_CC_ALARM	8		GI_OPR_LVL_G	2		PERTR175002A#	9				
GE_CE_10.8_G	9		GI_TBP_LOT_M	1		PSTSTEAMFAIG+	8				
GE_CE_10.8_G	12		GI_TBP_LOT_M	14		RLPPUMP-NREG#	11				
GE_CE_10.8_M	15		GI_TOP	1		TBP17.5-INCG#	15				
GE_CE_FR_11.7_G	9		GU_INTLKS1_X	8		TBPDENS1PREA#	10				
GE_CE_FR_11.7_G	10		G_LIT_TBP	1		TBPDENS1PREA#	15				
GE_CE_FR_11.7_M	15		G_LIT_TBP	9		TBPDENS2PREA#	12				
GE_CE_FR_17.5_G	9		G_LOT_TBP	14		TBPDENS2PREA#	15				
GE_CE_TO_8.7_G	9		JPRFEED-RECG+	1		TBPTK---PREA#	10				
GE_CE_TO_8.7_M	14		LOW-CE-FEED	1		TBPTK---PREA#	15				
GE_CE_TO_8.7_M	15		LST-CE--FAIG#	3		TBPTK2BPPREA#	12				
GE_FULL_906	15		LST-CE--FAIG+	2		TBPTK2BPPREA#	15				
GE_FULL_906	15		LSTCEHATFAIG+	2		TR-17.5-TO-8.7	9				
GE_FULL_906	16		LSTLE-CECALG+	2		TSTCETE-FAIG#	7				
GE_HIGH_906	16		LSTTK906FAIA#	11							
GE_LVL_INTLK_X	1		LSTTK906FAIA#	16							

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Cutset Report for 8.5E Evaporator

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	GI_TOP					2.02E-07	
1.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	7.80E-08	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
2.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	2.73E-08	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
3.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	2.28E-08	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N		
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N		
	TR-17.5-TO-8.7	Transfer Excess TBP From 17.5 to 8.7		1N	1.00E+00		

Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
4.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.04E-08	100.0
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
5.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	1.68E-08	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
6.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	1.42E-08	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR87EM1ACNA#	operator fails to feed remaining tank contents at end of 1st interval-clean out	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM2ACNA#	operator fails to feed remaining tank contents at end of 2nd interval-clean out	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM3ACNA#	operator fails to feed remaining tank contents at end of 3rd interval-clean out	1	1N 5.0E-3 N	5.00E-03N		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	PER87ORG100A#	organic remains in feed tank	1	1N 1.00E+00N	1.00E+00N		
7.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	7.14E-09	100.0
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y		

Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
8.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	5.89E-09	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
9.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	3.29E-09	100.0
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	OPRTK906CSNA#	Operator fails to respond to level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
10.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	1.64E-09	100.0
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		

Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
11.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	1.15E-09	100.0
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	OPRTK906CSNA#	Operator fails to respond to level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
12.	ALRTK906NRIG#	Low level alarm in tank 906 fails	5	6M 3.00E-05H	6.21E-02	9.69E-10	100.0
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	RLPPUMP-NREG#	Pump switch fails to open	1	1N 1.0E-3N	1.00E-03N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
13.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	7.49E-10	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTCETE-FAIG#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
14.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	5.75E-10	100.0

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Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
15.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	3.55E-10	100.0
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
16.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	1.96E-10	100.0
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTCETE-FAIG#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
17.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	1.24E-10	100.0
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		

Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
18.	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06	9.36E-11	100.0
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
19.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	6.86E-11	100.0
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
	TSTCETE-FAIG#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
20.	ALR-TLG-COMG#	Common cause evaporator alarm failure (level,temperature)	5	6M 3.00E-06H	6.45E-03	6.04E-11	100.0
	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06		
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
21.	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06	3.28E-11	100.0

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Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
22.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	3.16E-11	100.0
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	OPRTK906CSNA#	Operator fails to respond to level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTCETE-FAIG#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
23.	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	3.12E-11	100.0
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	LST-CE--FAIG#	Continous evaporator level instrument fails high	5	8H 5.00E-07 H	2.00E-06		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
24.	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06	2.73E-11	100.0
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		

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Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N		
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N		
	TR-17.5-TO-8.7	Transfer Excess TBP From 17.5 to 8.7		1N	1.00E+00		
25.	ALR-TLG-COMG#	Common cause evaporator alarm failure (level,temperature)	5	6M 3.00E-06H	6.45E-03	2.11E-11	100.0
	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06		
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
26.	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06	2.02E-11	100.0
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
27.	ALR-TLG-COMG#	Common cause evaporator alarm failure (level,temperature)	5	6M 3.00E-06H	6.45E-03	1.76E-11	100.0
	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06		
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		

Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N		
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N		
	TR-17.5-TO-8.7	Transfer Excess TBP From 17.5 to 8.7		1N	1.00E+00		
28.	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06	1.71E-11	100.0
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		
	OPR87EM1ACNA#	operator fails to feed remaining tank contents at end of 1st interval-clean c..	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM2ACNA#	operator fails to feed remaining tank contents at end of 2nd interval-clean out	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM3ACNA#	operator fails to feed remaining tank contents at end of 3rd interval-clean out	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	PER87ORG100A#	organic remains in feed tank	1	1N 1.00E+00N	1.00E+00N		
29.	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	1.58E-11	100.0
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCESPG100G#	Low SPG Not Detected	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTCETE-FAIG#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
30.	ALR-TLG-COMG#	Common cause evaporator alarm failure (level,temperature)	5	6M 3.00E-06H	6.45E-03	1.30E-11	100.0
	CAVCESTMFOWG#	Pneumatic steam control valve fails open	3	2H 3.00E-06 H	6.00E-06		
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01		
	LOW-CE-FEED	Low Feed Flow is Not Detected or Corrected		1.0N	1.00E+00		

Cutset Report for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		

Basic Event Data for 8.5E Evaporator

Event	C	Input	Calc.	Description	Source
ALR-TLG-COMG#	5	6M 3.00E-06H	6.45E-03	Common cause evaporator alarm failure (level,temperature)	COG: 6 Month [illegible]., Use Beta factor of .1 for common cause
ALRHL906NRIG#	5	6M 3.00E-05H	6.21E-02	High level alarm in tank 906 tank fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
ALRTK906NRIG#	5	6M 3.00E-05H	6.21E-02	Low level alarm in tank 906 fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
CAVCESTMFOWG#	3	2H 3.00E-06 H	6.00E-06	Pneumatic steam control valve fails open	discovered in 2 hours (round sheet every hour)
CAVCESTMFOWG+	4	2H 3.00E-06 H	6.00E-06	Pneumatic steam control valve fails open	discovered in 2 hours (round sheet every hour)
FRE-PMP-ADJG+	4	0.25H 4H	5.00E-01	Pump speed is adjusted	Adjusted 4 times per hour, discovered within 15 Minutes
FREBATCH-2WG+		48Y	4.80E+01Y	Frequency of a batch	48 times a year, Maximum Starts
JPRFEED-RECG+	4	96H 1.00E-08 H	9.60E-07	Large leak in jumper causes failure to feed evaporator	Would Discover by End of Cycle
LOW-CE-FEED		1.0N	1.00E+00	Low Feed Flow is Not Detected or Corrected	Assumed to Occur
LST-CE--FAIG#	5	8H 5.00E-07 H	2.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: 5E-7/hr for failure
LST-CE--FAIG+	4	8H 5.00E-07 H	4.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: 5E-7/hr for failure
LSTCEHATFAIG+	4	3M 5.00E-07 H	1.08E-03	Level instrument in hackman hat fails high	Discovered in 3 months (when calib.)
LSTLE-CECALG+	4	4H 2.0Y	9.12E-04	Frequency of continous evaporator level instrumetation calibration	Assume 4 hour for calibration: Calibrated 2/yr, discovered before next cycle
LSTTK906FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 906 level sensor failure	Assume discovered during calibration: FR 5E-7/hr
MDPTK8.7FRCG+	4	96H 1.00E-04 H	9.51E-03	Continous evaporator feed pump fails	Would Discover by End of Cycle (4 days)
OPR17.5-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	sump receipt tank transfer procedure does not allow a 2nd transfer
OPR87EM1ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents at end of 1st interval-clean out	Typical Circumstances
OPR87EM2ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents at end of 2nd interval-clean out	typical circumstances
OPR87EM3ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents at end of 3rd interval-clean out	Typical Circumstances
OPR906LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is calibrated to give a false reading	Typical Circumstances
OPRCELE-MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level Instrument is calibrated to give a high signal	Typical Circumstances
OPRGBLOCDENA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to 8.5E temp., level alarms (close block valve)	Several Competing Signals

Basic Event Data for 8.5E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
OPRGCETEIRNA#	1	1N 1.0E-2 N	1.00E-02N	Evaporator Temperature Sensor is Out of Calibration	Normal Calibration, Not Discovered Until Next Calibration
OPRLV906ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator over fills tank 906 (Level Procedurally Controlled)	Typical Circumstances, Level kept low to prevent large loss of organic
OPRTK906CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to level alarm in tank 906	Typical Circumstances, Further Loss could shut down process
PER-COLD035G#	1	1N 3.50E-01N	3.50E-01N	Cold streams sent to 8.7	1.5 Days of Cold Streams Out of 4 days of running
PER8.5OP013#	1	1N 1.30E-01N	1.30E-01N	Continuous Evaporator is in Operation	Operated 4 days/Month (2.5 Hot & 1.5 Cold)
PER87ORG100A#	1	1N 1.00E+00N	1.00E+00N	organic remains in feed tank	assumes no credit for feeding tank contents to the adequate mixing point
PERACCUMINC#	1	1N 1.00E-32N	1.00E-32N	30,000 lbs of organic accumulates in 8.7	COG: impossible
PERCESPG100G#	1	1N 1.00E+00N	1.00E+00N	Low SPG Not Detected	No Credit for SPG
PERFBLININC#	1	1N 1.00E-32N	1.00E-32N	Excess TBP is Received in 8.7 From 9.7	impossible event, (no planned B-Line processing)
PERTK175.20A#	1	1N 2.00E-03N	2.00E-03N	Sufficient TBP present in tank 17.5	a: 1 in 5 years (1/500 Batches)
PERTR175002A#	1	1N 2.00E-02N	2.00E-02N	Material Is Being Received From 17.5	Pu Recovery, Assume 1 out of 50 batches
PSTSTEAMFAIG+	4	4D 1.00E-06 H	9.60E-05	Steam pressure switch fails	Assume would be discovered by next cycle: FR 1E-6/hr
RLPPUMP-NREG#	1	1N 1.0E-3N	1.00E-03N	Pump switch fails to open	Per Demand, Generic Data
TBP17.5-INCG#		1.0E-32N	1.00E-32	Several batches containing excess TBP are received from 17.5 (30,000 lbs total)	impossible - 3 consecutive transfers from 17.5 during a batch
TBPDENS1PREA#		1.0E-32N	1.00E-32	Process upsets causes dilute 2AW or high density in 11.7S	COG: impossible (would involve phase inversion, can't get 10,000 lbs organic)
TBPDENS2PREA#		1.0E-32H	8.76E-29Y	Process upsets causes dilute 2W or high density in 11.7S	COG: impossible (would involve phase inversion, can't get 10,000 lbs organic)
TBPTK---PREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess organic in feed	Estimated as 1/10years - Not detecte for 12 hours
TBPTK2BPPREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess TBP in canyon product	Estimated as 1/10years - Not detecte for 12 hours
TR-17.5-TO-8.7		1N	1.00E+00	Transfer Excess TBP From 17.5 to 8.7	Assumed to be present and always transferred
TSTCETE-FAIG#	3	4D 1.00E-06 H	9.60E-05	Continous Evaporator Temperature Sensor Has Failed	Assumes Discovered by next cycle: FR 1E-6/hr

Type Code Data for 8.5E Evaporator

Type Code	Rate	Description	Source	EF	D
ALR COM	3.00E-06H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I		
ALR NRI	3.00E-05H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
CAV FOW	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Water)	WSRC-TR-93-262, CAV-FO-W	10	L
FRE ADJ	4H	Speed of Feed Pump Adjusted 4 Times per hour	Operations personnel		
JPR REC	1.00E-08 H	Jumper, Rupture (external) (Chemical)	WSRC-TR-93-262, JPR-RE-C	30	L
LST CAL	2.0Y	Level Instrument Calibration Frequency	Assumed Value		
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
MDP FRC	1.00E-04 H	Pump, Motor-Driven, Fails to run (Chemical)	WSRC-TR-93-262, MDP-FR-C	10	L
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR CSN	1.0E-2 N	Failure to respond to compelling signal (Nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal	5	L
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR IRN	1.0E-2 N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal	5	L
OPR MCN	5.0E-3 N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	L
PER .20	2.00E-03N	0.2% chance			
PER 002	2.00E-02N	2% chance			
PER 013	1.30E-01N	13% Chance			
PER 035	3.50E-01N	35% chance			
PER 100	1.00E+00N	100% chance			
PER INC	1.00E-32N	Incredible Event			
PST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Press., Failure (Instr. & Control)	WSRC-TR-93-262, PST-FA-I	3	L
RLP NRE	1.0E-3N	Relay fails to open	WSRC-TR-93-262m RLP-NRE		
TBP PRE	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L

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APPENDIX E - 9.3E EVAPORATOR FAULT TREE AND DATA

The following abbreviations appear on the fault tree print out and in the basic event file for the fault tree:

FR=Failure Rate

a:= assumption

COG= cognizant engineer estimate/information

TRUNC= Truncation limit of cutset evaluator

The Beta Factor method used to estimate common cause alarm failure is explained in Reference 15.

NOTE: Events in this tree with a probability of "1E-32" are incredible. They do not contribute to the top event frequency and were included only to show that they had been considered. The number "1E-32" was used because it is the smallest number CAFTA is capable of handling.

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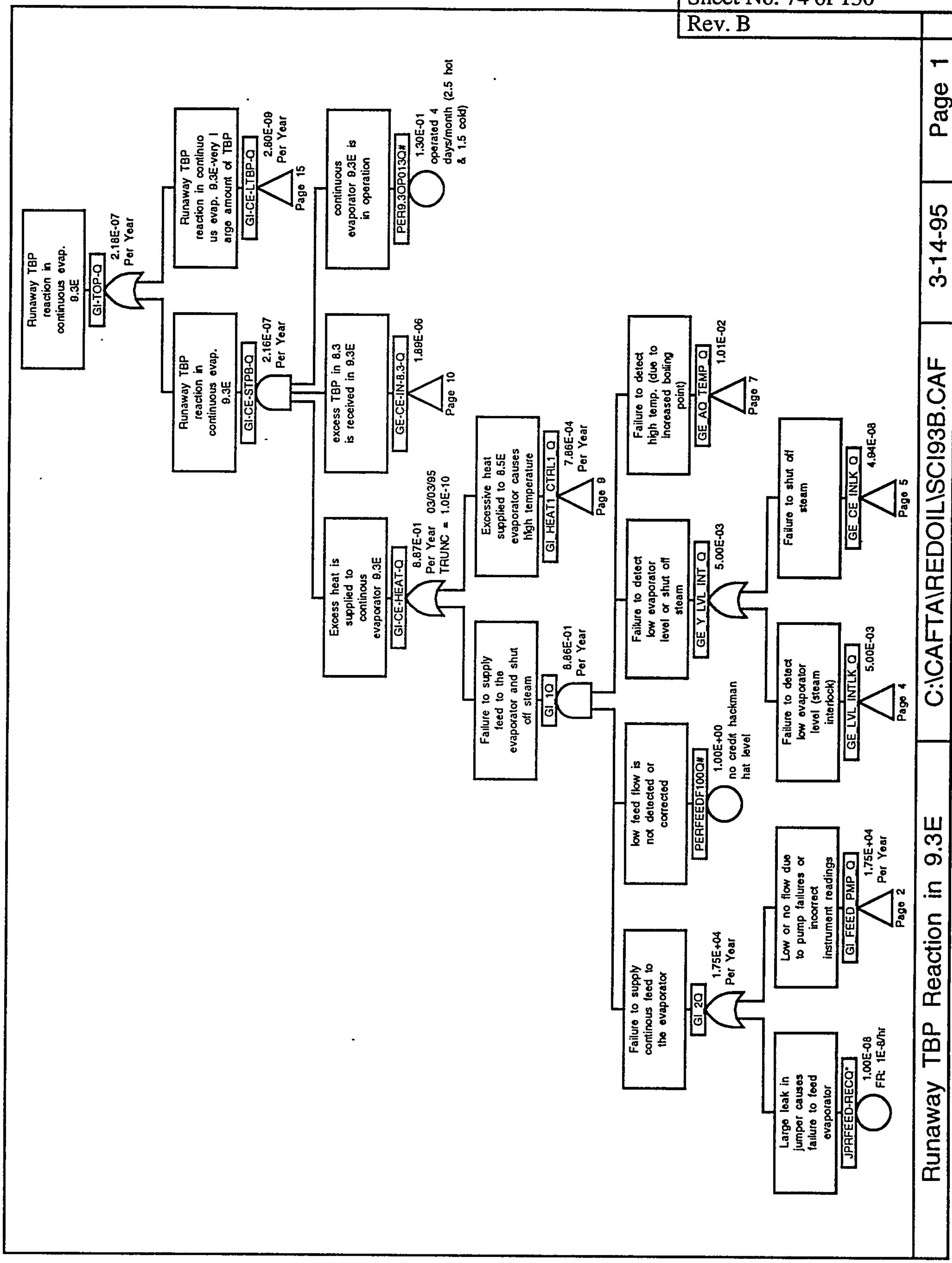

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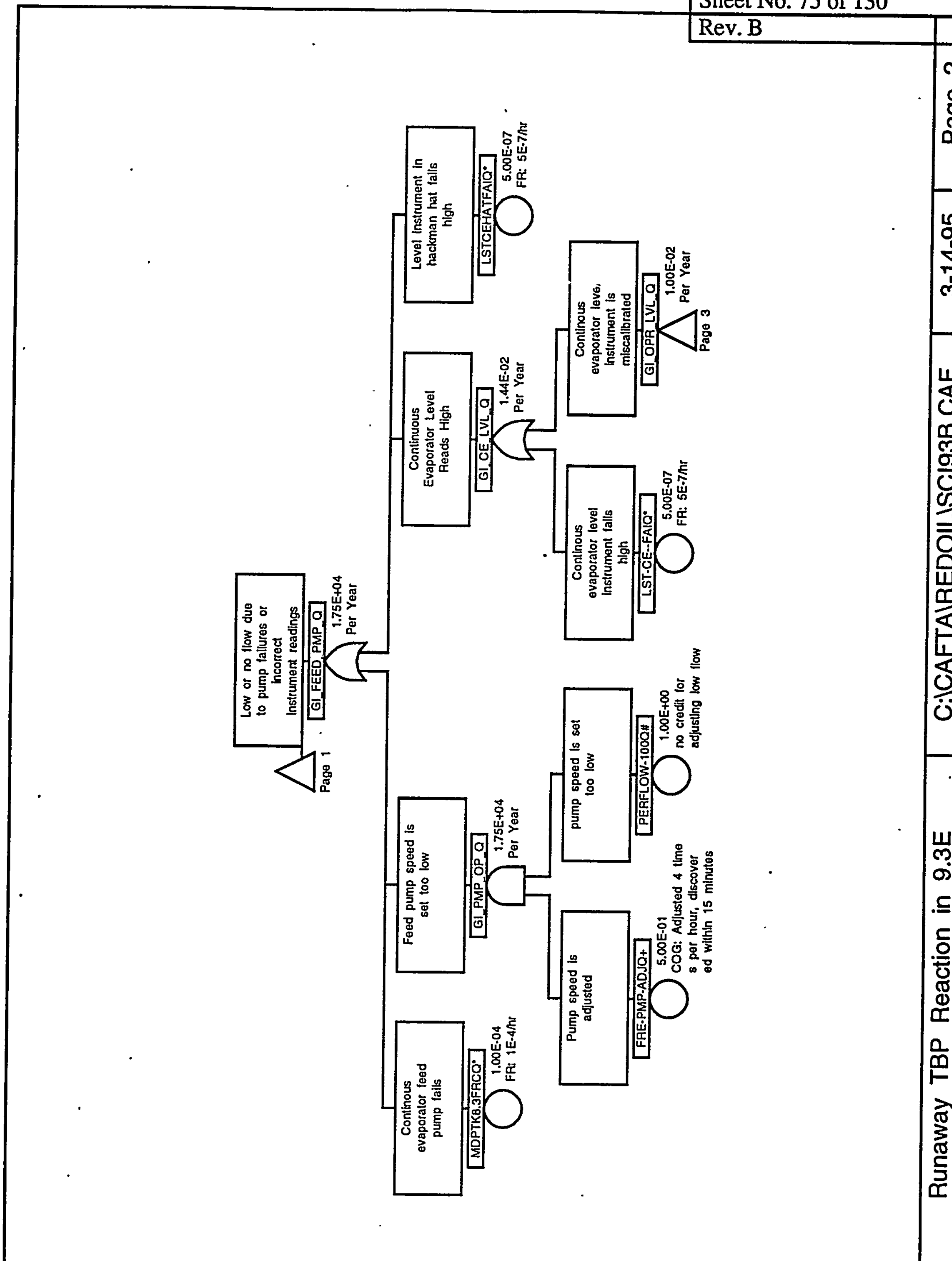

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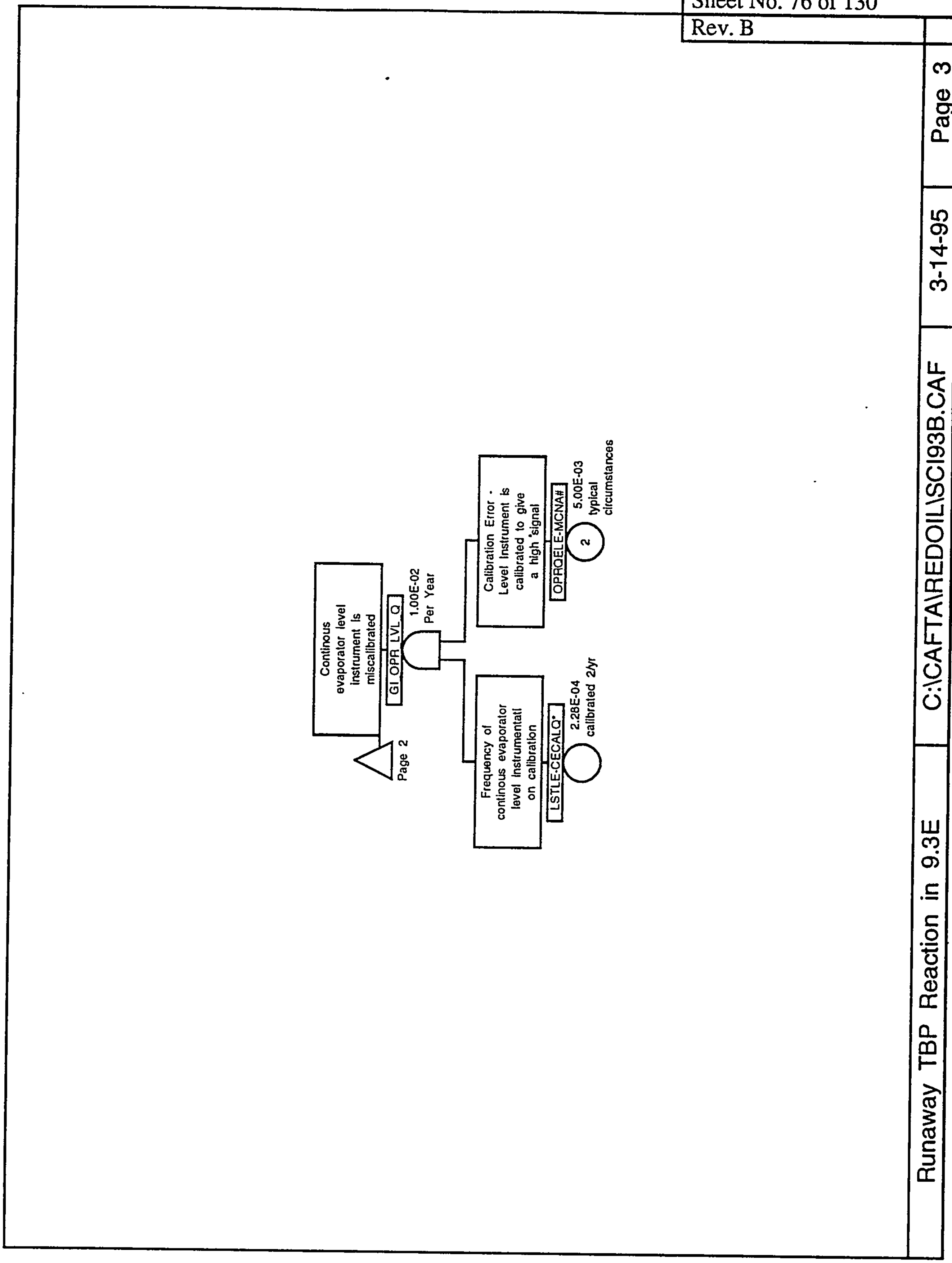

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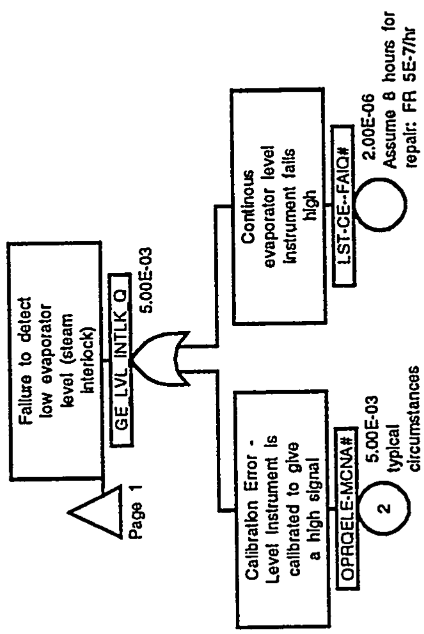

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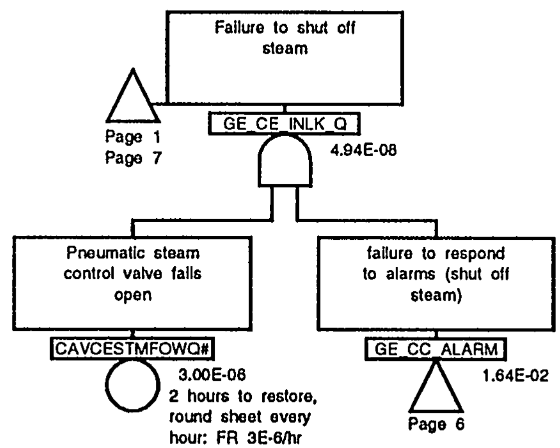
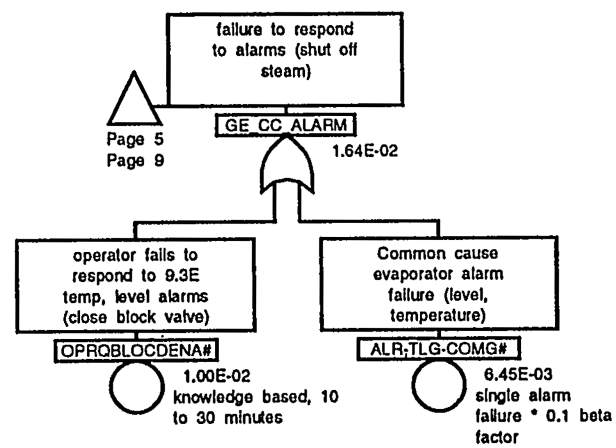


Runaway TBP Reaction in 9.3E	C:\CAFTA\REDOIL\SCI93B.CAF	3-14-95	Page 5



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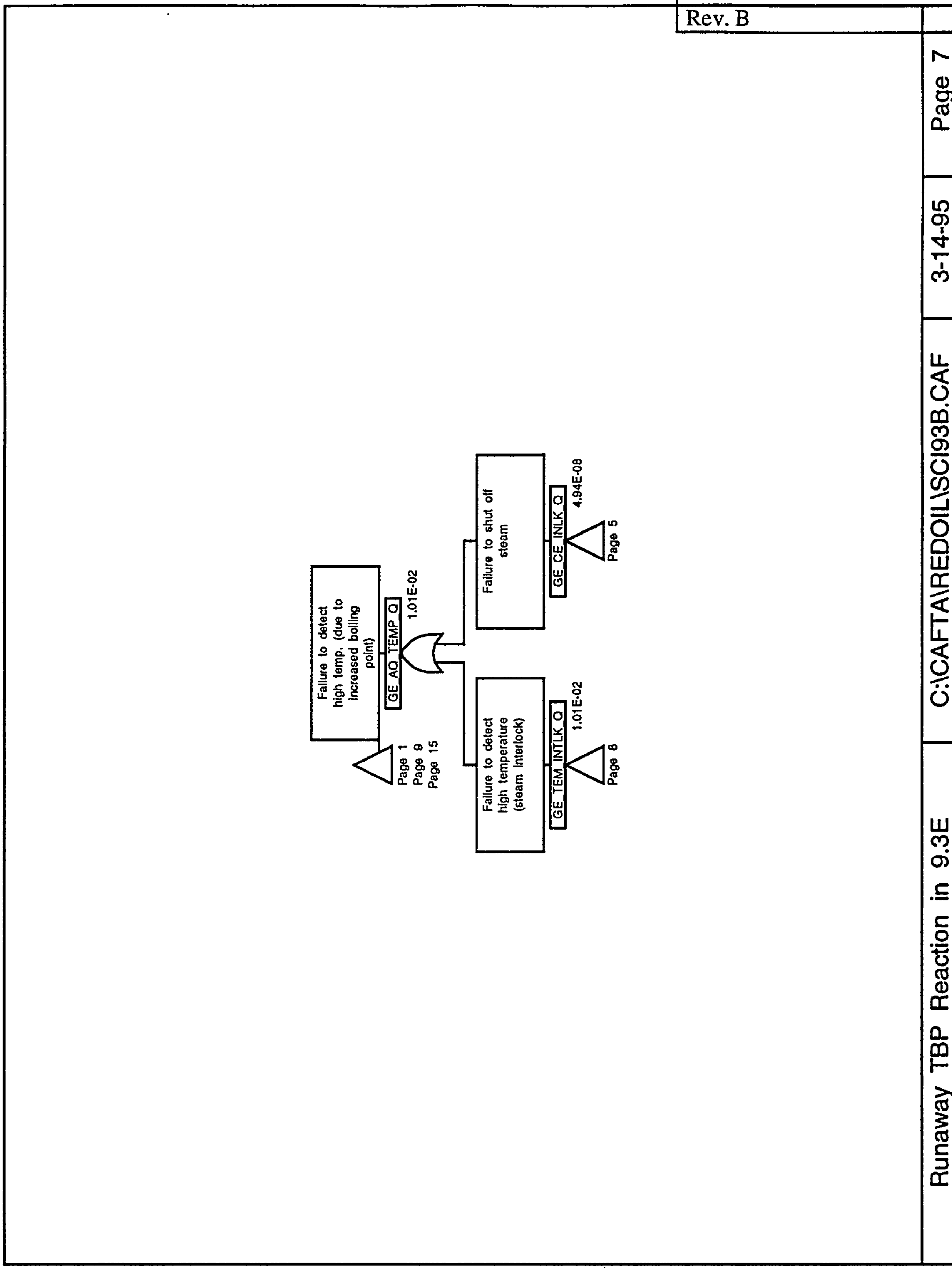

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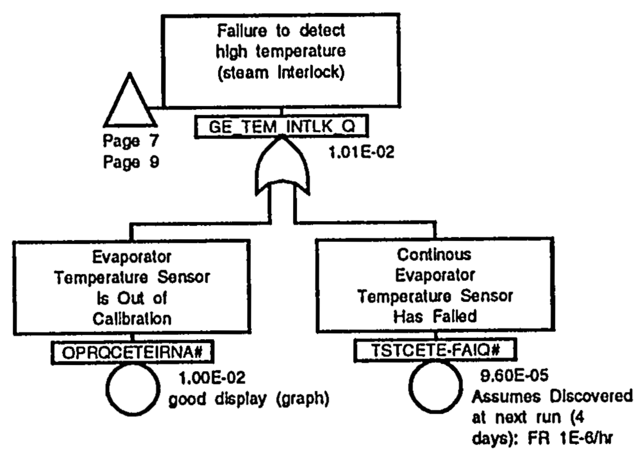

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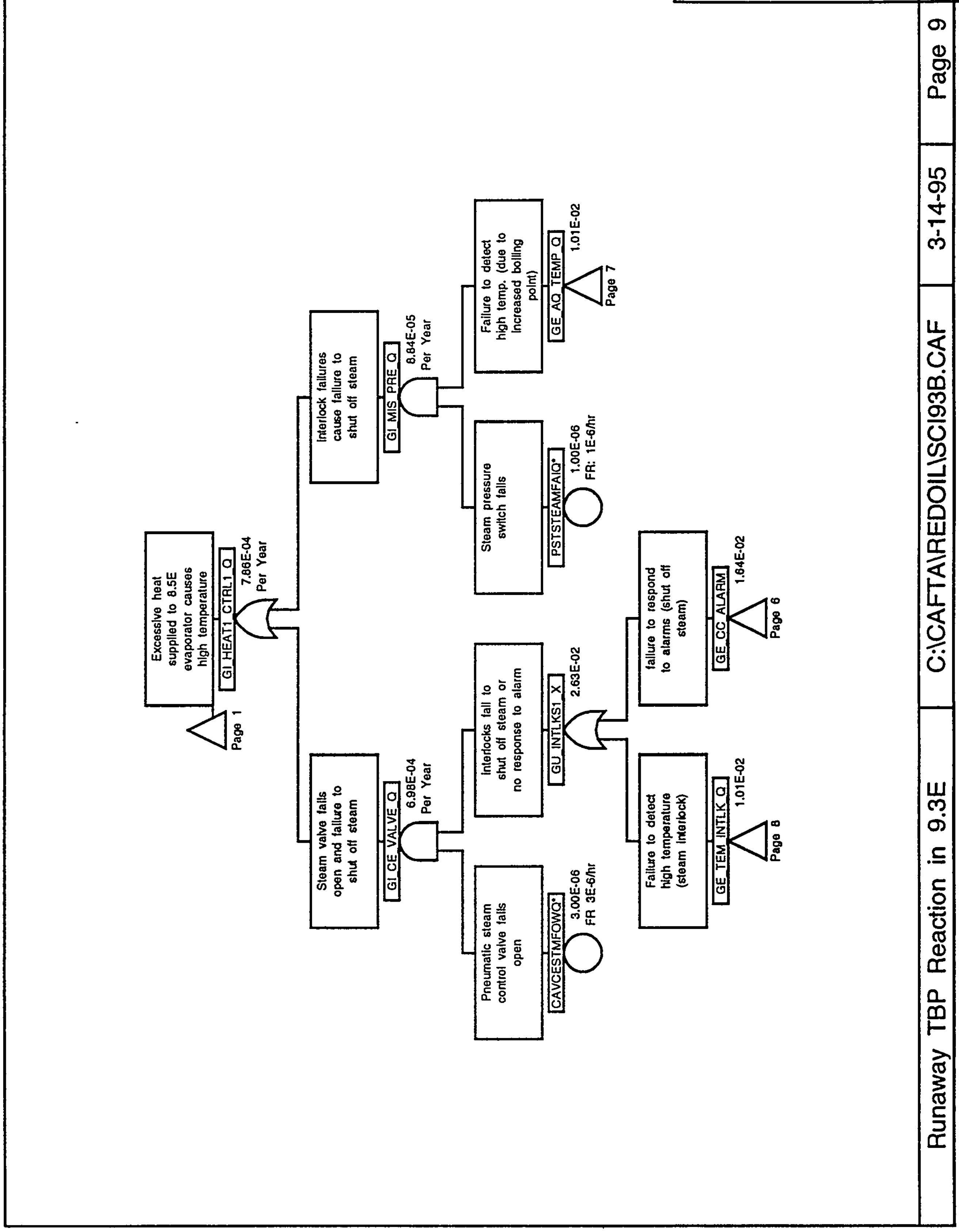

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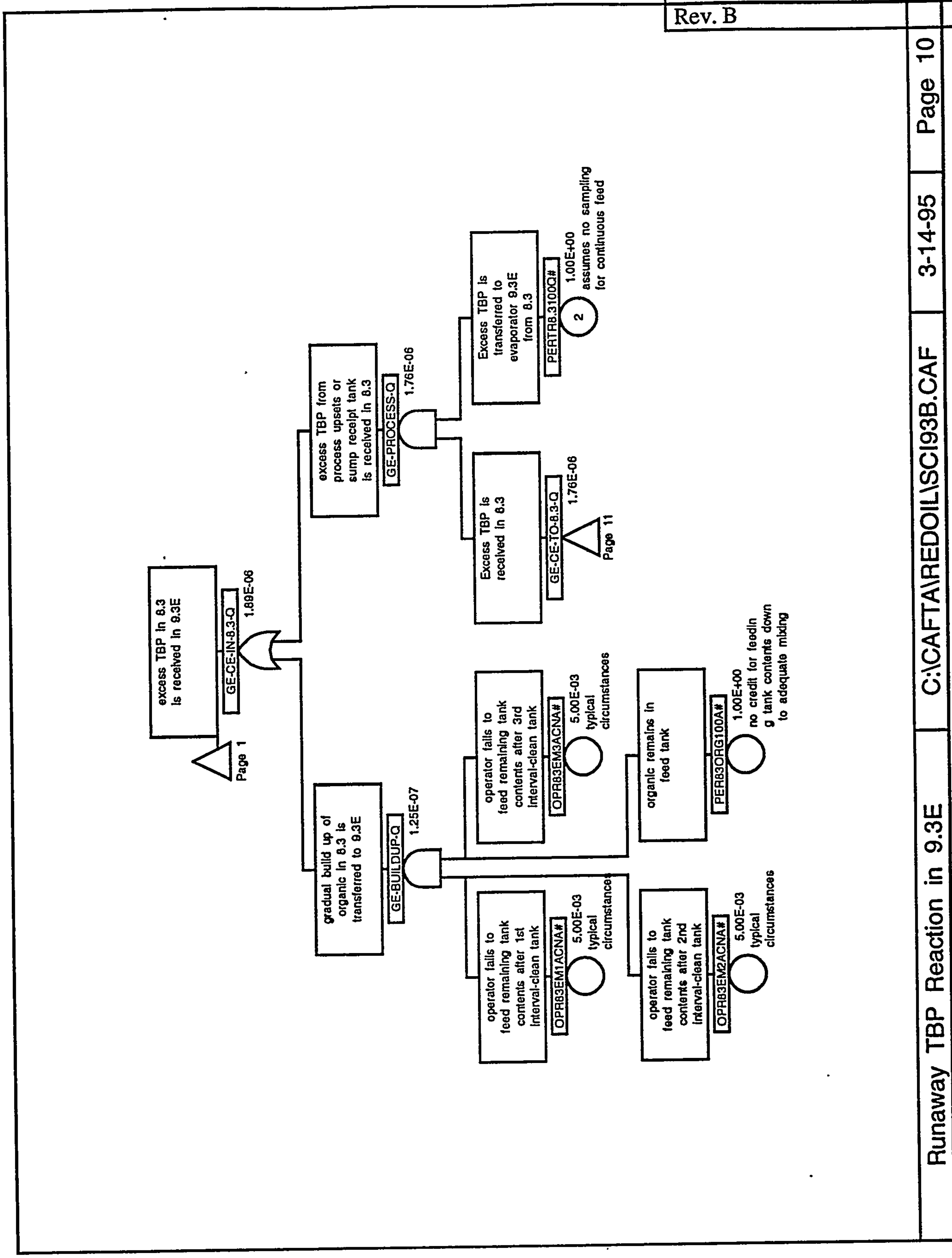

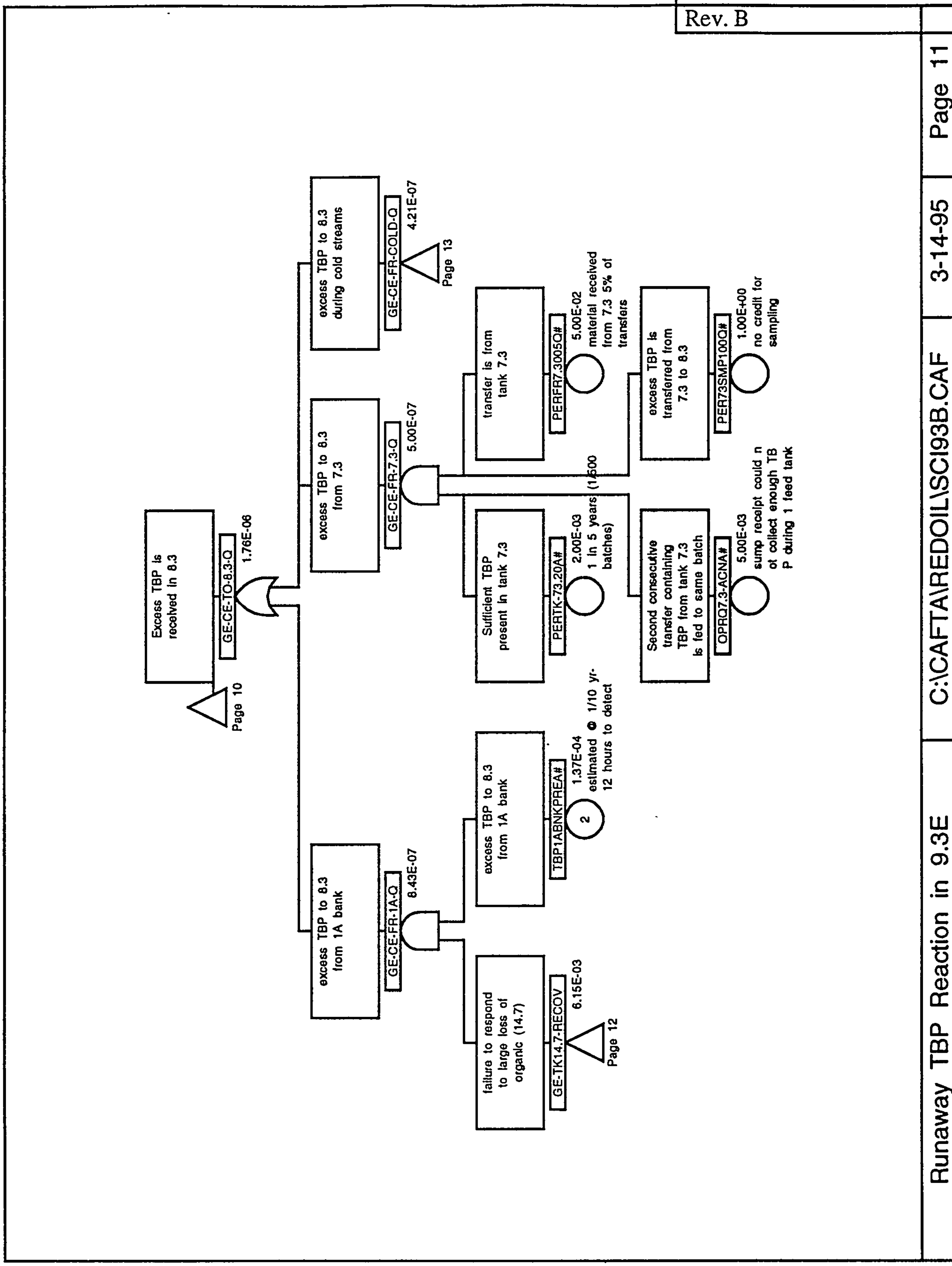
Excess TBP is received in 8.3
GE-CE-TO-8.3-Q
1.76E-06
Page 10
excess TBP to 8.3 from 1A bank
GE-CE-FR-1A-Q
8.43E-07
excess TBP to 8.3 from 7.3
GE-CE-FR-7.3-Q
5.00E-07
excess TBP to 8.3 during cold streams
GE-CE-FR-COLD-Q
4.21E-07
Page 13
failure to respond to large loss of organic (14.7)
GE-TK14.7-RECOV
6.15E-03
Page 12
excess TBP to 8.3 from 1A bank
TBP1ABNKPREA#
2
1.37E-04
estimated @ 1/10 yr-12 hours to detect
Sufficient TBP present in tank 7.3
PERTK-73.20A#
2.00E-03
1 in 5 years (1/500 batches)
transfer is from tank 7.3
PERFR7.3005Q#
5.00E-02
material received from 7.3 5% of transfers
Second consecutive transfer containing TBP from tank 7.3 is fed to same batch
OPRQ7.3-ACNA#
5.00E-03
sump receipt could not collect enough TBP during 1 feed tank
excess TBP is transferred from 7.3 to 8.3
PER73SMP100Q#
1.00E+00
no credit for sampling
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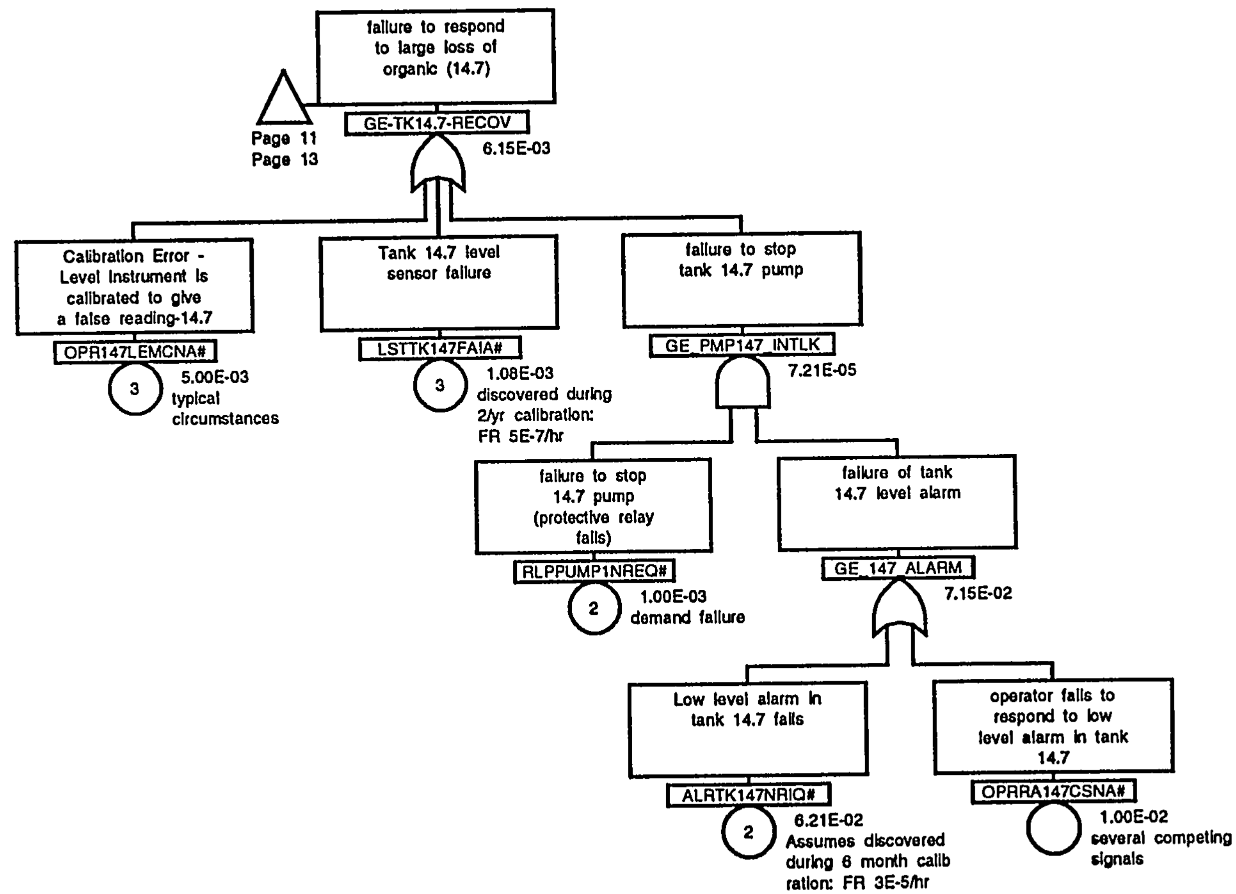

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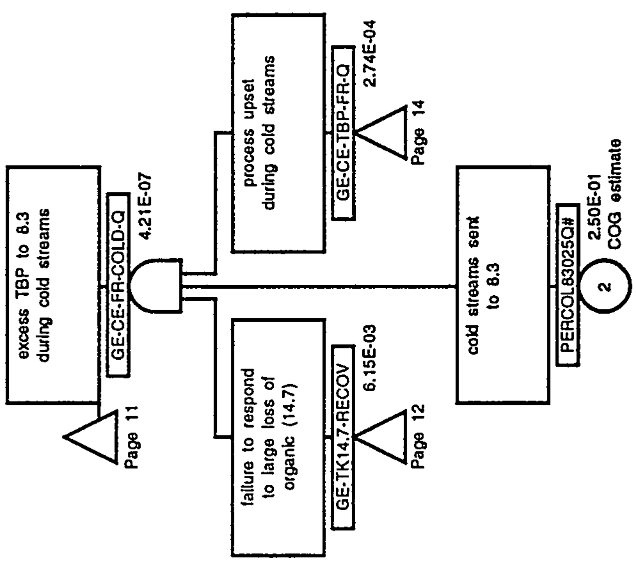

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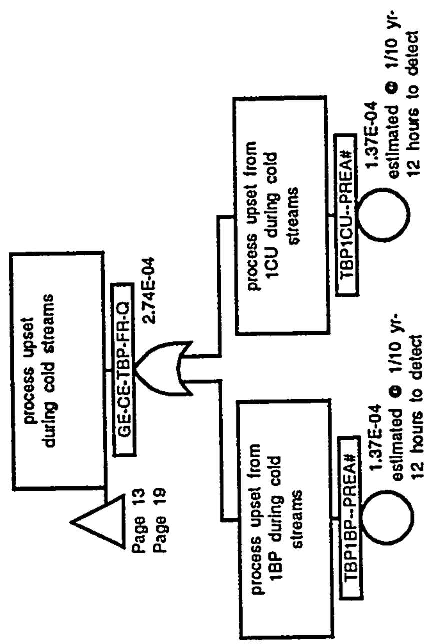

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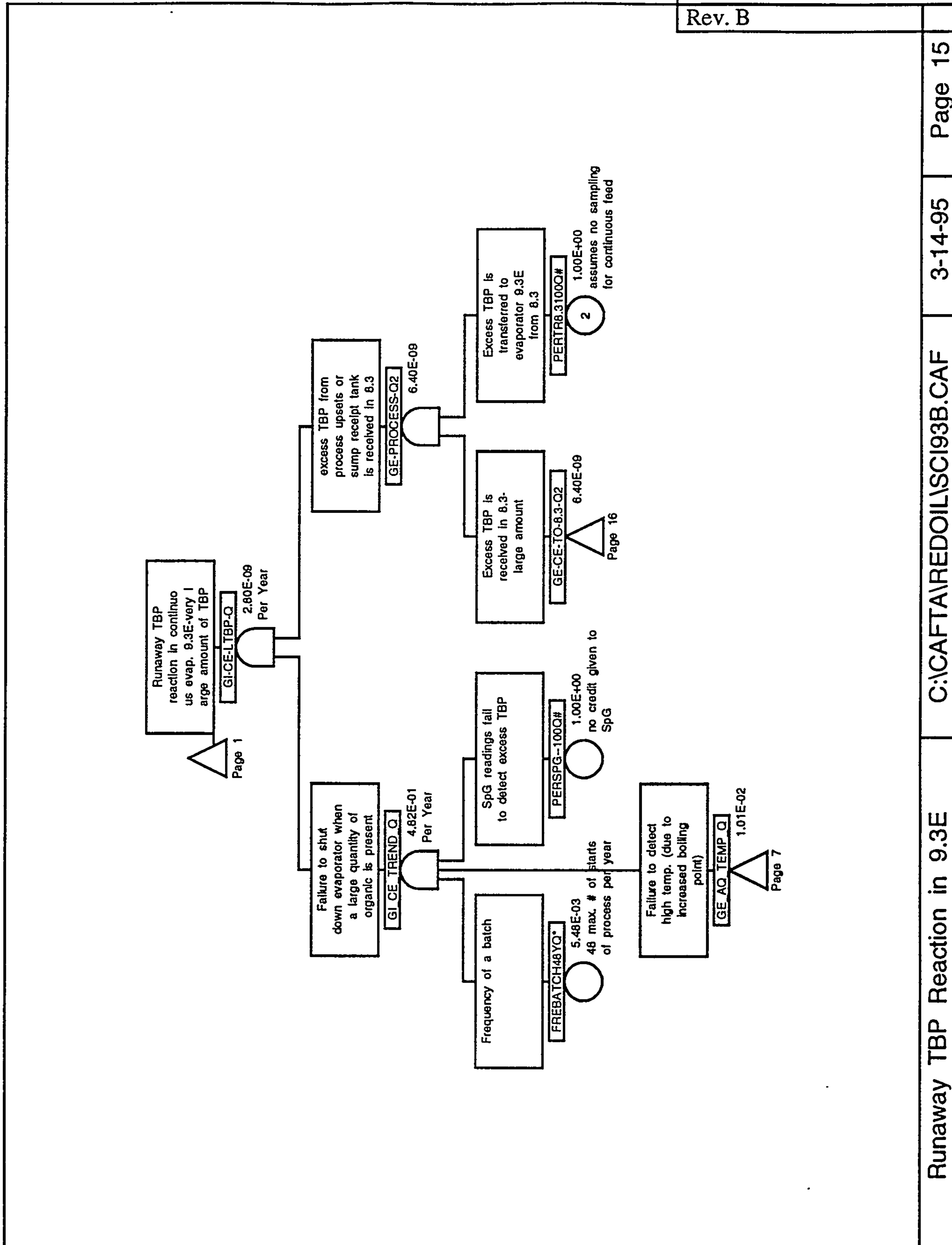

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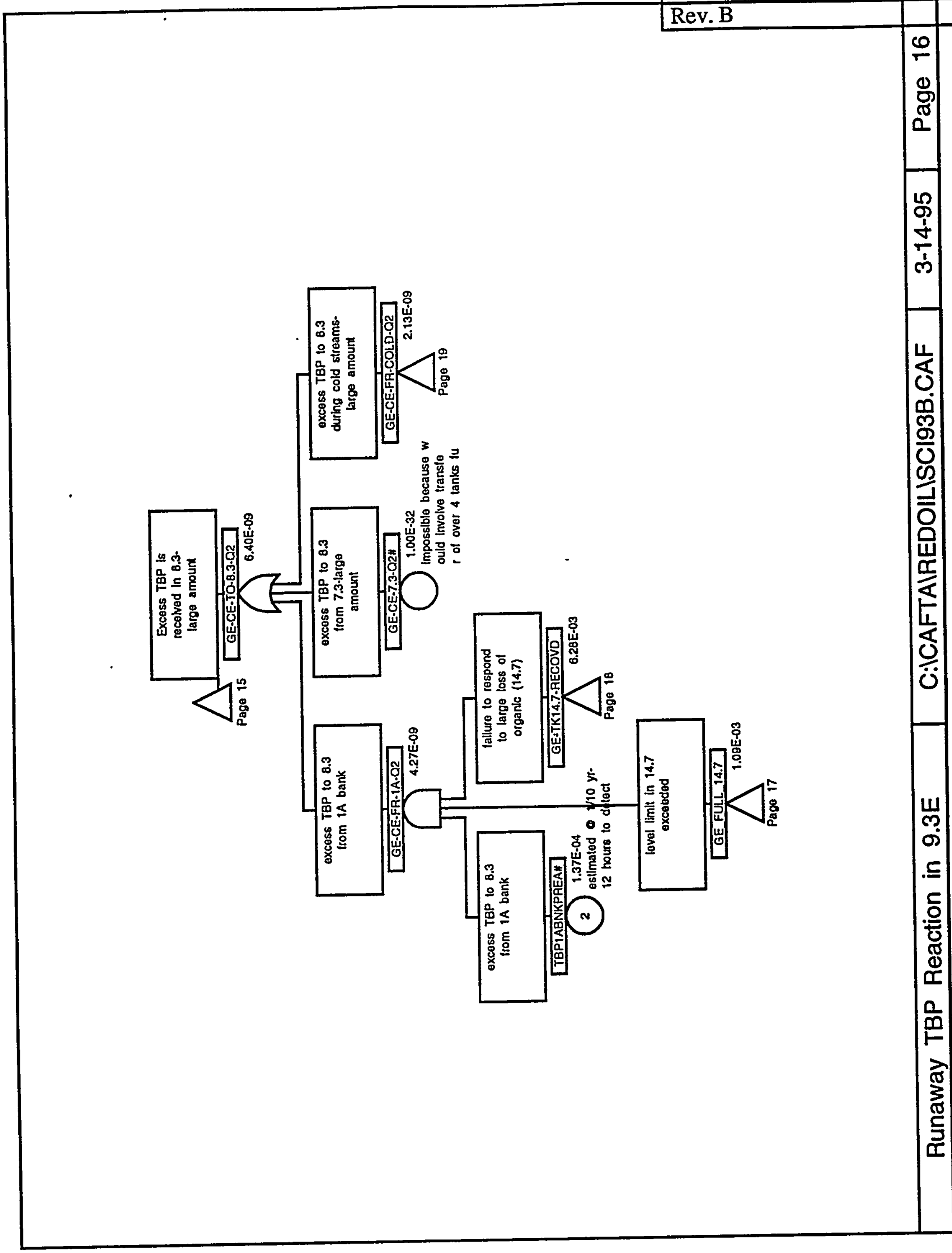

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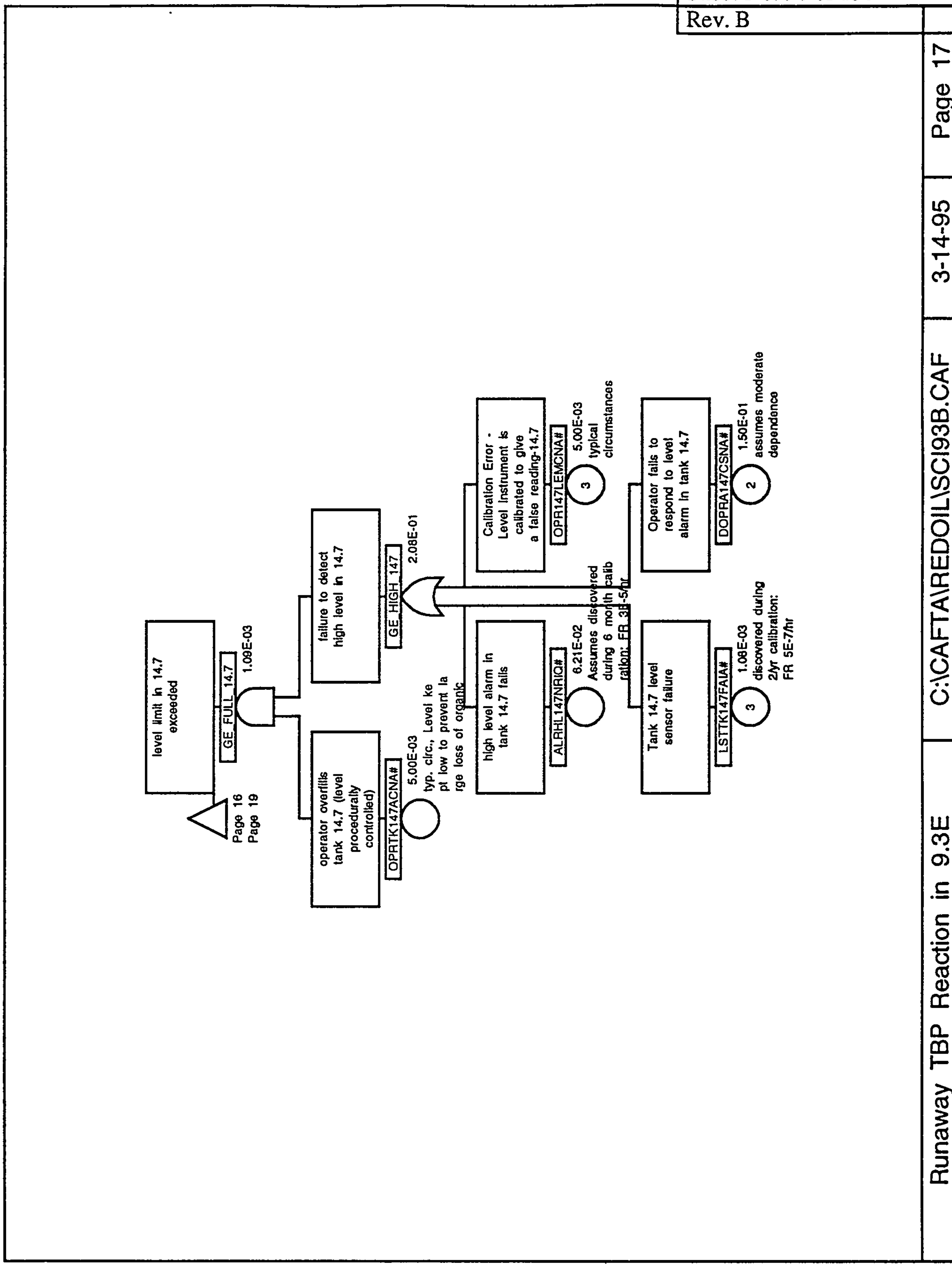

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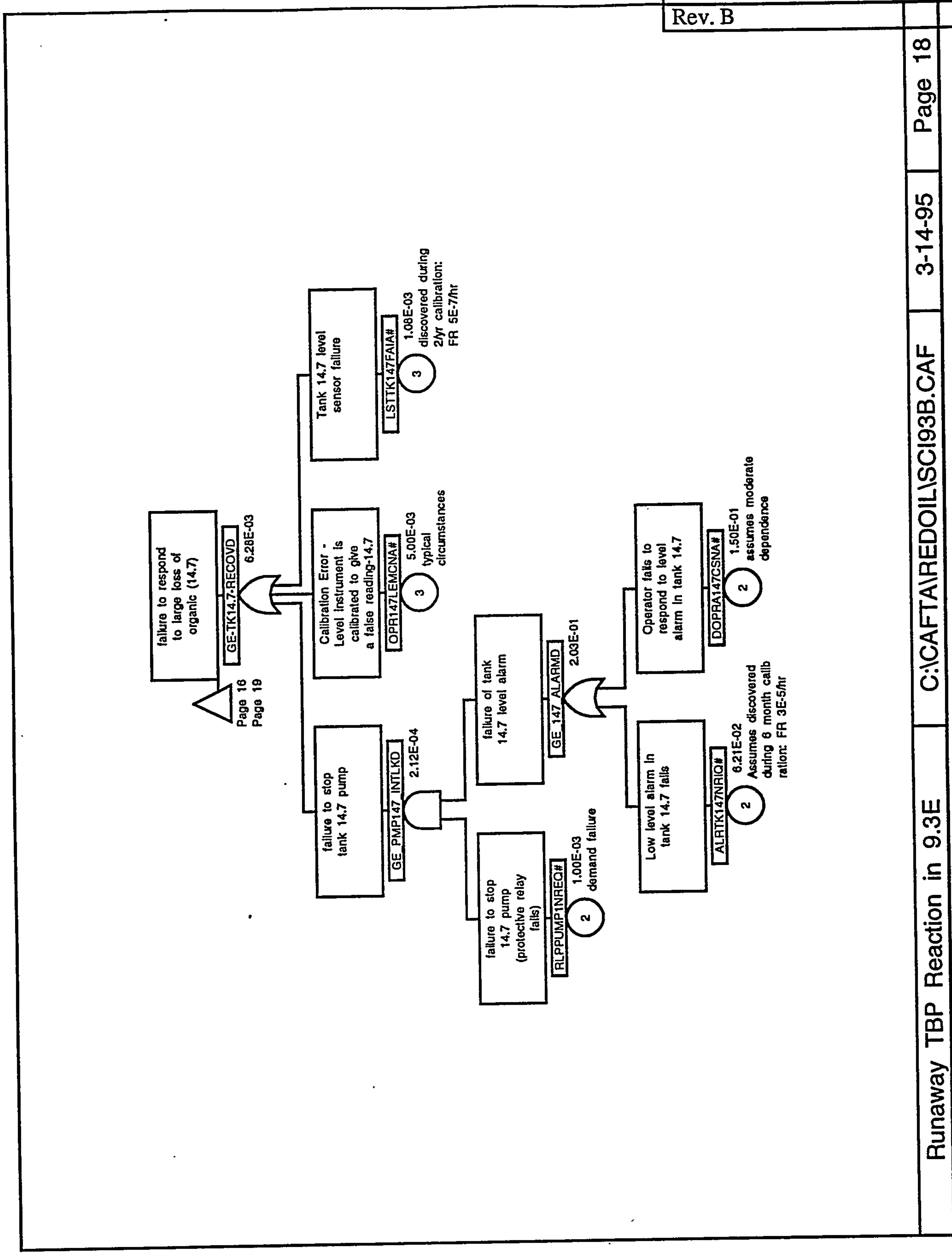

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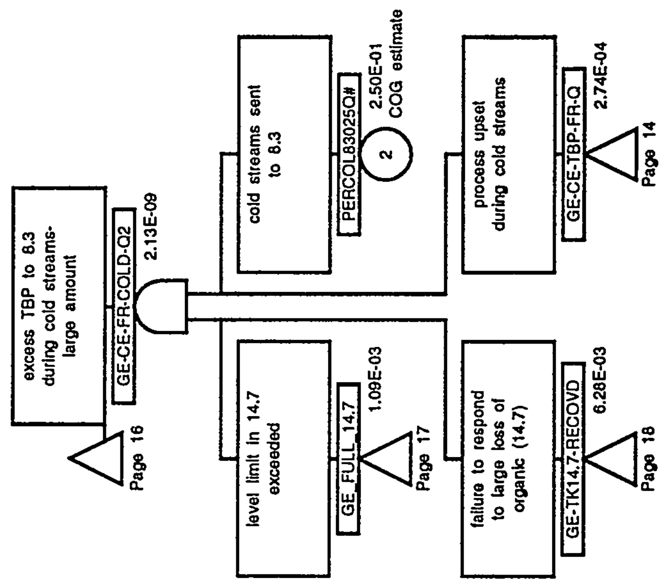

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
ALR-TLG-COMG#	6		GE_AQ_TEMP_Q	1		GI_OPR_LVL_Q	3		RLPPUMP1NREQ#	12	
ALRHL147NRIQ#	17		GE_AQ_TEMP_Q	7		GI_PMP_OP_Q	2		RLPPUMP1NREQ#	18	
ALRTK147NRIQ#	12		GE_AQ_TEMP_Q	9		GU_INTLKS1_X	9		TBP1ABNKPREA#	11	
ALRTK147NRIQ#	18		GE_AQ_TEMP_Q	15		JPRFEED-RECQ*	1		TBP1ABNKPREA#	16	
CAVCESTMFOWQ#	5		GE_CC_ALARM	5		LST-CE--FAIQ#	4		TBP1BP--PREA#	14	
CAVCESTMFOWQ*	9		GE_CC_ALARM	6		LST-CE--FAIQ*	2		TBP1CU--PREA#	14	
DOPRA147CSNA#	17		GE_CC_ALARM	9		LSTCEHATFAIQ*	2		TSTCETE-FAIQ#	8	
DOPRA147CSNA#	18		GE_CE_INLK_Q	1		LSTLE-CECALQ*	3				
FRE-PMP-ADJQ+	2		GE_CE_INLK_Q	5		LSTTK147FAIA#	12				
FREBATCH48YQ*	15		GE_CE_INLK_Q	7		LSTTK147FAIA#	17				
GE-BUILDUP-Q	10		GE_FULL_14.7	16		LSTTK147FAIA#	18				
GE-CE-7.3-Q2#	16		GE_FULL_14.7	17		MDPTK8.3FRCQ*	2				
GE-CE-FR-1A-Q	11		GE_FULL_14.7	19		OPR147LEMCNA#	12				
GE-CE-FR-1A-Q2	16		GE_HIGH_147	17		OPR147LEMCNA#	17				
GE-CE-FR-7.3-Q	11		GE_LVL_INTLK_Q	1		OPR147LEMCNA#	18				
GE-CE-FR-COLD-Q	11		GE_LVL_INTLK_Q	4		OPR83EM1ACNA#	10				
GE-CE-FR-COLD-Q	13		GE_PMP147_INTLK	12		OPR83EM2ACNA#	10				
GE-CE-FR-COLD-Q2	16		GE_PMP147_INTLKD	18		OPR83EM3ACNA#	10				
GE-CE-FR-COLD-Q2	19		GE_TEM_INTLK_Q	7		OPRQ7.3-ACNA#	11				
GE-CE-IN-8.3-Q	1		GE_TEM_INTLK_Q	8		OPRQBLOCDENA#	6				
GE-CE-IN-8.3-Q	10		GE_TEM_INTLK_Q	9		OPRQCETEIRNA#	8				
GE-CE-TBP-FR-Q	13		GE_Y_LVL_INT_Q	1		OPRQELE-MCNA#	3				
GE-CE-TBP-FR-Q	14		GI-CE-HEAT-Q	1		OPRQELE-MCNA#	4				
GE-CE-TBP-FR-Q	19		GI-CE-LTBP-Q	1		OPRRA147CSNA#	12				
GE-CE-TO-8.3-Q	10		GI-CE-LTBP-Q	15		OPRTK147ACNA#	17				
GE-CE-TO-8.3-Q	11		GI-CE-STPB-Q	1		PER73SMP100Q#	11				
GE-CE-TO-8.3-Q2	15		GI-TOP-Q	1		PER83ORG100A#	10				
GE-CE-TO-8.3-Q2	16		GI_1Q	1		PER9.3OP013Q#	1				
GE-PROCESS-Q	10		GI_2Q	1		PERCOL83025Q#	13				
GE-PROCESS-Q2	15		GI_CE_LVL_Q	2		PERCOL83025Q#	19				
GE-TK14.7-RECOV	11		GI_CE_TREND_Q	15		PERFEEDF100Q#	1				
GE-TK14.7-RECOV	12		GI_CE_VALVE_Q	9		PERFLOW-100Q#	2				
GE-TK14.7-RECOV	13		GI_FEED_PMP_Q	1		PERFR7.3005Q#	11				
GE-TK14.7-RECOVD	16		GI_FEED_PMP_Q	2		PERSPG--100Q#	15				
GE-TK14.7-RECOVD	18		GI_HEAT1_CTRL1_Q	1		PERTK-73.20A#	11				
GE-TK14.7-RECOVD	19		GI_HEAT1_CTRL1_Q	9		PERTR8.3100Q#	10				
GE_147_ALARM	12		GI_MIS_PRE_Q	9		PERTR8.3100Q#	15				
GE_147_ALARMD	18		GI_OPR_LVL_Q	2		PSTSTEAMFAIQ*	9				

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Cutset Report for 9.3E Evaporator

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	GI-TOP-Q					2.18E-07	
1.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	7.80E-08	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04		
2.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	5.69E-08	100.0
	OPRQ7.3-ACNA#	Second consecutive transfer containing TBP from tank 7.3 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER73SMP100Q#	excess TBP is transferred from 7.3 to 8.3	1	1N 1.00E+00N	1.00E+00N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERFR7.3005Q#	transfer is from tank 7.3	1	1N 5.00E-02N	5.00E-02N		
	PERTK-73.20A#	Sufficient TBP present in tank 7.3	1	1N 2.00E-03N	2.00E-03N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
3.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	1.95E-08	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		

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Cutset Report for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1BP--PREA#	process upset from 1BP during cold streams	3	12H 0.1Y	1.37E-04		
4.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	1.95E-08	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1CU--PREA#	process upset from 1CU during cold streams	3	12H 0.1Y	1.37E-04		
5.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	1.68E-08	100.0
	LSTTK147FAIA#	Tank 14.7 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		

Cutset Report for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04		
6.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	1.42E-08	100.0
	OPR83EM1ACNA#	operator fails to feed remaining tank contents after 1st interval-clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPR83EM2ACNA#	operator fails to feed remaining tank contents after 2nd interval-clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPR83EM3ACNA#	operator fails to feed remaining tank contents after 3rd interval-clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER83ORG100A#	organic remains in feed tank	1	1N 1.00E+00N	1.00E+00N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
7.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	4.21E-09	100.0
	LSTTK147FAIA#	Tank 14.7 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		

Cutset Report for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	TBP1CU--PREA#	process upset from 1CU during cold streams	3	12H 0.1Y	1.37E-04		
8.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	4.21E-09	100.0
	LSTTK147FAIA#	Tank 14.7 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1BP--PREA#	process upset from 1BP during cold streams	3	12H 0.1Y	1.37E-04		
9.	FREBATCH48YQ*	Frequency of a batch	1	1H 48Y	5.48E-03	1.63E-09	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRTK147ACNA#	operator overfills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERSPG--100Q#	SpG readings fail to detect excess TBP	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04		
10.	ALRTK147NRIQ#	Low level alarm in tank 14.7 fails	5	6M 3.00E-05 H	6.21E-02	9.69E-10	100.0
	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		

Cutset Report for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	RLPPUMP1NREQ#	failure to stop 14.7 pump (protective relay fails)	1	1N 1E-3N	1.00E-03N		
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04		
11.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	7.49E-10	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04		
	TSTCETE-FAIQ#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
12.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	.25H 4H	5.00E-01	5.47E-10	100.0
	OPRQ7.3-ACNA#	Second consecutive transfer containing TBP from tank 7.3 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N		
	PER73SMP100Q#	excess TBP is transferred from 7.3 to 8.3	1	1N 1.00E+00N	1.00E+00N		
	PER9.3OP013Q#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N		
	PERFEEDF100Q#	low feed flow is not detected or corrected	1	1N 1.00E+00N	1.00E+00N		
	PERFLOW-100Q#	pump speed is set too low	1	1N 1.00E+00N	1.00E+00N		
	PERFR7.3005Q#	transfer is from tank 7.3	1	1N 5.00E-02N	5.00E-02N		

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Cutset Report for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	PERTK-73.20A#	Sufficient TBP present in tank 7.3	1	1N 2.00E-03N	2.00E-03N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TSTCETE-FAIQ#	Continous Evaporator Temperature Sensor Has Failed	3	4D 1.00E-06 H	9.60E-05		
13.	FREBATCH48YQ*	Frequency of a batch	1	1H 48Y	5.48E-03	4.09E-10	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRTK147ACNA#	operator overfills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N		
	PERSPG--100Q#	SpG readings fail to detect excess TBP	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1BP--PREA#	process upset from 1BP during cold streams	3	12H 0.1Y	1.37E-04		
14.	FREBATCH48YQ*	Frequency of a batch	1	1H 48Y	5.48E-03	4.09E-10	100.0
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		
	OPRTK147ACNA#	operator overfills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N		
	PERSPG--100Q#	SpG readings fail to detect excess TBP	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1CU--PREA#	process upset from 1CU during cold streams	3	12H 0.1Y	1.37E-04		
15.	FREBATCH48YQ*	Frequency of a batch	1	1H 48Y	5.48E-03	3.53E-10	100.0
	LSTTK147FAIA#	Tank 14.7 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N		

Cutset Report for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	OPRTK147ACNA#	operator overfills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PERSPG--100Q#	SpG readings fail to detect excess TBP	1	1N 1.00E+00N	1.00E+00N		
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N		
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04		

Basic Event Data for 9.3E Evaporator

Event	C	Input	Calc.	Description	Source
ALR-TLG-COMG#	5	6M 3.00E-06H	6.45E-03	Common cause evaporator alarm failure (level, temperature)	single alarm failure * 0.1 beta factor
ALRHL147NRIQ#	5	6M 3.00E-05 H	6.21E-02	high level alarm in tank 14.7 fails	Assumes discovered during 6 month calibration: FR 3E-5/hr
ALRTK147NRIQ#	5	6M 3.00E-05 H	6.21E-02	Low level alarm in tank 14.7 fails	Assumes discovered during 6 month calibration: FR 3E-5/hr
CAVCESTMFOWQ#	5	2H 3.00E-06 H	3.00E-06	Pneumatic steam control valve fails open	2 hours to restore, round sheet every hour: FR 3E-6/hr
CAVCESTMFOWQ*	1	1H 3.00E-06 H	3.00E-06	Pneumatic steam control valve fails open	FR 3E-6/hr
DOPRA147CSNA#		0.15N	1.50E-01	Operator fails to respond to level alarm in tank 14.7	assumes moderate dependence
FRE-PMP-ADJQ+	4	.25H 4H	5.00E-01	Pump speed is adjusted	COG: Adjusted 4 times per hour, discovered within 15 minutes
FREBATCH48YQ*	1	1H 48Y	5.48E-03	Frequency of a batch	48 max. # of starts of process per year
GE-CE-7.3-Q2#		1E-32N	1.00E-32	excess TBP to 8.3 from 7.3-large amount	impossible because would involve transfer of over 4 tanks full
JPRFEED-RECQ*	1	1H 1.00E-08 H	1.00E-08	Large leak in jumper causes failure to feed evaporator	FR: 1E-8/hr
LST-CE--FAIQ#	5	8H 5.00E-07 H	2.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: FR 5E-7/hr
LST-CE--FAIQ*	1	1H 5.00E-07 H	5.00E-07	Continous evaporator level instrument fails high	FR: 5E-7/hr
LSTCEHATFAIQ*	1	1H 5.00E-07 H	5.00E-07	Level instrument in hackman hat fails high	FR: 5E-7/hr
LSTLE-CECALQ*	1	1H 2Y	2.28E-04	Frequency of continous evaporator level instrumentation calibration	calibrated 2/yr
LSTTK147FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 14.7 level sensor failure	discovered during 2/yr calibration: FR 5E-7/hr
MDPTK8.3FRCQ*	1	1H 1.00E-04 H	1.00E-04	Continous evaporator feed pump fails	FR: 1E-4/hr
OPR147LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is calibrated to give a false reading-14.7	typical circumstances
OPR83EM1ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents after 1st interval-clean tank	typical circumstances
OPR83EM2ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents after 2nd interval-clean tank	typical circumstances
OPR83EM3ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents after 3rd interval-clean tank	typical circumstances
OPRQ7.3-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Second consecutive transfer containing TBP from tank 7.3 is fed to same batch	sump receipt could not collect enough TBP during 1 feed tank run time
OPRQBLOCDENA#	1	1N 1.0E-2 N	1.00E-02N	operator fails to respond to 9.3E temp, level alarms (close block valve)	knowledge based, 10 to 30 minutes
OPRQCETEIRNA#	1	1N 1.0E-2 N	1.00E-02N	Evaporator Temperature Sensor is Out of Calibration	good display (graph)

Basic Event Data for 9.3E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
OPRQELE-MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level Instrument is calibrated to give a high signal	typical circumstances
OPRRA147CSNA#	1	1N 1E-2N	1.00E-02N	operator fails to respond to low level alarm in tank 14.7	several competing signals
OPRTK147ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator overfills tank 14.7 (level procedurally controlled)	typ. circ., Level kept low to prevent large loss of organic
PER73SMP100Q#	1	1N 1.00E+00N	1.00E+00N	excess TBP is transferred from 7.3 to 8.3	no credit for sampling
PER83ORG100A#	1	1N 1.00E+00N	1.00E+00N	organic remains in feed tank	no credit for feeding tank contents down to adequate mixing point
PER9.3OP013Q#	1	1N 1.30E-01N	1.30E-01N	continuous evaporator 9.3E is in operation	operated 4 days/month (2.5 hot & 1.5 cold)
PERCOL83025Q#	1	1N 2.50E-01N	2.50E-01N	cold streams sent to 8.3	COG estimate
PERFEEDF100Q#	1	1N 1.00E+00N	1.00E+00N	low feed flow is not detected or corrected	no credit hackman hat level
PERFLOW-100Q#	1	1N 1.00E+00N	1.00E+00N	pump speed is set too low	no credit for adjusting low flow
PERFR7.3005Q#	1	1N 5.00E-02N	5.00E-02N	transfer is from tank 7.3	material received from 7.3 5% of transfers
PERSPG--100Q#	1	1N 1.00E+00N	1.00E+00N	SpG readings fail to detect excess TBP	no credit given to SpG
PERTK-73.20A#	1	1N 2.00E-03N	2.00E-03N	Sufficient TBP present in tank 7.3	1 in 5 years (1/500 batches)
PERTR8.3100Q#	1	1N 1.00E+00N	1.00E+00N	Excess TBP is transferred to evaporator 9.3E from 8.3	assumes no sampling for continuous feed
PSTSTEAMFAIQ*	1	1H 1.00E-06 H	1.00E-06	Steam pressure switch fails	FR: 1E-6/hr
RLPPUMP1NREQ#	1	1N 1E-3N	1.00E-03N	failure to stop 14.7 pump (protective relay fails)	demand failure
TBP1ABNKPREA#	3	12H 0.1Y	1.37E-04	excess TBP to 8.3 from 1A bank	estimated @ 1/10 yr- 12 hours to detect
TBP1BP--PREA#	3	12H 0.1Y	1.37E-04	process upset from 1BP during cold streams	estimated @ 1/10 yr- 12 hours to detect
TBP1CU--PREA#	3	12H 0.1Y	1.37E-04	process upset from 1CU during cold streams	estimated @ 1/10 yr- 12 hours to detect
TSTCETE-FAIQ#	3	4D 1.00E-06 H	9.60E-05	Continous Evaporator Temperature Sensor Has Failed	Assumes Discovered at next run (4 days): FR 1E-6/hr

Type Code Data for 9.3E Evaporator

Type Code	Rate	Description	Source	EF	D
ALR COM	3.00E-06H	common cause alarm failure (single * 0.1 beta factor)	WSRC-TR-93-262, ALR-NR-I * 0.1 beta factor for common cause	10	L
ALR NRI	3.00E-05 H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
CAV FOW	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Water)	WSRC-TR-93-262, CAV-FO-W	10	L
FRE 48Y	48Y	frequency of a batch	operations personnel		
FRE ADJ	4H	Speed of Feed Pump Adjusted 3 Times per shift	Operations personnel		
JPR REC	1.00E-08 H	Jumper, Rupture (external) (Chemical)	WSRC-TR-93-262, JPR-RE-C	30	L
LST CAL	2Y	level instrument calibration	operations personnel		
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
MDP FRC	1.00E-04 H	Pump, Motor-Driven, Fails to run (Chemical)	WSRC-TR-93-262, MDP-FR-C	10	L
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR CSN	1E-2N	failure to respond to compelling signal (nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal		
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR IRN	1.0E-2 N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal	5	L
OPR MCN	5.0E-3 N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	L
PER .20	2.00E-03N	0.2% chance			
PER 005	5.00E-02N	5% chance			
PER 013	1.30E-01N	13% chance			
PER 025	2.50E-01N	25% chance			
PER 100	1.00E+00N	100% chance			
PST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Press., Failure (Instr. & Control)	WSRC-TR-93-262, PST-FA-I	3	L
RLP NRE	1E-3N	Relay, protective, fails to open/close	WSRC-TR-93-262, RLE-NR-E	10	l
TBP PRE	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L

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APPENDIX F - 7.6E & 7.7 EVAPORATOR FAULT TREE AND DATA

The following abbreviations appear on the fault tree print out and in the basic event file for the fault tree:

FR=Failure Rate

a:= assumption

COG= cognizant engineer estimate/information

TRUNC= Truncation limit of cutset evaluator

The Beta Factor method used to estimate common cause alarm failure is explained in Reference 15.

NOTE: Events in this tree with a probability of "1E-32" are incredible. They do not contribute to the top event frequency and were included only to show that they had been considered. The number "1E-32" was used because it is the smallest number CAFTA is capable of handling.

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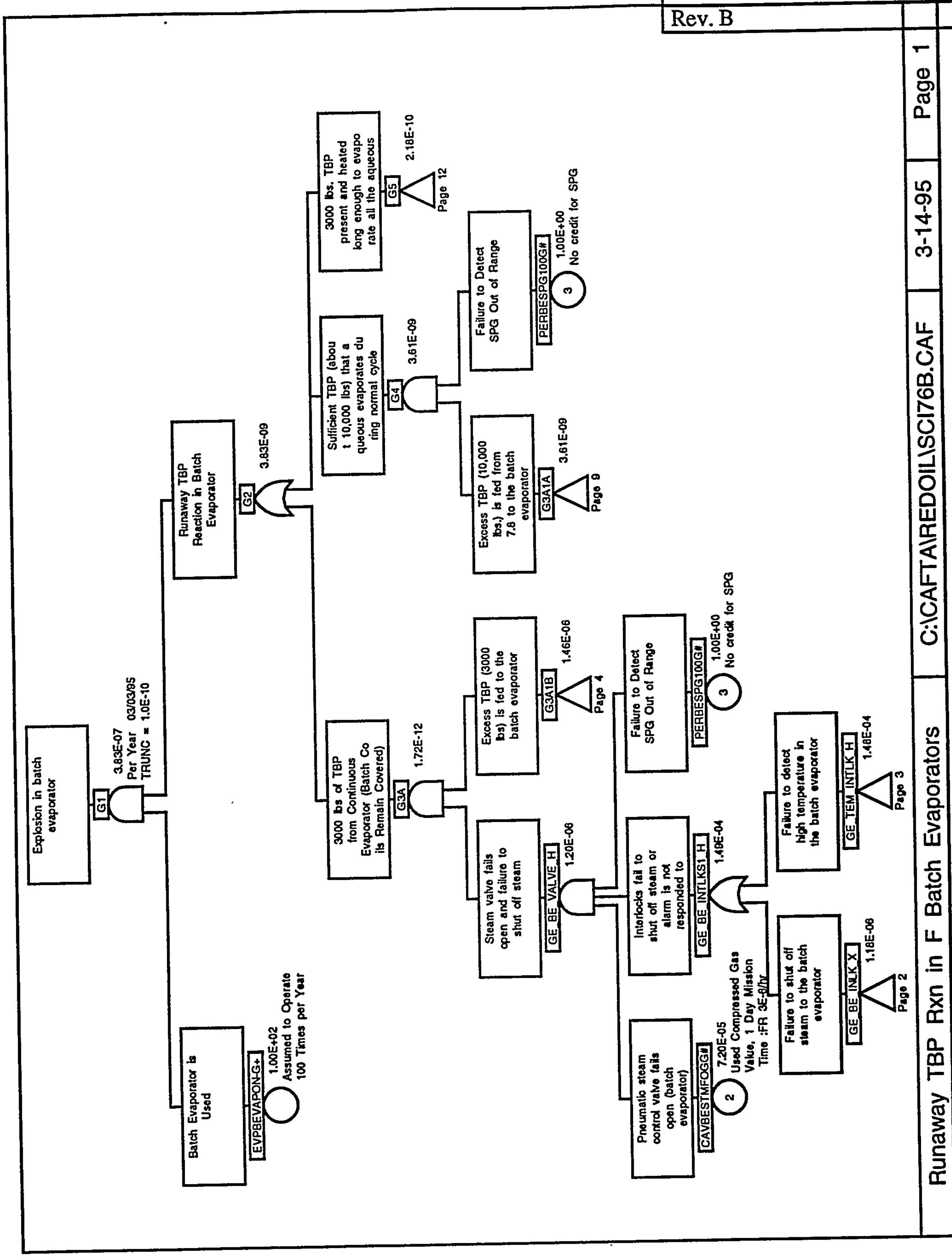

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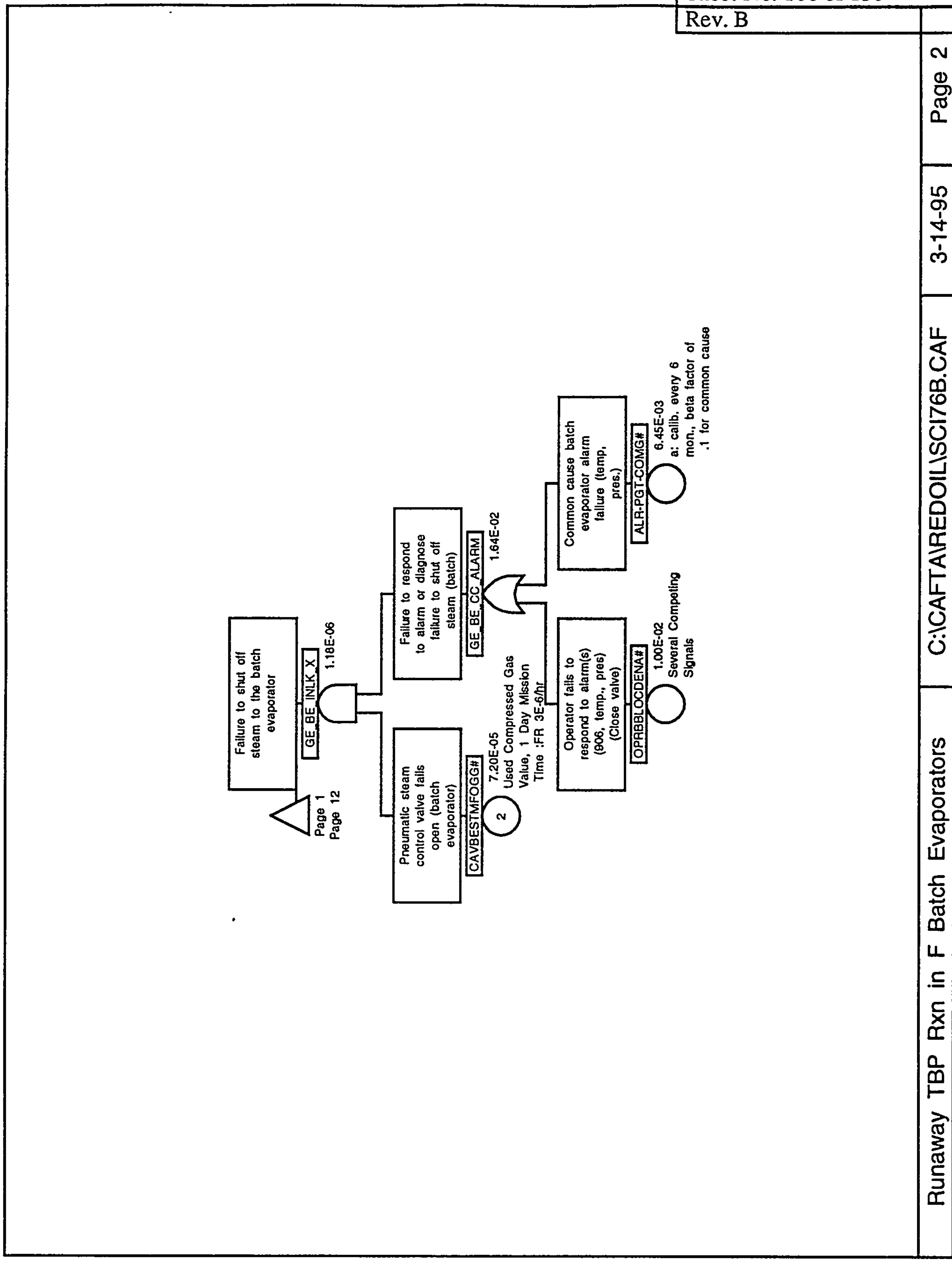

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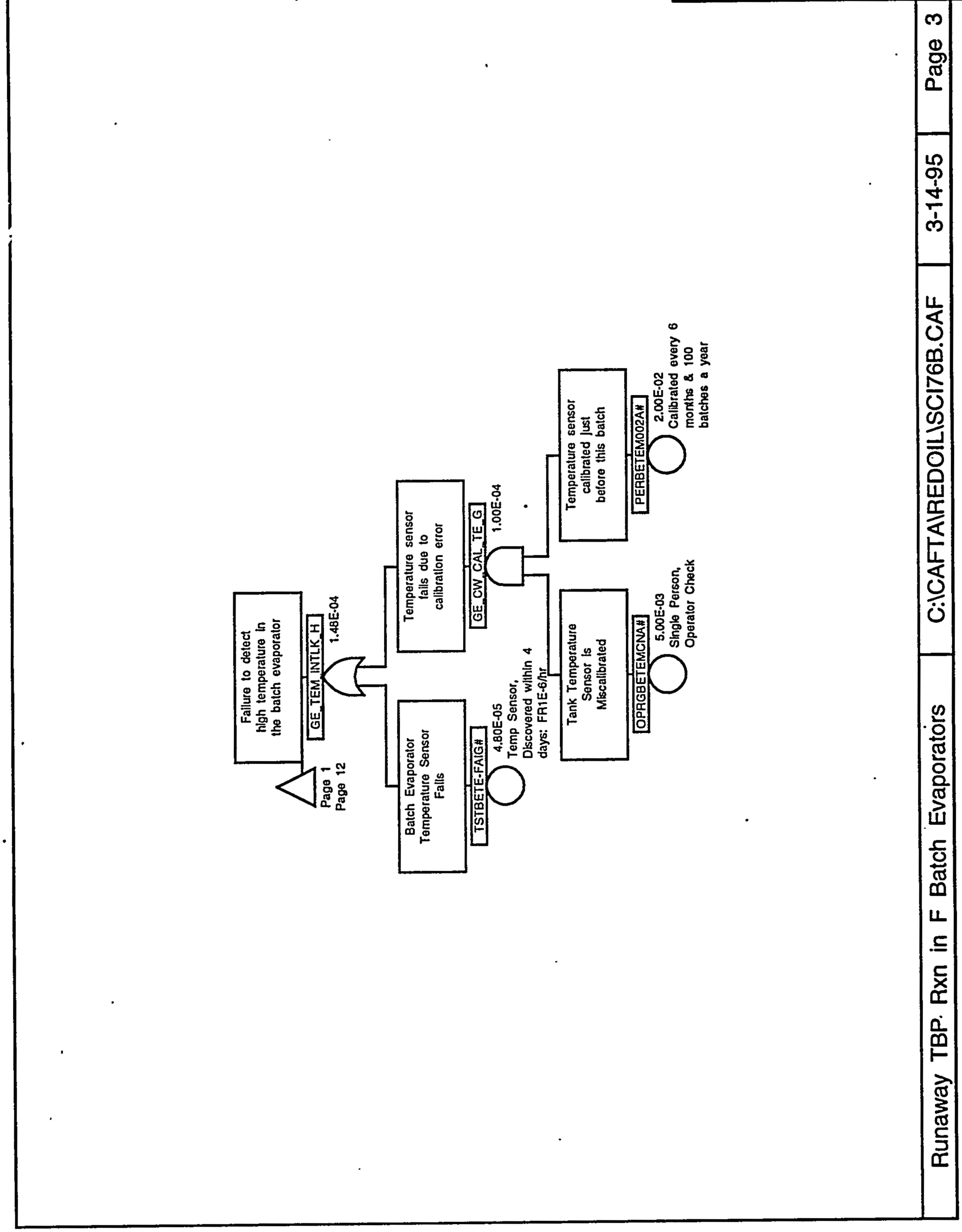

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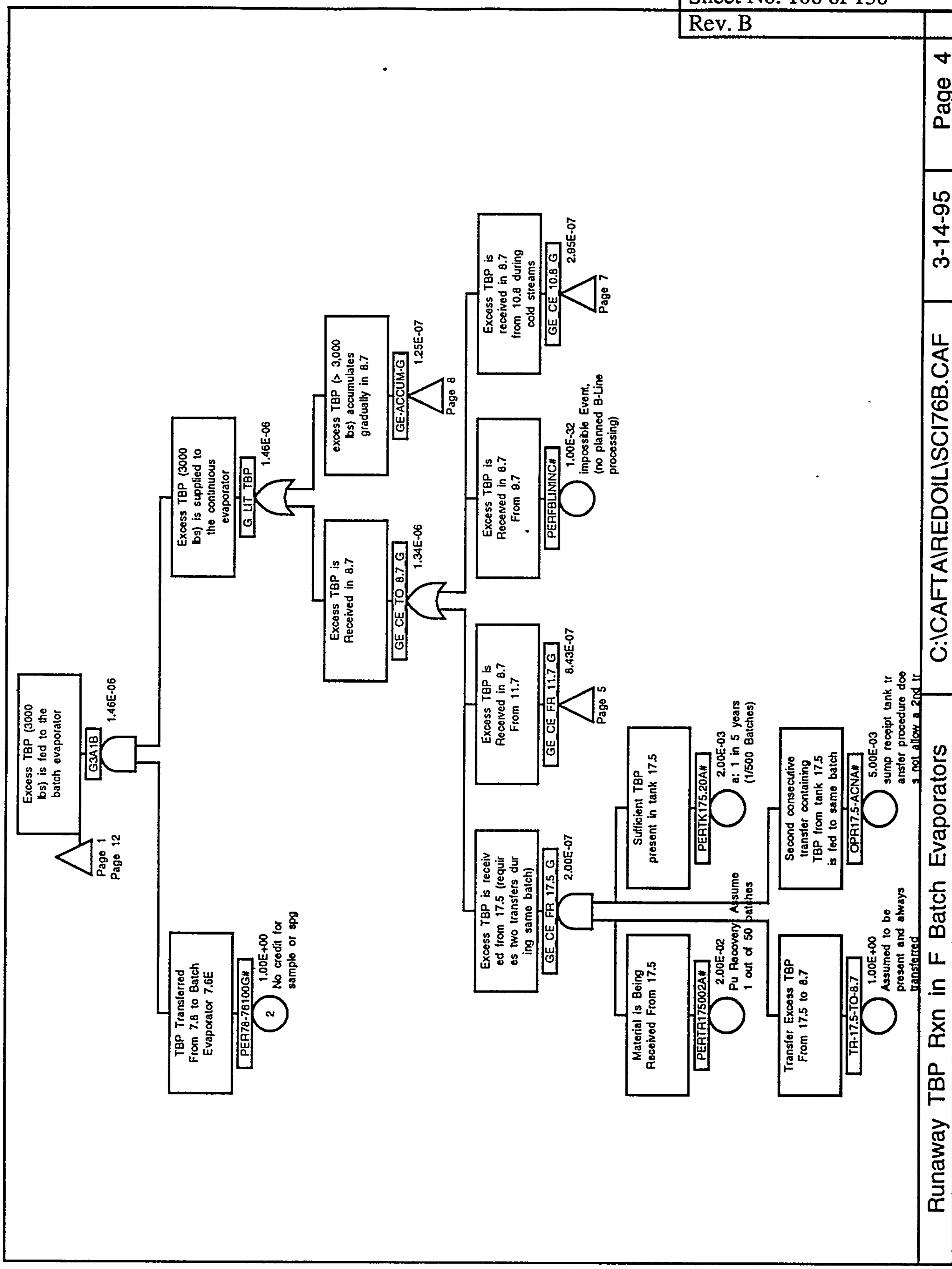

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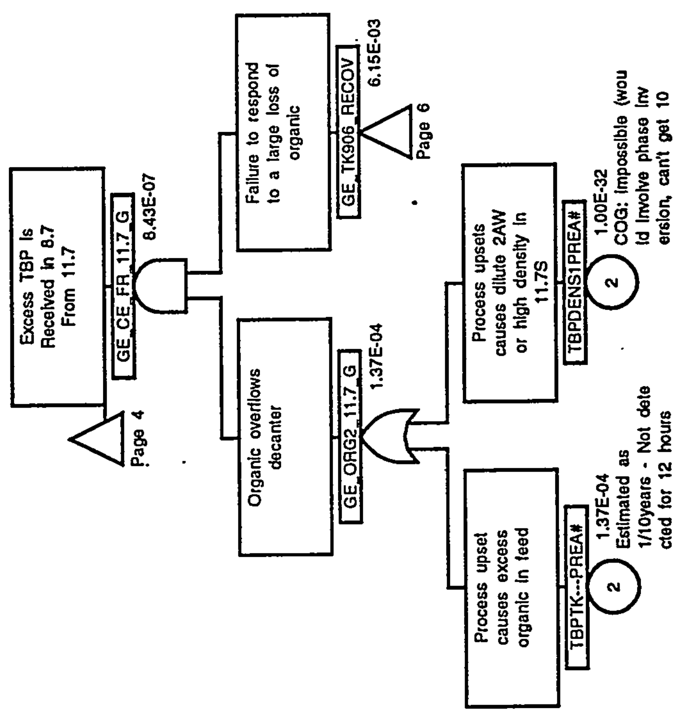

Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\SCI76B.CAF | 3-14-95 | Page 5

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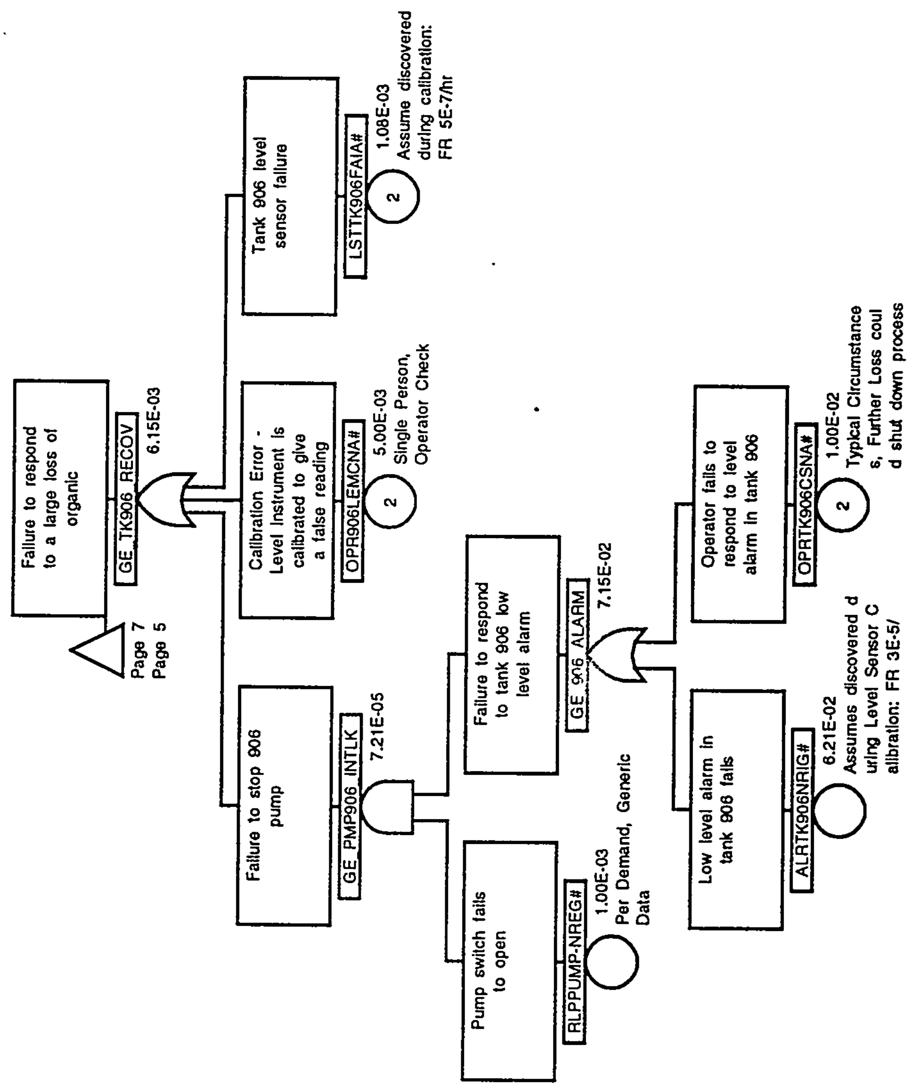

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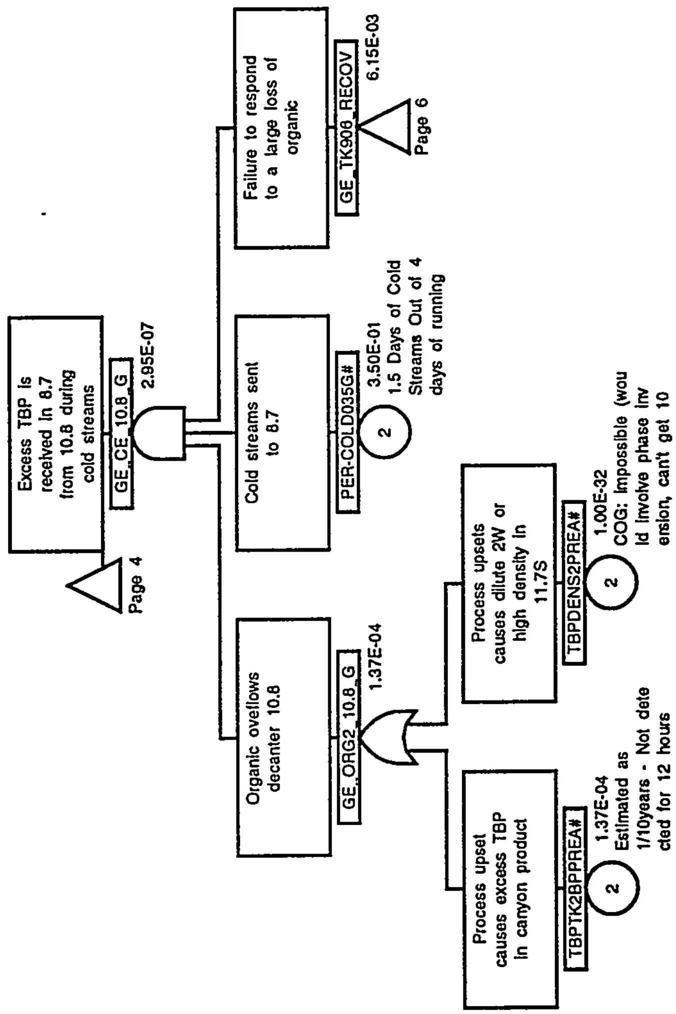

Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\SCI76B.CAF	3-14-95	Page 7

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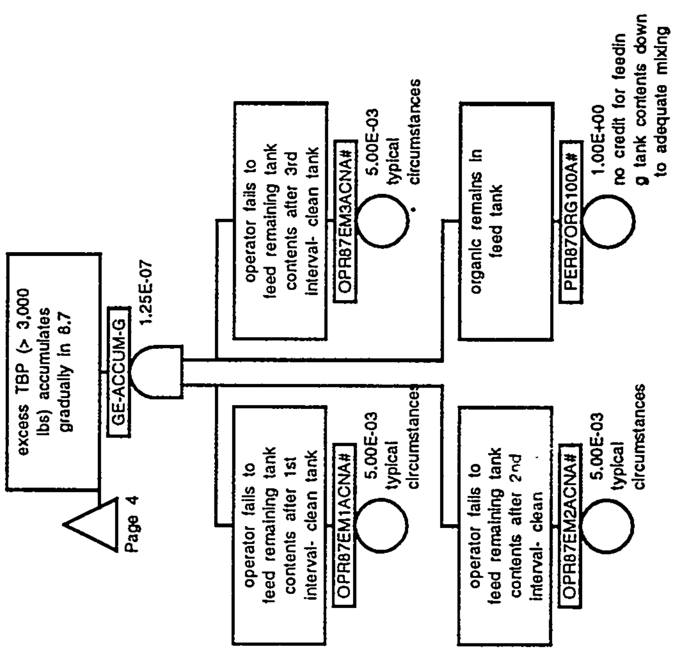

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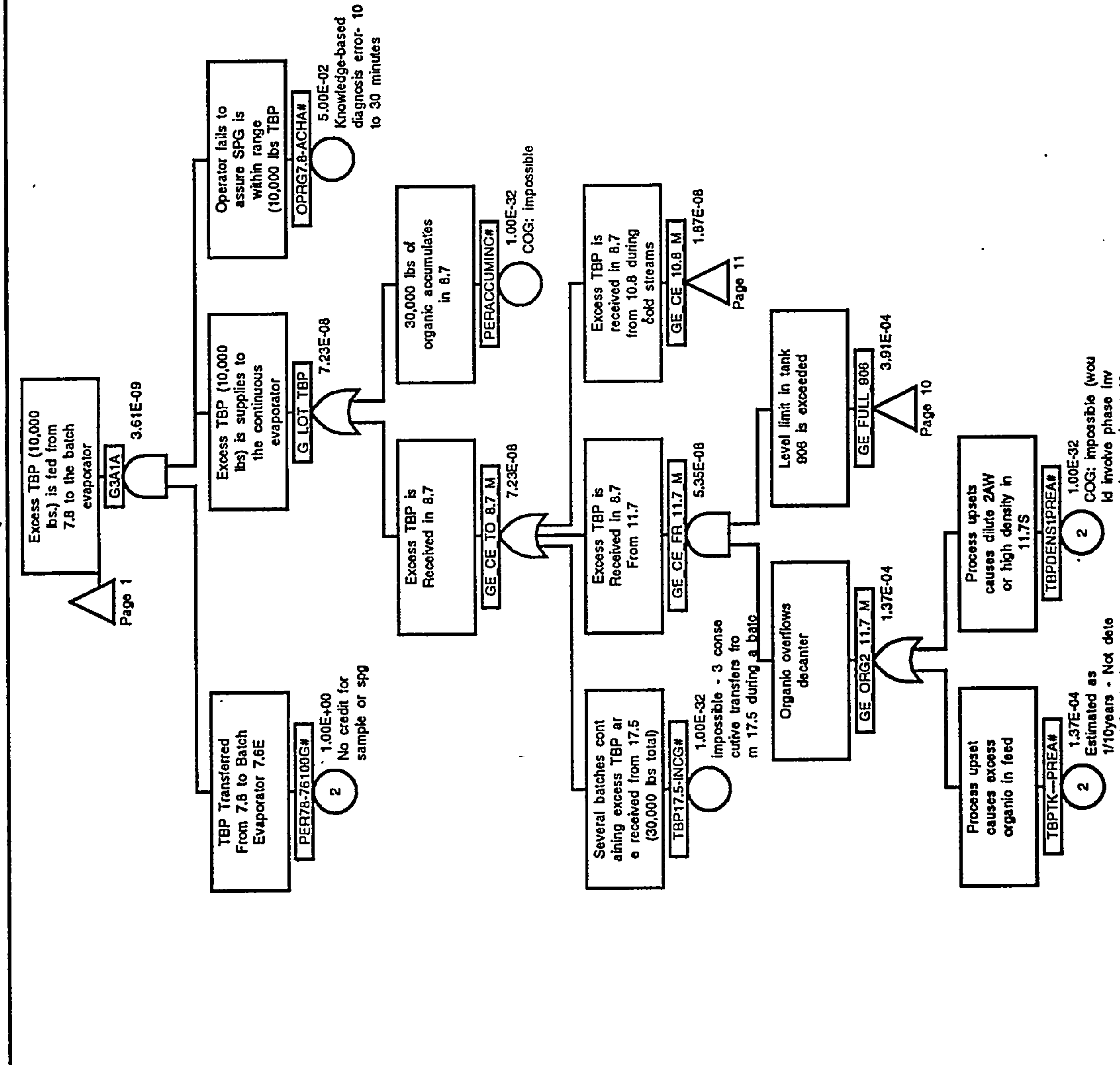

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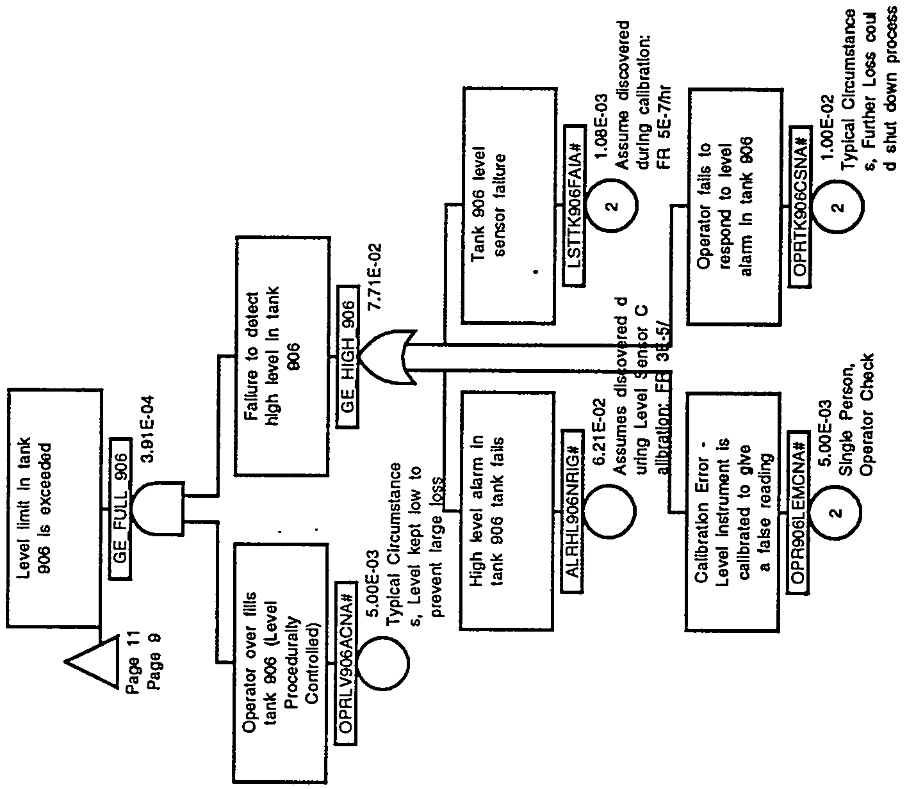

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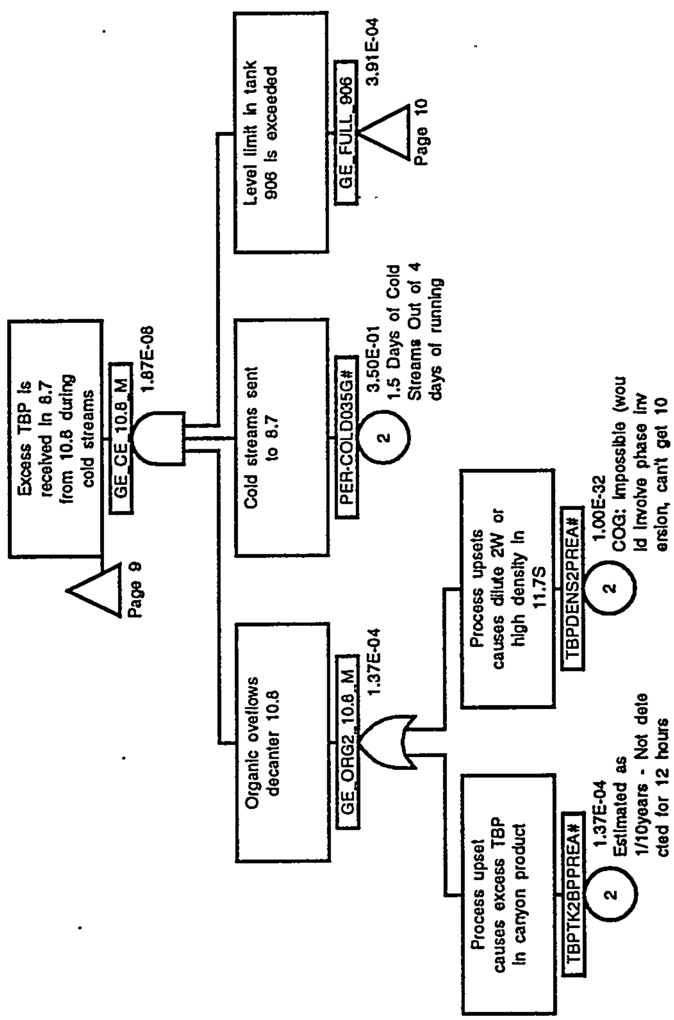

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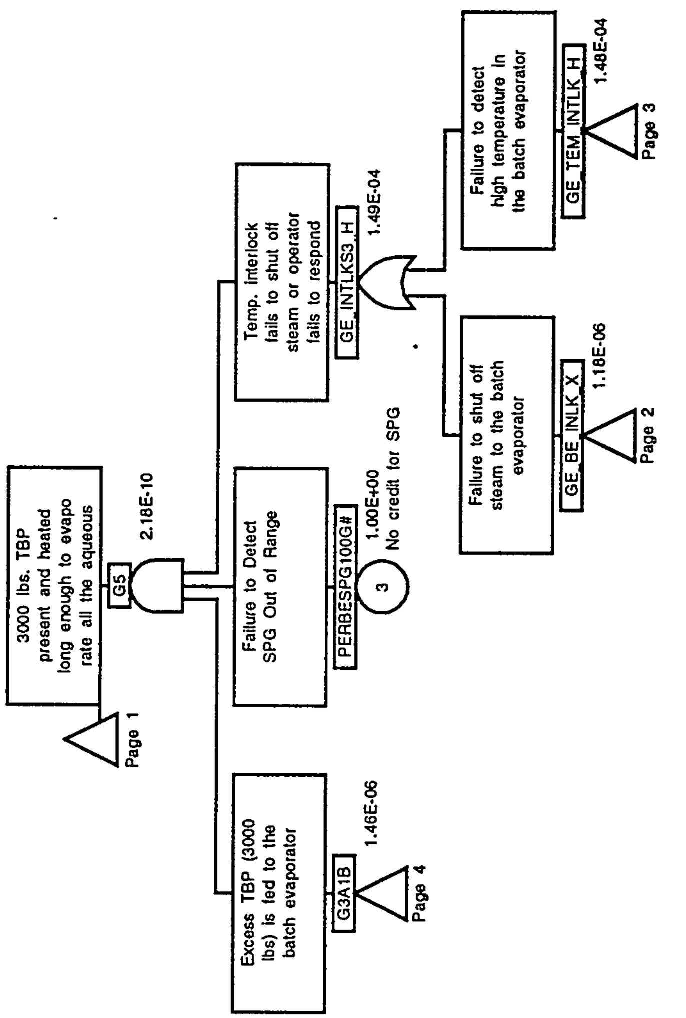

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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
ALR-PGT-COMG#	2		GE_FULL_906	10		PERBESPG100G#	1				
ALRHL906NRIG#	10		GE_FULL_906	11		PERBESPG100G#	12				
ALRTK906NRIG#	6		GE_HIGH_906	10		PERBETEM002A#	3				
CAVBESTMFOGG#	1		GE_INTLKS3_H	12		PERFBLININC#	4				
CAVBESTMFOGG#	2		GE_ORG2_10.8_G	7		PERTK175.20A#	4				
EVPBEVAPON-G+	1		GE_ORG2_10.8_M	11		PERTR175002A#	4				
G1	1		GE_ORG2_11.7_G	5		RLPPUMP-NREG#	6				
G2	1		GE_ORG2_11.7_M	9		TBP17.5-INCG#	9				
G3A	1		GE_PMP906_INTLK	6		TBPDENS1PREA#	5				
G3A1A	1		GE_TEM_INTLK_H	1		TBPDENS1PREA#	9				
G3A1A	9		GE_TEM_INTLK_H	3		TBPDENS2PREA#	7				
G3A1B	1		GE_TEM_INTLK_H	12		TBPDENS2PREA#	11				
G3A1B	4		GE_TK906_RECOV	5		TBPTK---PREA#	5				
G3A1B	12		GE_TK906_RECOV	6		TBPTK---PREA#	9				
G4	1		GE_TK906_RECOV	7		TBPTK2BPPREA#	7				
G5	1		G_LIT_TBP	4		TBPTK2BPPREA#	11				
G5	12		G_LOT_TBP	9		TR-17.5-TO-8.7	4				
GE-ACCUM-G	4		LSTTK906FAIA#	6		TSTBETE-FAIG#	3				
GE-ACCUM-G	8		LSTTK906FAIA#	10							
GE_906_ALARM	6		OPR17.5-ACNA#	4							
GE_BE_CC_ALARM	2		OPR87EM1ACNA#	8							
GE_BE_INLK_X	1		OPR87EM2ACNA#	8							
GE_BE_INLK_X	2		OPR87EM3ACNA#	8							
GE_BE_INLK_X	12		OPR906LEMCNA#	6							
GE_BE_INTLKS1_H	1		OPR906LEMCNA#	10							
GE_BE_VALVE_H	1		OPRBBLOCDENA#	2							
GE_CE_10.8_G	4		OPRG7.8-ACHA#	9							
GE_CE_10.8_G	7		OPRGBETEMCNA#	3							
GE_CE_10.8_M	9		OPRLV906ACNA#	10							
GE_CE_10.8_M	11		OPRTK906CSNA#	6							
GE_CE_FR_11.7_G	4		OPRTK906CSNA#	10							
GE_CE_FR_11.7_G	5		PER-COLD035G#	7							
GE_CE_FR_11.7_M	9		PER-COLD035G#	11							
GE_CE_FR_17.5_G	4		PER78-76100G#	4							
GE_CE_TO_8.7_G	4		PER78-76100G#	9							
GE_CE_TO_8.7_M	9		PER87ORG100A#	8							
GE_CW_CAL_TE_G	3		PERACCUMINC#	9							
GE_FULL_906	9		PERBESPG100G#	1							

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Cutset Report for 7.6E & 7.7E Evaporators

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	G1					3.83E-07	
1.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.13E-07	55.5
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
2.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	7.44E-08	74.9
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.3[illegible]04		
3.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	3.42E-08	83.8
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	OPRTK906CSNA#	Operator fails to respond to level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
4.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.71E-08	88.3

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
5.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.20E-08	91.4
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	OPRTK906CSNA#	Operator fails to respond to level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
6.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	6.85E-09	93.2
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
7.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	5.99E-09	94.8
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
8.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	3.70E-09	95.8
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
9.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	3.29E-09	96.6
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
10.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	2.40E-09	97.2
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
11.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	2.00E-09	97.8
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N		
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N		
	TR-17.5-TO-8.7	Transfer Excess TBP From 17.5 to 8.7		1.0N	1.00E+00		
12.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.48E-09	98.1
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
13.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.29E-09	98[illegible]
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRG7.8-ACHA#	Operator fails to assure SPG is within range (10,000 lbs TBP	1	1N 5.0E-2 N	5.00E-02N		
	OPRLV906ACNA#	Operator over fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
14.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.25E-09	98.8
	OPR87EM1ACNA#	operator fails to feed remaining tank contents after 1st interval- clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM2ACNA#	operator fails to feed remaining tank contents after 2nd interval- clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM3ACNA#	operator fails to feed remaining tank contents after 3rd interval- clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PER87ORG100A#	organic remains in feed tank	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	[illegible]		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
15.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.15E-09	99.1
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
16.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	9.60E-10	99.4
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N		
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	TR-17.5-TO-8.7	Transfer Excess TBP From 17.5 to 8.7		1.0N	1.00E+00		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
17.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	7.10E-10	99.5
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
18.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	6.00E-10	99.7
	OPR87EM1ACNA#	operator fails to feed remaining tank contents after 1st interval- clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM2ACNA#	operator fails to feed remaining tank contents after 2nd interval- clean tank	1	1N 5.0E-3 N	5.00E-03N		
	OPR87EM3ACNA#	operator fails to feed remaining tank contents after 3rd interval- clean tank	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PER87ORG100A#	organic remains in feed tank	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
19.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	5.17E-10	99.8
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		

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Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
20.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	2.48E-10	99.9
	LSTTK906FAIA#	Tank 906 level sensor failure	5	6M 5.00E-07 H	1.08E-03		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
21.	ALRTK906NRIG#	Low level alarm in tank 906 fails	5	6M 3.00E-05H	6.21E-02	8.50E-11	99.9
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	[illegible]		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	RLPPUMP-NREG#	Pump switch fails to open	1	1N 1.0E-3N	1.00E-03N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
22.	CAVBESTMFOGG#	Pneumatic steam control valve fails open (batch evaporator)	3	24H 3.00E-06 H	7.20E-05	4.93E-11	99.9
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	OPRBBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres) (Close valve)	1	1N 1.0E-2 N	1.[illegible]E-02N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
23.	ALRTK906NRIG#	Low level alarm in tank 906 fails	5	6M 3.00E-05H	6.21E-02	4.08E-11	9[illegible].9
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	RLPPUMP-NREG#	Pump switch fails to open	1	1N 1.0E-3N	1.00E-03N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
24.	ALR-PGT-COMG#	Common cause batch evaporator alarm failure (temp, pres.)	5	6M 3.00E-06H	6.45E-03	3.18E-11	100.0
	CAVBESTMFOGG#	Pneumatic steam control valve fails open (batch evaporator)	3	24H 3.00E-06 H	7.20E-05		
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.[illegible]0E+02Y		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
25.	ALRTK906NRIG#	Low level alarm in tank 906 fails	5	6M 3.00E-05H	6.21E-02	2.98E-11	100.0
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00[illegible]+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.[illegible]-02N		
	RLPPUMP-NREG#	Pump switch fails to open	1	1N 1.0E-3N	1.00E-03N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
26.	CAVBESTMFOGG#	Pneumatic steam control valve fails open (batch evaporator)	3	24H 3.00E-06 H	7.20E-05	1.73E-11	100.0
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)	CUM %
	OPRBBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres) (Close valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
27.	CAVBESTMFOGG#	Pneumatic steam control valve fails open (batch evaporator)	3	24H 3.00E-06 H	7.20E-05	1.44E-11	100.0
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N		
	OPRBBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres) (Close valve)	1	1N 1.0E-2 N	1.00E-02N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N		
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N		
	TR-17.5-TO-8.7	Transfer Excess TBP From 17.5 to 8.7		1.0N	1.00E+00		
28.	ALRTK906NRIG#	Low level alarm in tank 906 fails	5	6M 3.00E-05H	6.21E-02	1.43E-11	100.0
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	RLPPUMP-NREG#	Pump switch fails to open	1	1N 1.0E-3N	1.00E-03N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		
	TSTBETE-FAIG#	Batch Evaporator Temperature Sensor Fails	5	4D 1.00E-06 H	4.80E-05		
29.	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	1.37E-11	100.0
	OPRGBETEMCNA#	Tank Temperature Sensor is Miscalibrated	1	1N 5.0E-3 N	5.00E-03N		

Cutset Report for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)	CUM %
	OPRTK906CSNA#	Operator fails to respond to level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	PERBETEM002A#	Temperature sensor calibrated just before this batch	1	1N 2.00E-02N	2.00E-02N		
	RLPPUMP-NREG#	Pump switch fails to open	1	1N 1.0E-3N	1.00E-03N		
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04		
30.	ALR-PGT-COMG#	Common cause batch evaporator alarm failure (temp, pres.)	5	6M 3.00E-06H	6.45E-03	1.11E-11	100.0
	CAVBESTMFOGG#	Pneumatic steam control valve fails open (batch evaporator)	3	24H 3.00E-06 H	7.20E-05		
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y		
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N		
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N		
	PER78-76100G#	TBP Transferred From 7.8 to Batch Evaporator 7.6E	1	1N 1.00E+00N	1.00E+00N		
	PERBESPG100G#	Failure to Detect SPG Out of Range	1	1N 1.00E+00N	1.00E+00N		
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04		

Basic Event Data for 7.6E & 7.7E Evaporators

Event	C	Input	Calc.	Description	Source
ALR-PGT-COMG#	5	6M 3.00E-06H	6.45E-03	Common cause batch evaporator alarm failure (temp, pres.)	a: calib. every 6 mon., beta factor of .1 for common cause
ALRHL906NRIG#	5	6M 3.00E-05H	6.21E-02	High level alarm in tank 906 tank fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
ALRTK906NRIG#	5	6M 3.00E-05H	6.21E-02	Low level alarm in tank 906 fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
CAVBESTMFOGG#	3	24H 3.00E-06 H	7.20E-05	Pneumatic steam control valve fails open (batch evaporator)	Used Compressed Gas Value, 1 Day Mission Time :FR 3E-6/hr
EVPBEVAPON-G+		100Y	1.00E+02Y	Batch Evaporator is Used	Assumed to Operate 100 Times per Year
LSTTK906FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 906 level sensor failure	Assume discovered during calibration: FR 5E-7/hr
OPR17.5-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	sump receipt tank transfer procedure does not allow a 2nd transfer
OPR87EM1ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents after 1st interval- clean tank	typical circumstances
OPR87EM2ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents after 2nd interval- clean tank	typical circumstances
OPR87EM3ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to feed remaining tank contents after 3rd interval- clean tank	typical circumstances
OPR906LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is calibrated to give a false reading	Single Person, Operator Check
OPRBBLOCDENA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to alarm(s) (906, temp., pres) (Close valve)	Several Competing Signals
OPRG7.8-ACHA#	1	1N 5.0E-2 N	5.00E-02N	Operator fails to assure SPG is within range (10,000 lbs TBP	Knowledge-based diagnosis error- 10 to 30 minutes
OPRGBETEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Tank Temperature Sensor is Miscalibrated	Single Person, Operator Check
OPRLV906ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator over fills tank 906 (Level Procedurally Controlled)	Typical Circumstances, Level kept low to prevent large loss of organic
OPRTK906CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to level alarm in tank 906	Typical Circumstances, Further Loss could shut down process
PER-COLD035G#	1	1N 3.50E-01N	3.50E-01N	Cold streams sent to 8.7	1.5 Days of Cold Streams Out of 4 days of running
PER78-76100G#	1	1N 1.00E+00N	1.00E+00N	TBP Transferred From 7.8 to Batch Evaporator 7.6E	No credit for sample or spg
PER87ORG100A#	1	1N 1.00E+00N	1.00E+00N	organic remains in feed tank	no credit for feeding tank contents down to adequate mixing point
PERACCUMINC#	1	1N 1.00E-32N	1.00E-32N	30,000 lbs of organic accumulates in 8.7	COG: impossible
PERBESPG100G#	1	1N 1.00E+00N	1.00E+00N	Failure to Detect SPG Out of Range	No credit for SPG
PERBETEM002A#	1	1N 2.00E-02N	2.00E-02N	Temperature sensor calibrated just before this batch	Calibrated every 6 months & 100 batches a year
PERFBLININC#	1	1N 1.00E-32N	1.00E-32N	Excess TBP is Received in 8.7 From 9.7	impossible E\ (no planned B-Line processing)

Basic Event Data for 7.6E & 7.7E Evaporators (CONT.)

Event	C	Input	Calc.	Description	Source
PERTK175.20A#	1	1N 2.00E-03N	2.00E-03N	Sufficient TBP present in tank 17.5	a: 1 in 5 years (1/500 Batches)
PERTR175002A#	1	1N 2.00E-02N	2.00E-02N	Material Is Being Received From 17.5	Pu Recovery, Assume 1 out of 50 batches
RLPPUMP-NREG#	1	1N 1.0E-3N	1.00E-03N	Pump switch fails to open	Per Demand, Generic Data
TBP17.5-INCG#		1.0E-32N	1.00E-32	Several batches containing excess TBP are received from 17.5 (30,000 lbs total)	impossible - [illegible] consecutive transfers from 17.5 during a batch
TBPDENS1PREA#		1.0E-32N	1.00E-32	Process upsets causes dilute 2AW or high density in 11.7S	COG: impossible (would involve phase inversion, can't get 10,000 lbs organic)
TBPDENS2PREA#		1.0E-32H	8.76E-29Y	Process upsets causes dilute 2W or high density in 11.7S	COG: impossible (would involve phase inversion, can't get 10,000 lbs organic)
TBPTK---PREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess organic in feed	Estimated as 1/10years - Not detected for 12 hours
TBPTK2BPPREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess TBP in canyon product	Estimated as 1/10years - Not detected for 12 hours
TR-17.5-TO-8.7		1.0N	1.00E+00	Transfer Excess TBP From 17.5 to 8.7	Assumed to be present and always transferred
TSTBETE-FAIG#	5	4D 1.00E-06 H	4.80E-05	Batch Evaporator Temperature Sensor Fails	Temp Sensor, Discovered within 4 days: FR1E-6/hr

Type Code Data for 7.6E & 7.7E Evaporators

Type Code	Rate	Description	Source	EF	D
ALR COM	3.00E-06H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I		
ALR NRI	3.00E-05H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
CAV FOG	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Compressed Gas)	WSRC-TR-93-262, CAV-FO-G	10	L
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
OPR ACH	5.0E-2 N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High	5	L
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR CSN	1.0E-2 N	Failure to respond to compelling signal (Nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal	5	L
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR MCN	5.0E-3 N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	L
PER .20	2.00E-03N	0.2% chance			
PER 002	2.00E-02N	2% chance			
PER 035	3.50E-01N	35% chance			
PER 100	1.00E+00N	100% chance			
PER INC	1.00E-32N	Incredible Event			
RLP NRE	1.0E-3N	Relay fails to open	WSRC-TR-93-262m RLP-NRE		
TBP PRE	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated a [illegible]ce in Ten Years		
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L

APPENDIX B DETAILED ANALYSIS FOR EVAPOATORS

Calculation Cover Sheet

Project F-Canyon BIO	Calculation No. S-CLC-F-00100	Project Number NA
Title Frequency Determination for Runaway TBP/Nitric Acid Reactions in Support of the F-Canyon BIO (U)	Functional Classification NS Discipline Risk Analysis Group	Sheet 1 of 135

_ Preliminary x Committed _Confirmed

Computer Program No.
_CAFTA (Computer Applied Fault Tree Ar :sis) Version Rele: No. 2.2c

Purpose and Objective

The purpose of this Calc-Note is to determine the frequency of runaway TBP/Nitric Acid reactions in F-Canyon.

Summary of Conclusion

The frequency for runaway TBP reactions and explosions in various tanks in F-Canyon are given in the table below. All of these tanks represent an acceptable frequency considering the proposed two years of operation.

Tank	Frequency of Reaction (/yr)	Mean Time Between Failures (yrs)	Frequency of Explosion (/yr)	Mean Time Between Failures (yrs)
Sump Receipt				
17.5	1.69E-04	5,900	3.38E-07	3,000,000
7.3	1.88E-04	5,000	3.77E-07	2,600,000
Feed Tank				
12.5	5.83E-06	170,000	5.83E-07	1,700,000
Mixer Settler				
2Pu	-	-	9.74E-07	1,000,000

Revision

Rev. No.	Revision Description
Rev. 0	Initial Issue
Rev. 1	Revised to include explosion frequencies and the 2nd Pu Mixer Settler

Sign Off

Rev. No.	Originator (Print) Sign/Date	Verification / Checking Method	Verifier /Checker (Print) Sign/Date	Manager (Print) Sign/Date
Rev. 1	C. Ray Lux Lance Christiansen Kathy Marshall Terri Slaven			

Classification

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1.0 OPEN ITEMS

The potential for criticality and a fire in the cell as potential initiators for runaway reactions needs to be studied. The evaporators and tanks in re-run are not included as a part of this report. Present plans do not call for the operation of the re-run tanks and the evaporators will be operated as caustic evaporators to avoid runaway TBP/nitric reactions. Since the evaporators will be operated using caustic solutions, the bottom will also necessarily be caustic and therefore have no TBP/Nitric concerns.

Full QA certification of CAFTA pends resolution of NCR 94-11-005.

2.0 INTRODUCTION

A very small potential exists in the SRS separations operations for an uncontrolled reaction between tri-n-butyl phosphate (TBP) and nitric acid that could result in unacceptable damage to separations facilities and a significant release of radioactive materials.

The recent TBP and nitric acid accident in Tomsk, Russia, resulted in considerable damage and radioactive release. Explosions have also occurred at SRS during the early years of operations. While the SRS separations facilities have operated without incident for many years since the last accident, it is prudent to revisit the SRS defense in depth approach to preventing such an accident and to upgrade preventive procedures and hardware if appropriate.

This study examines the current SRS licensing position with respect to this potential incident. It gives the administrative, procedural, and hardware controls that should result in the frequency of a potential incident being acceptable (less than once in a hundred thousand years) considering the limited planned operational period of these facilities. The frequencies calculated here include a number of changes that were identified as a part of this red oil analysis effort.

As previously stated this is the current position. Experimental and analytical evaluations have not been completed; therefore, the possibility exists of new information and revisions to these fault trees.

3.0 INPUT

Basic data used to quantify the fault tree came from four primary sources: WSRC-TR-93-581, "Savannah River Site Generic Data Base Development"(Ref. 1), WSRC-TR-93-581, "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities", (Ref. 2), DPSTSY-200-1F, Systems Analysis, F-Canyon Operations (Ref. 3), and DPSTSA-200-10, Sup-4, Safety Analysis, F-Canyon Operations (Ref. 4.). In a few cases the Separation Facilities Fault Tree Data Bank (Ref. 5) or judgment by knowledge personnel was used. Complete sources for the basic events in the fault tree are listed in the "Type Code" Report, which is part of this Calc-Note.

3.1 General Assumptions

- It is assumed that a red oil explosion will not occur with less than 3,000 pounds of TBP.
- There is a 10 percent chance that if TBP is present in the feed tanks due to operational errors, it will exceed 3,000 pounds (Ref. 6).

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- There is 1 chance in 500 that if TBP is present in the sump receipt tanks that it will exceed 3,000 pounds (Ref. 7 , Appendix 1).
- The operator is able to determine by some positive means that the agitator is functioning (e.g. specific gravity meter or ammeter read out).
- No HAN will be used in the process to eliminate the possibility of uncontrolled reactions between HAN and nitric acid.
- Combining nitric acid and water can not create enough heat to raise a tank at ambient canyon temperature to the red oil reaction temperature range.
- Cooling water and agitation will be provided during all transfers.
- Since no data could be located for agitator blade/shaft failure, they were assumed to occur at a rate of 10% of the agitator failure rate.
- Based on some preliminary heat transfer calculations, it is assumed that sufficient cooling can be supplied to a tank by the combination of the agitator and either the canyon exhaust or the cooling water system.
- All transfers and additions will cease during a power failure.
- Temperature is monitored on a routine basis for all tanks.
- Steam jet transfers are carefully monitored from the control room (Warm canyon transfers are also monitored in the gang valve corridor).
- All analyses were performed for full operation of the canyon only (start-up, shutdown, & maintenance modes were not addressed).

3.2 Additional Sump Receipt Tank Assumptions

- Both sump receipt tanks have dedicated head tanks (17.5 presently does not have one).
- The uncontrolled reactions for re-run represent a conservative estimate for the sump receipt tanks. Of these reactions, 10% were due to valving errors. The remaining frequency can be assumed to be split equally between HAN/FS reactions and transfers from sumps.
- Approximately 100 batches per year are received in each sump receipt tank.
- Tank 7.3 has no cooling coils.
- Tank 7.3 has no procedural requirement to monitor temperature during additions or during rounds checks.
- It is assumed that an ammonium nitrate reaction in the 7.2 process vessel vent filter will generate enough heat to cause a runaway TBP reaction in 7.3 if the canyon exhaust is inoperative.
- There is a procedural requirement to vacuum test the filter once a month, and flush the filter on a periodic and as needed basis.

3.3 Additional Mixer Settler Assumptions

- For a runaway TBP reaction to occur in the 2nd Pu Mixer Settler, the following three events would have to occur :

  1. 2nd Pu M r Settler is overheated.
  2. Undetect ailure of the Canyon Exhaust System.
  3. Failure to .ovide sufficient mixing.

- It is assumed that in order to overheat the 2nd Pu Mixer Settler, two of the three inlet streams (2AF, 2AS, and 2AX) to the 2nd Pu Mixer Settler are required to be overheated. The 2AF stream is always designated as one of the two that is required to be overheated. This is due to the larger volumetric flow of this stream in comparison to the 2AS and the 2AX streams.

- It is assumed that undetected failure of the Canyon Exhaust System constitutes the loss of normal and emergency power or failure of the Canyon Exhaust System.

- It is assumed that failure to provide mixing for the 2nd Pu Mixer Settler constitutes either two adjacent impellers failing in the Mixer Settler , the impeller drive (Variable Frequency Drive) not in normal position, or undetected failure of the Variable Frequency Drive.

- It is conservatively assumed that the 2AF stream can be overheated in the heat exchanger by sufficient volumetric flow of steam and water provided by the mix valve for the 2AF stream.

- It is assumed that flow control valves are calibrated once every eight months.

- It is assumed that it takes approximately one hour to fill the tank that feeds the 2AF stream for the 2nd Pu Mixer Settler.

- It is assumed that a strong acid addition will not overheat the 2nd Pu Mixer Settler. This assumption is based on chemical analysis results provided by SRTC.

- It is assumed that an uncontrolled reaction in the 2nd Pu Mixer Settler is incredible. Chemicals are added to the mixer settlers only through the head tanks and all additions are to a constantly moving solution, making a large uncontrolled reaction which significantly raises the temperature of a mixer settler an incredible event.

4.0 ANALYSIS METHOD AND CALCULATIONS

The logic for modeling a red oil explosion in F-Canyon was developed with the assistance of knowledgeable separations personnel (Ronnye Eubanks and Dave Chostner). To simplify the task, the F-Canyon tanks were divided into 6 categories: feed tanks, sump receipt tanks, the mixer settlers, evaporators, and evaporator bottoms tanks. Only the first three categories are addressed as a part of this study.

Due to several distinct differences between the sump receipt tanks, a fault tree had to be drawn for each tank. However, for the feed tanks and the mixer settlers, tank 12.5 and the 2nd Pu mixer settler, respectively, were identified as having the greatest potential consequences and a high frequency. Once constructed, the fault trees were evaluated using the fault tree evaluation code CAFTA, Version 2.2c (Ref. 8). The appendices contain copies of the fault trees, the associated cutsets, and copies of the data base used in the evaluation.

For the feed tanks, three different categories of tanks could be identified. Tanks which provided no red oil concerns, tanks for which the frequency would be less than that for 12.5, and tanks requiring further investigation. The tanks which fit into each of these categories are listed in the tables below. The reason for not having a red oil concern is listed in the first table. The reasons for having a frequency less than tank 12.5 is fewer heat sources and chemicals available for addition. Items were placed in the last table if there was uncertainty as to the availability of heat sources and/or chemicals compared to Tank 12.5. This last group of tanks will be evaluated as a part of a later study and will not be used for processing until then.

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Feed Tanks Which Present No Red Oil Concern

Tank No.	Reason for No Concern
5.2	No Organic Present
5.3	No Organic Present
6.1D	No Organic Present
6.4D	No Organic Present
6.8	Evaporator Overheads, No TBP
8.1	No Organic Present
8.3	No Heat Source, Dilute
8.5C	Evaporator Overheads, No TBP
9.1BT	Evaporator Overheads, No TBP
9.1C	Evaporator Overheads, No TBP
9.1E	Evaporator Overheads, No TBP
10.2	No Organic Present
10.3	No Organic Present
10.4	No Organic Present
11.1C	No Organic Present
11.2	No Organic Present
11.4	Evaporator Overheads, No TBP
12.1	Evaporator Overheads, No TBP
12.2	No Organic Present
13.1	No Organic Present
13.3	No Organic Present
14.7	No Heat Source
16.1E	Not Used
17.1	No Organic Present
17.5	Evaporator Overheads, No TBP
17.7C	Evaporator Overheads, No TBP
18.5	No Heat Source
18.6E	Basic, No Acid
18.7	Basic, No Acid
18.8	Evaporator Overheads, No TBP

Feed Tanks Which Have a "Red Oil" Frequency ≤ to Tank 12.5

Tank No.	Tank No.
7.8	12.8
8.7	13.5
9.5	13.7
9.6	13.8
9.8	14.5-1
10.1	14.5-2
11.8	14.8

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12.6	Decanters

Feed Tanks Which Require Further Evaluation

Tank No.	Tank No.
6.6	16.3
15.4	16.4
16.2	17.2

One fault tree was drawn for the Mixer Settlers in F-Canyon to explore the possibilities of a Runaway TBP Reaction. The 2nd Pu Mixer Settler was selected for analysis in comparison to the other Mixer Settlers, due to the radiological consequences the 2nd Pu Mixer Settler posed and the possibility that the streams could be overheated.

Two separate frequencies were calculated for each of the tanks. One was the frequency with which a runaway reaction would occur. The second was the frequency with which an explosion would occur. The difference between these two trees was the amount of TBP in these tanks. The frequency for obtaining more than 3,000 pounds , the amount necessary for an explosion, was provided by Tom Campbell of regulatory programs (Ref. 6 and Ref. 7 , contained in Appendix 1) for all except the mixer-settlers. The mixer-settlers were assumed to always contain more than 3,000 pounds of TBP and therefore if a reaction occurred, it would be an explosion.

5.0 RESULTS AND CONCLUSIONS

The frequency for runaway and explosive TBP reactions in various tanks in F-Canyon are given in the table below. All of these tanks represent an acceptable frequency considering the proposed two years of operation.

Tank	Frequency of Reaction (/yr)	Mean Time Between Failures (yrs)	Frequency of Explosion (/yr)	Mean Time Between Failures (yrs)
Sump Receipt				
17.5	1.69E-04	5,900	3.38E-07	3,000,000
7.3	1.88E-04	5,000	3.77E-07	2,600,000
Feed Tank				
12.5	5.83E-06	170,000	5.83E-07	1,700,000
Mixer Settler				
2Pu	-	-	9.74E-07	1,000,000

6.0 REFERENCES

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5 Durant, W. S., D. F. Baughman, and C. S. Townsend. *Separation Facilities Fault Tree Data Bank (SEPR) 1992 Status Report (U).* WSRC-TR-93-309. Westinghouse Savannah River Co. Aiken, SC. May 31, 1993.

6 Memo from T. G. Campbell to C. R. Lux, *Probability for Large Mass of TBP in Canyon Vessels.* NMP-SDG-94-0079. May 24, 1994.

7 Memo from T. G. Campbell to Lance W. Christiansen, *Probability for Accumulation of TBP in Canyon Sumps.*, June 3, 1994.

8 *CAFTA User's Manual.* Science Applications International Corporation. Los Altos, CA. May 29, 1992.

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7.0 APPENDICES

Appendix 1
Tom Campbell Memo for Sumps

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INTER-OFFICE MEMORANDUM
Savannah River Site

03-Jun-1994 04:30pm EDT

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASRS2)
Dept: NPSR
Tel: 2-3319

Probability for Accumulation of TBP in Canyon Sumps

Process solvent is expected to be received in canyon sump receipt tanks from time to time due to overflows and leaks from canyon tanks and piping. Procedures require that accumulated solvent be removed from receipt tanks before amounts (about 3000 pounds of TBP) are reached that could be a concern from a "red oil" reaction standpoint. The only way an amount can be received that is large enough to be of concern is from a single sump transfer. Experience indicates that the frequency of receiving such a large mass of organic material unexpectedly into a canyon vessel is very low. Myself, Ronnye Eubanks, and Dave Chostner conservatively estimate that a receipt of solvent, containing more than 3000 pounds of TBP, can be expected in the sump receipt tanks less than once every five years. This value is considered conservative because loss of such a large volume would be detected during operations. Actions other than transfer to sump receipt would be expected in these situations. Also, in our collective experience in the canyons (more than 40 years) we can recall of no occasion when such a large volume of organic material was received into a sump receipt tank from a leak, spill, or transfer error. Please incorporate this value (once in 5 years for receipt of large volumes of solvent in sump receipt) into the sump receipt tank fault trees for "red oil".

Distribution:

To: Lance W. Christiansen
(CHRISTIANSEN-LW-L0489 @A1@SLSRP1)

CC: ONELIO M. EBRA-LIMA (EBRALIMA-OM-T5452 @A1@SLSRP1)
CC: Ray Lux (LUX-CR-T7244 @A1@SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 AT A1 AT SASRS2)
CC: David F. Chostner
(CHOSTNER-DF-03090 AT A1 AT SASRS2)
CC: Ronnye A. L. Eubanks
(EUBANKS-RA-06258 AT A1 AT SASRS2)
CC: Sandra H. Marek (MAREK-SH-07923 AT A1 AT SASRS2)

Appendix 2
Basic Event Data for Feed Tanks (Tank 12.5)

Basic Event Report for Feed Tanks (Tank 12.5) (CONT.)

Event	C	Input	Calc.	Description	Source
OPRFSJETACLA#	1	1N 5.0E-4N	5.00E-04N	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	Present Throughout Transfer so should be low
OPRFSPG-ACNA#	1	1N 5.0E-3N	5.00E-03N	Operator Fails to Check for Fluctuation in SpG Instrument (Agitator Failure)	Use TC Value
OPRFTEMPMCNA#	1	1N 5.0E-3N	5.00E-03N	Miscalibration of Temperature Sensor for 12.5	Single person, Operator Check
OPRFTEMPVRHA#	1	1N 5.0E-2N	5.00E-02N	Operator Fails to Notice Temperature Increase During Transfer to 12.5	Scanning Effort Only
PERBETEMTWOA#	1	1N 0.02N	2.00E-02N	Temperature sensor calibrated just before this batch	Calibrated every 6 months & 96 batches a year
PERFBEMATHEA#	1	1N 0.38N	3.80E-01N	Maintenance is Performed Just Before This Batch	Assumes 3 Maintenance Activities/Month and 8 Batches/Month
PERFTCALHLFA#	1	1N 0.005N	5.00E-03N	Temperature Sensor for 12.5 Calibrated Just Before Required	Estimated Used 6/Day and Calibrated Every 6 Months
PNVBECWSFCLF#	5	7D 1.0E-06H	8.40E-05	Supply Control Valve on Cooling Water Fails Closed	Assumes Discovered within a week
RAHRIVERSPRF#	3	24H 5.0E-06H	1.20E-04	Spurious radiation alarms forces shut off cooling water	Fails during 24 hour cooling period
SJ-FT125PREF+	4	1H 4D	1.43E-01	Transfer to Tank 12.5 is Required	Use Frequency From TC File, 6/Day
SW-DG292BFLA#	1	1N 5E-3N	5.00E-03N	switch gear failure causes failure of 292 diesel generator to supply power	Demand Failure From Systems Analysis
TA-F----BFLA#	5	6M 3.0E-05H	6.21E-02	Temperature Alarm for 12.5 Fails	Assume not discovered until 6 month calibration cycle
TBP3000-PR3F#		0.1N	1.00E-01	TBP Present in Feed Exceeds 3000 Pounds	NMP-SDG-94-0079, 5/24/94 Campbell to Lux Based on data bank runs
TBPTK---PREF#	3	7D 0.1Y	1.92E-03	Process upset causes excess organic in feed	1st Cycle Process Upset Not Discovered for 1 Week (1/10 yr None Seen)
TE-BETE-BFLF#	5	7D 1.0E-06H	8.40E-05	Tank 12.5 Temperature Sensor Fails	Assumes Discovered within a week
TE-FT125BFLA#	3	24H 1.0E-06H	2.40E-05	Temperature Sensor for Tank 12.5 Fails	Required 24 hours during Cooling & Discovered at Next Use

Type Codes for Feed Tanks (Tank 12.5)

Type Code	Rate	Description	Source
AG- BFL A	5.0E-06H	Agitator Fails	WSRC-TR-93-262, page 19, AGI-FA-C, Agitator Failure
AG- BLA A	5.0E-07H	Agitator Blades/Shaft Fail	WSRC-TR-93-262, page 19, AGI-FA-C, Agitator Failure, Less Likely /10
CHM FIR F	1.0E-7H	Large fire in cell causes pyrolysis of TBP	Bounds DPSTSA-200-10, SUP-4
CHM UNR F	1.6E-05H	Uncontrolled Reaction in Solvent Extraction	DPSTSY-200-1F
DCS INA F	3.0E-06H	Common cause failure of DCS temperature and agitation equipment	WSRC-TR-93-262
DG- FTR A	3.0E-04H	Emergency diesel fail run	DPSTSY-200-1F vol. 2 p P-32
DG- FTS A	3.0E-02N	Emergency diesel fail start	DPSTSY-200-1F vol. 2 p P-32
DG- MSC A	2E-3N	operator error/misc. causes diesel generator failure	DPSTSY-200-1F vol. 2 p P-32
EXH BFL A	0.03Y	Failure of F-Canyon Ventilation System	SRT-SEP-93-009, Fault Tree Analysis of Diesel Generators in F-Canyon, 1/39yr
EXM CRI F	2.0E-07H	Heat from criticality causes secondary "red oil" reaction	DPSTSA-200-10, SUP-4, Table 5-7
FPW BFL A	1.0E-04H	Failure of utility power	DPSTSY-200-1F
HCV FCL F	3.0E-07H	Spurious Operation of Motor Operated Valve	WSRC-TR-93-262, page 12, MOV-OC-W, Spurious Operation of Motor Operated Valve
HX- LKS F	1.0E-07H	Heat Exchanger Tube Leaks	WSRC-TR-93-262, page 15, HTX-LI-W, Heat Exchanger Tube Leakage
HX- PLG F	3.0E-08H	Heat Exchanger Tube Plugs	WSRC-TR-93-262, page 15, HTX-PG-W, Heat Exchanger Tube Plugs
NCW BFL A	1.0E-05H	"Normal" Cooling Water Fails at Header Level	DPSTSY-200-1F
OPR ACH A	5.0E-2N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High
OPR ACL A	5.0E-4N	Failure of Administrative Control	WSRC-TR-93-581, Table 4, Item 1, Low
OPR ACN A	5.0E-3N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal
OPR MCN A	5.0E-3N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal
OPR RMN A	5.0E-3N	Failure to restore following maintenance (Nominal)	WSRC-TR-93-581, Table 4, Item 14, Nominal
OPR TEH A	3.0E-5H	Transfer error (per Tank) (High)	WSRC-TR-93-581, Table 4, Item 17, High
OPR VIN A	1.0E-1N	Failure of visual inspection (Nominal)	WSRC-TR-93-581, Table 4, Item 31, Nominal
OPR VRH A	5.0E-2N	Failure to verify within control room (High)	WSRC-TR-93-581, Table 4, Item 3, High
PER HLF A	0.005N	One Half of One Percent Chance	Probability of Occurrence
PER THE A	0.38N	38 %	Probability of occurrence
PER TWO A	0.02N	Two Percent Chance	Probability of Occurrence
PNV FCL F	1.0E-06H	Air-Operated Valve Fails Closed	WSRC-TR-93-262, page 12, AOV-CC-W, Air Operated Valve Spurious Operation
RAH SPR F	5.0E-06H	SPURIOUS ALARM FAILURE	WSRC-TR-93-262, page 30, ALR-SO-I, Alarm/Annunciator Fails to AlarmInternal)
SJ- PRE F	4D	Transfer Required to Tank 12.5	Conservative Estimate
SW- BFL A	5E-3N	switch gear failure	DPSTSY-200-1F vol. 2 p P-32
TA- BFL A	3.0E-05H	Alarm / Annunciator Fails to Alarm	WSRC-TR-93-262, page 30, ALR-NR-I, Alarm/Annunciator Fails to AlarmInternal)
TBP PRE F	0.1Y	Process upset causes excess organic in feed (recycle)	Conservatie estimate, loss of weir control, bank flooding, etc
TE- BFL A	1.0E-06H	Temperature Sensor Fails	WSRC-TR-93-262, page 30, TST-FA-I, Temperature Sensor Failure

Type Codes for Feed Tanks (Tank 12.5) (CONT.)

Type Code	Rate	Description	Source
TE- BFL F	1.0E-06H	Temperature Sensor Fails	WSRC-TR-93-262, page 30, TST-FA-I, Temperature Sensor Failure

Appendix 3
Fault Tree and Cutsets for Feed Tanks (Tank 12.5)

Calculation No.
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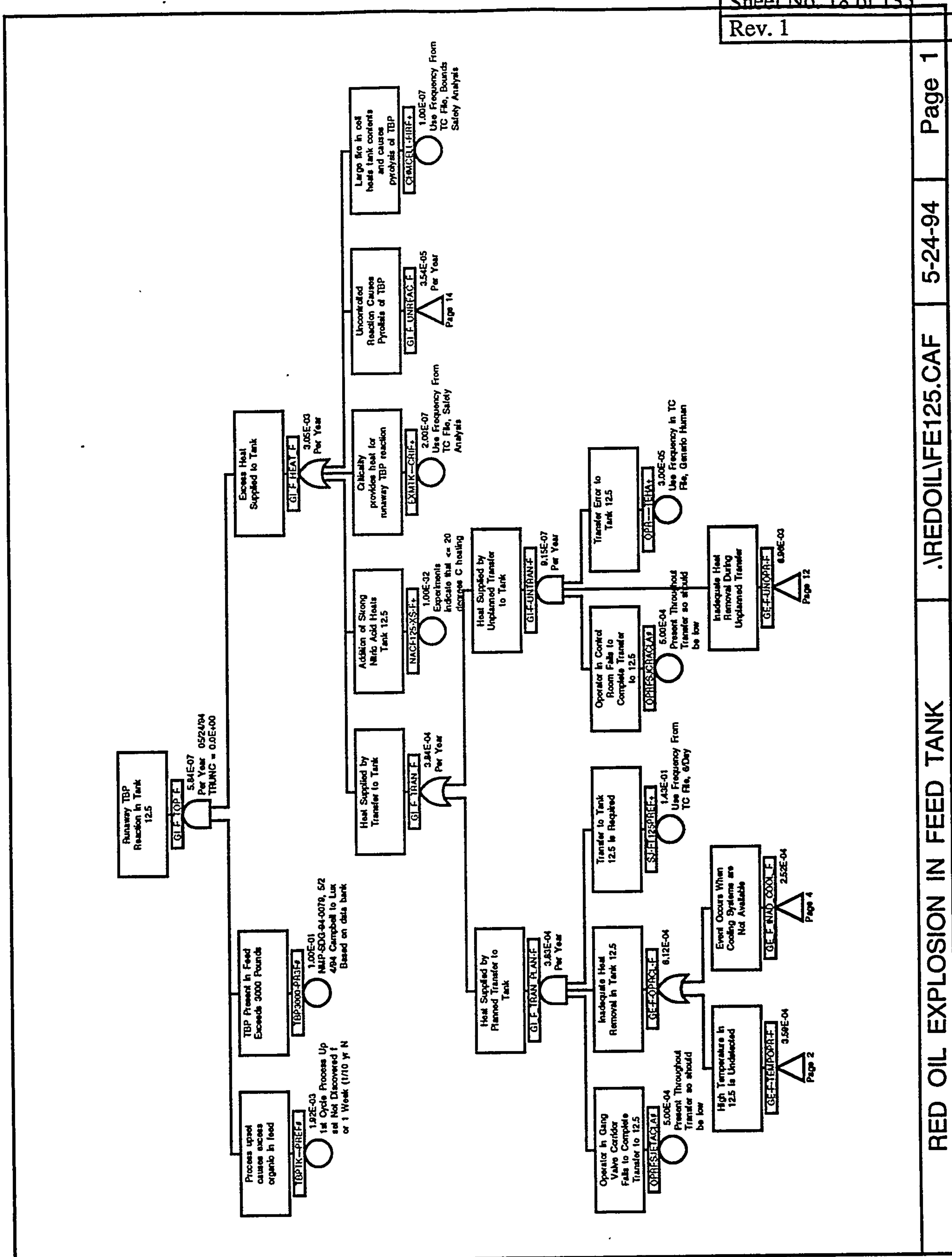

Calculation No. S-CLC-F-00100
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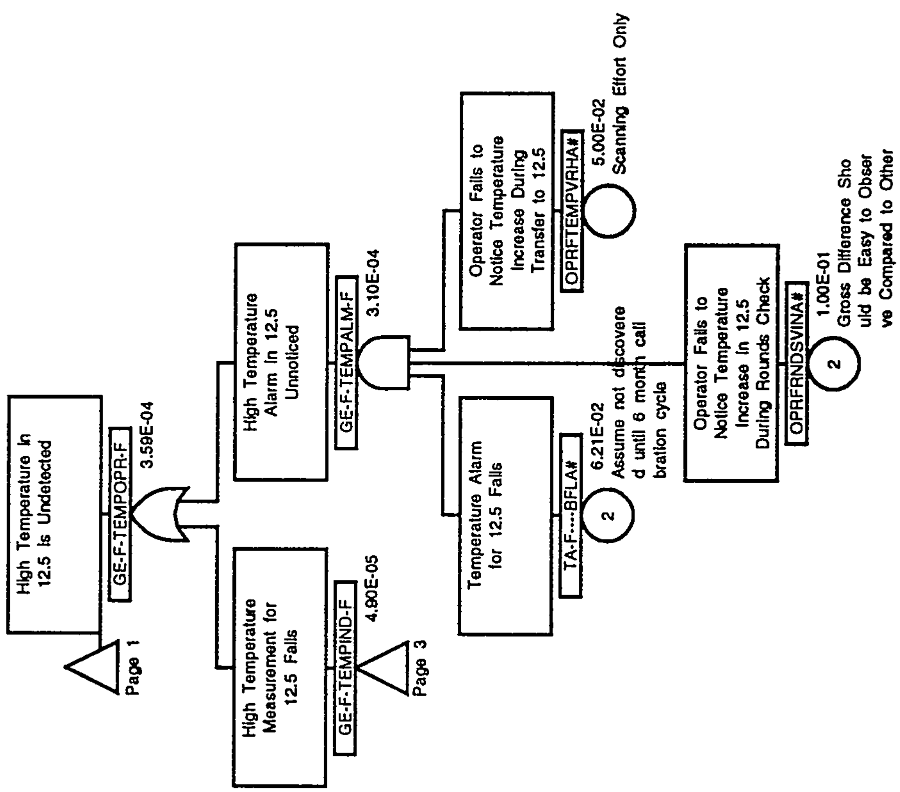
Rev. 1



RED OIL EXPLOSION IN FEED TANK | .\REDOIL\FE125.CAF | 5-24-94 | Page 2

Calculation No. S-CLC-F-00100
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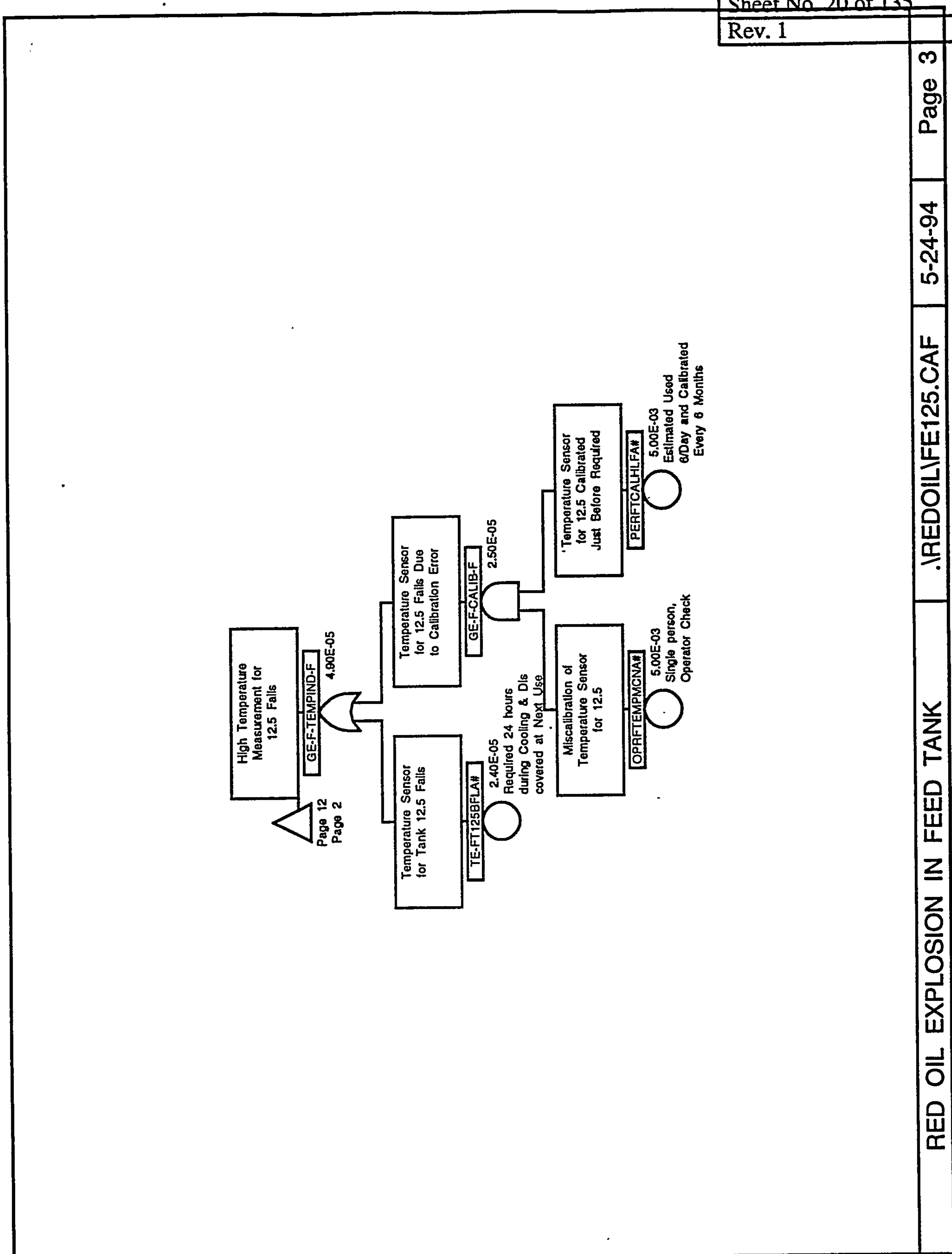

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Sheet No. 21 of 135
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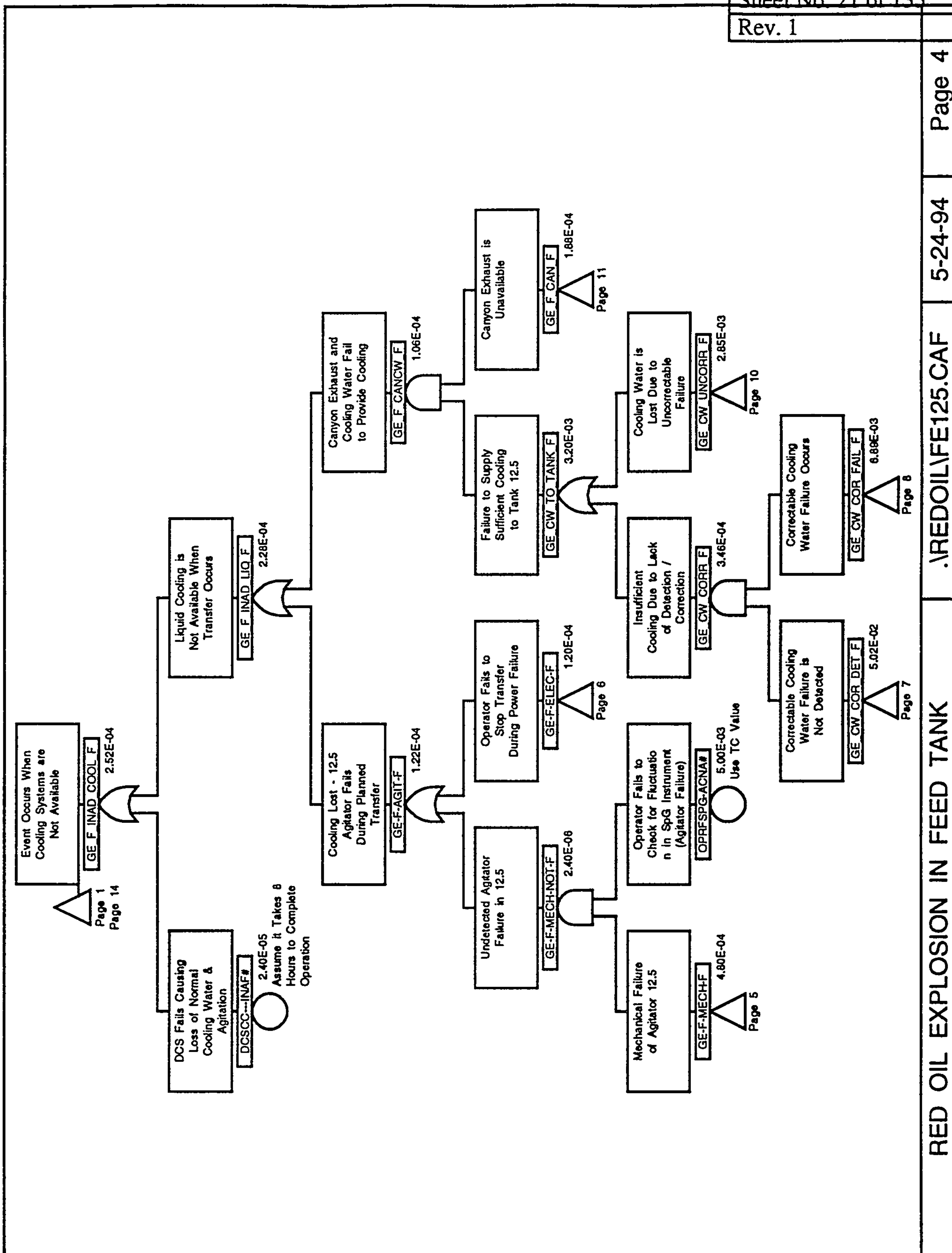

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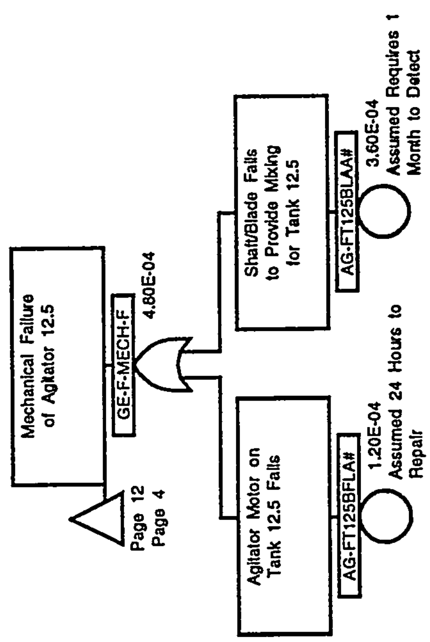
Sheet No. 22 of 135
Rev. 1



RED OIL EXPLOSION IN FEED TANK | .\REDOIL\FE125.CAF | 5-24-94 | Page 5

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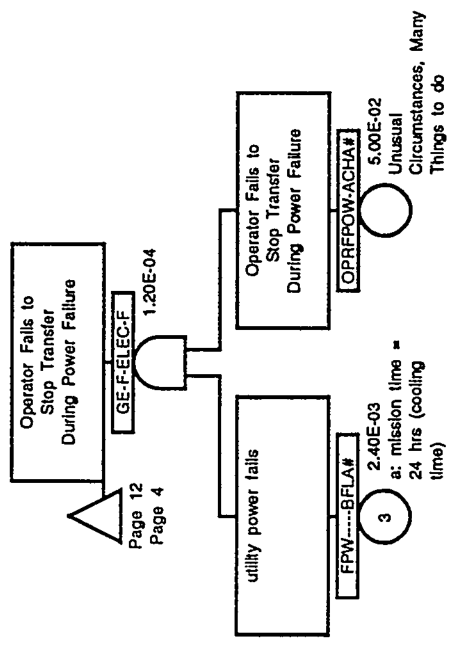

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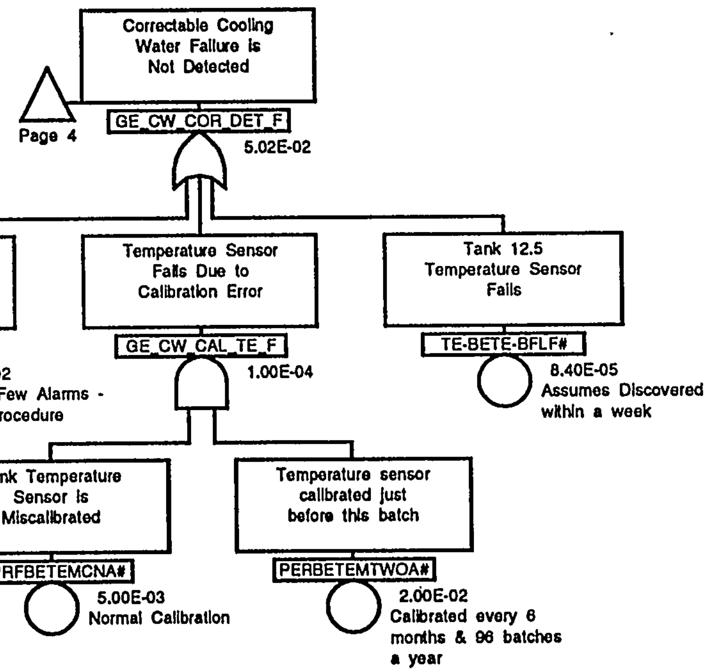

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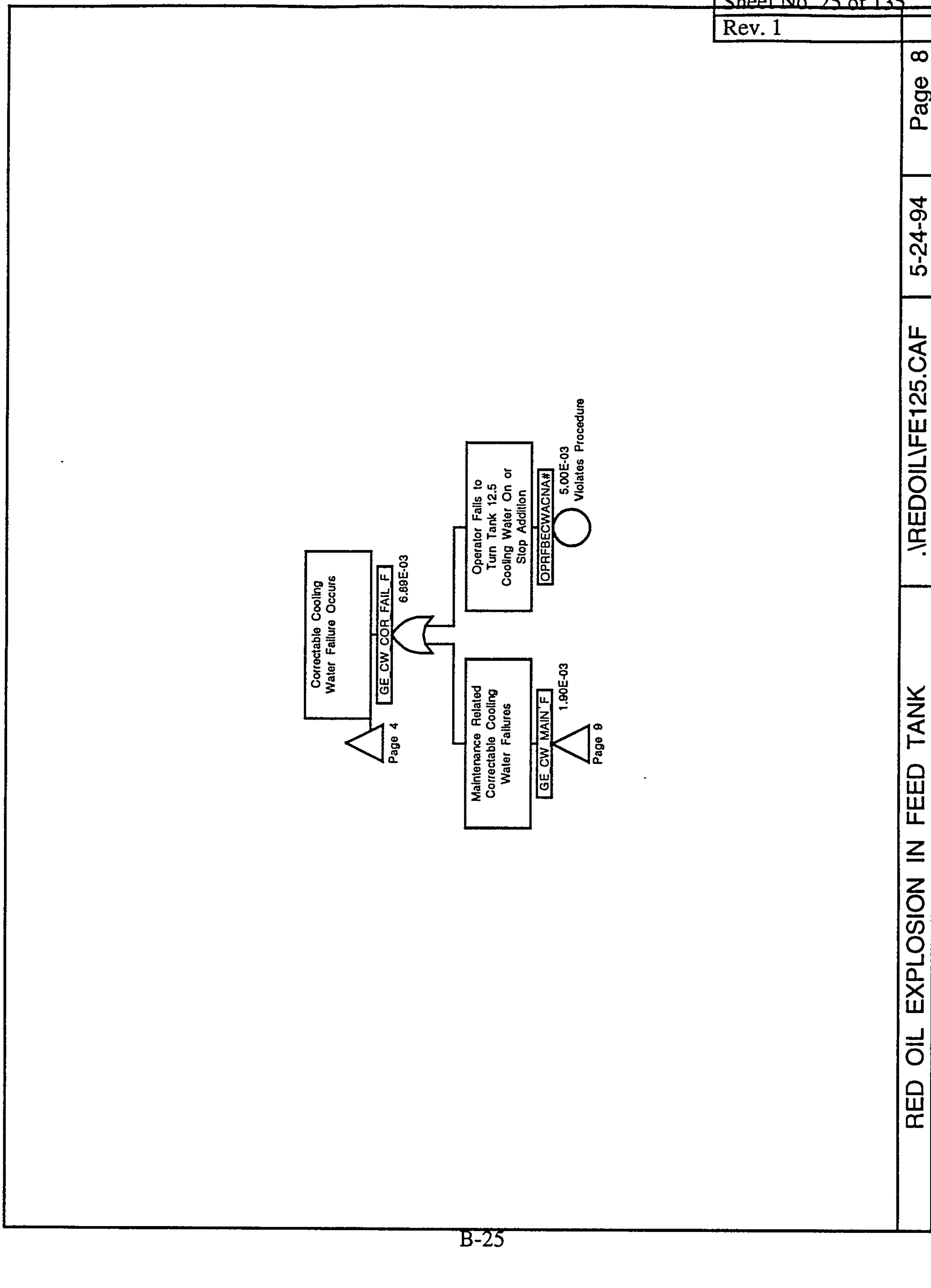

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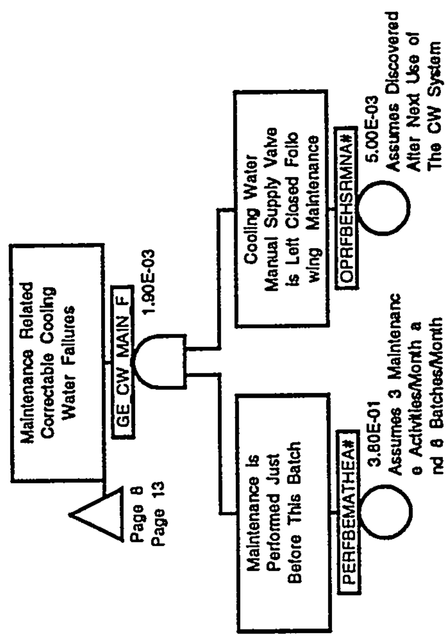

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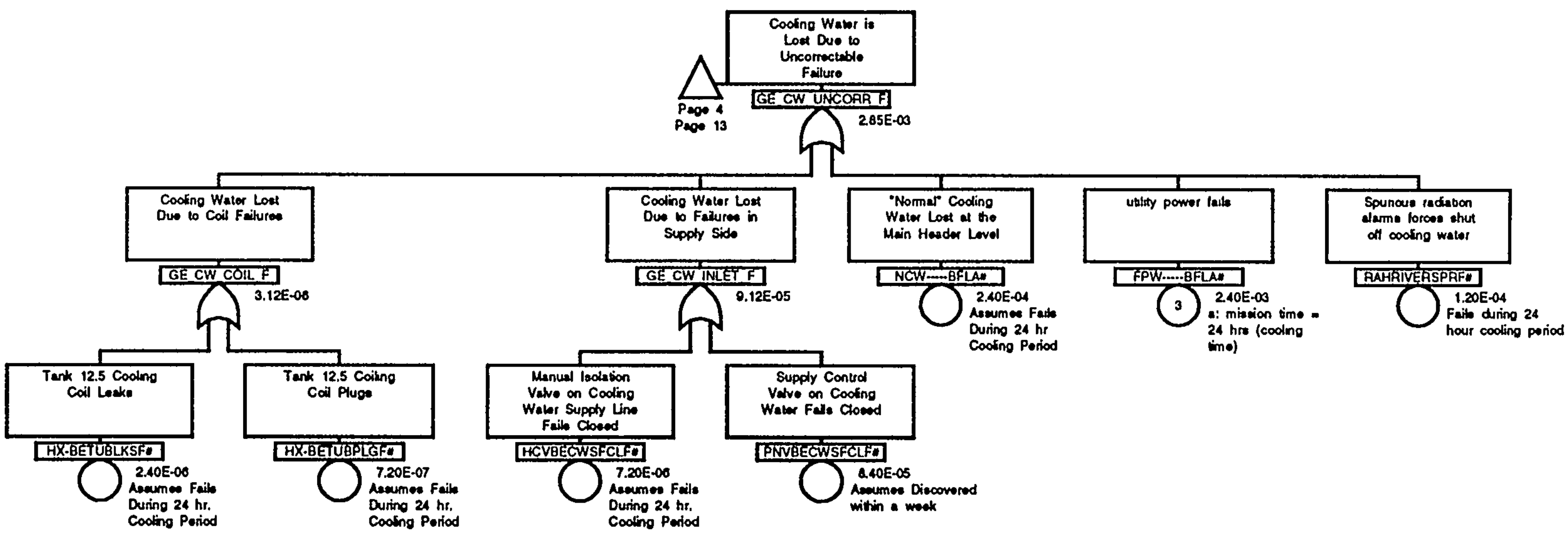

RED OIL EXPLOSION IN FEED TANK | .\REDOIL\FE125.CAF | 5-24-94 | Page 10

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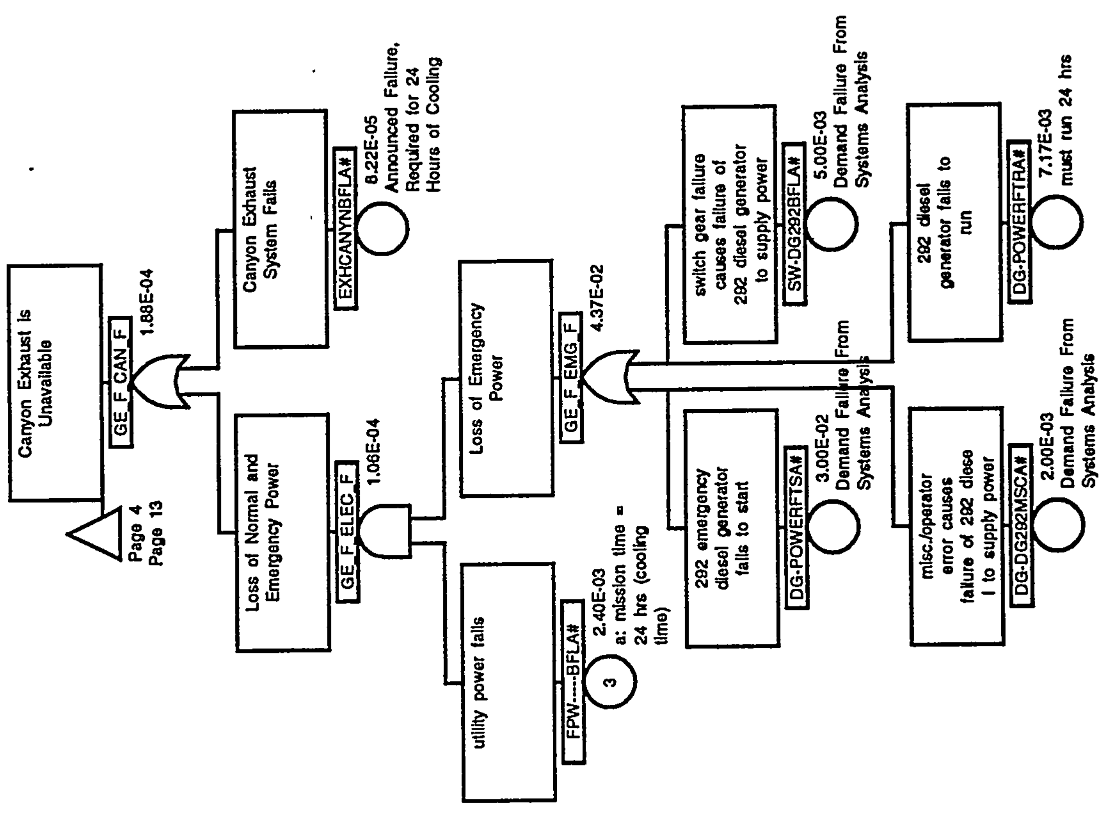

RED OIL EXPLOSION IN FEED TANK | .\REDOIL\FE125.CAF | 5-24-94 | Page 11

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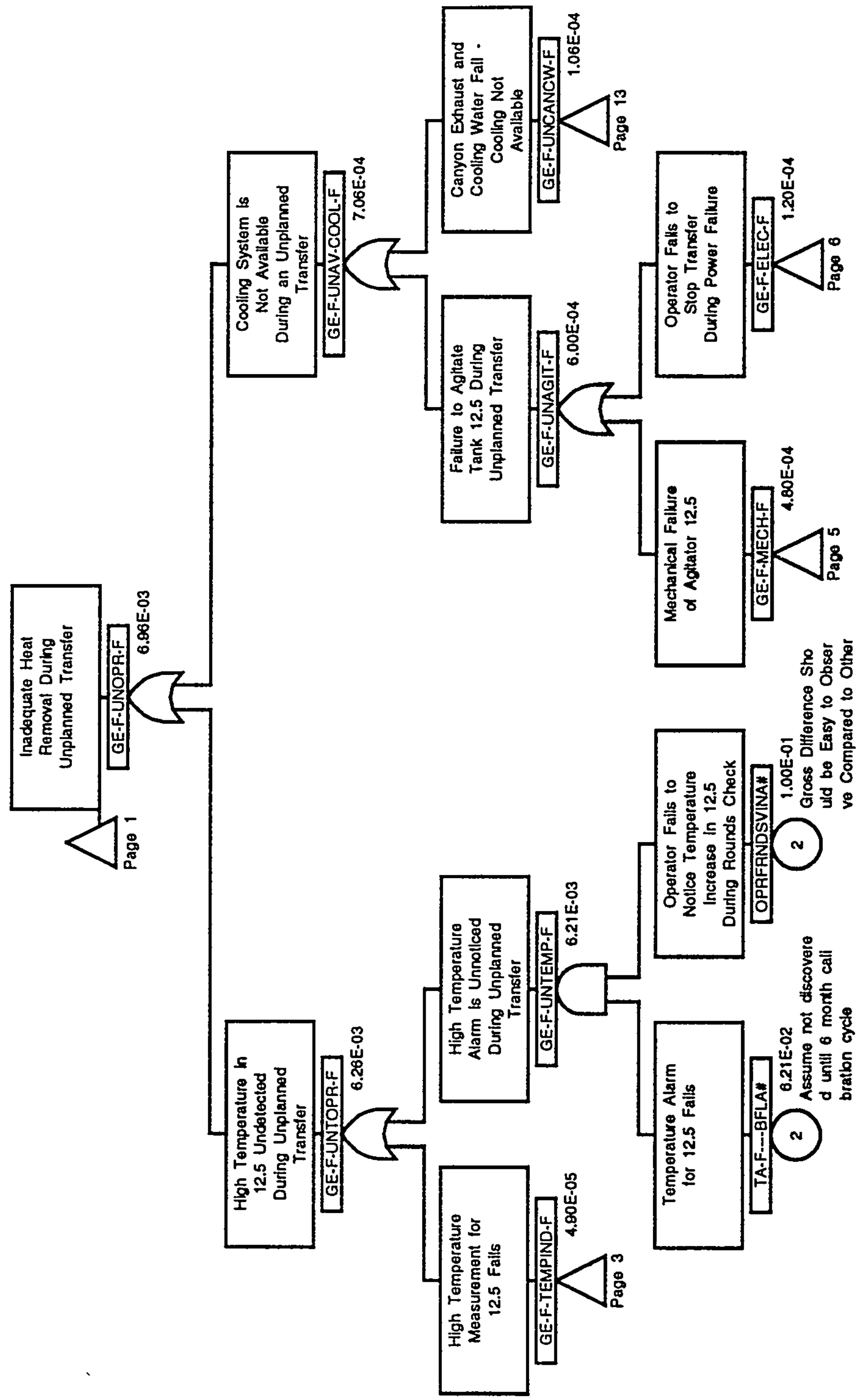

RED OIL EXPLOSION IN FEED TANK | \REDOIL\FE125.CAF | 5-24-94 | Page 12

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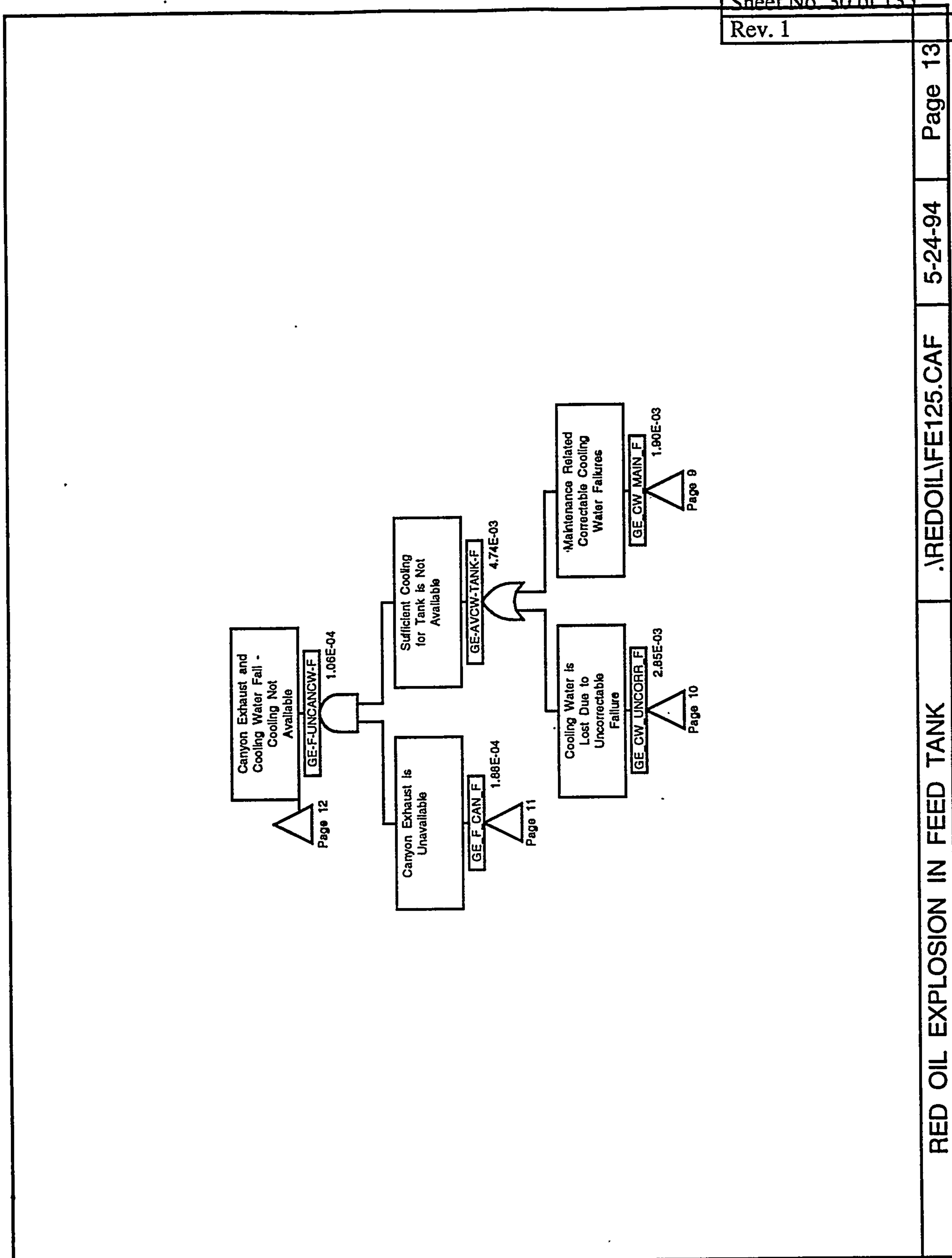

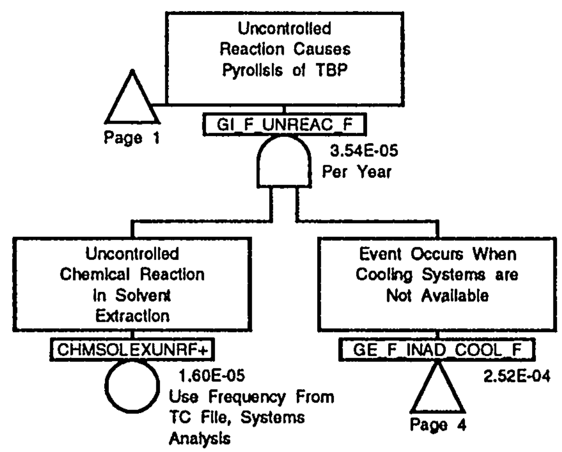

RED OIL EXPLOSION IN FEED TANK	.\REDOIL\FE125.CAF	5-24-94	Page 14

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AG-FT125BFLA#	5		GE_CW_CAL_TE_F	7		OPRFBECWACNA#	8				
AG-FT125BLAA#	5		GE_CW_COIL_F	10		OPRFBEHSRMNA#	9				
CHMCELL-FIRF+	1		GE_CW_CORR_F	4		OPRFBETEMCNA#	7				
CHMSOLEXUNRF+	14		GE_CW_COR_DET_F	4		OPRFBETEVRHA#	7				
DCSCC---INAF#	4		GE_CW_COR_DET_F	7		OPRFPOW-ACHA#	6				
DG-DG292MSCA#	11		GE_CW_COR_FAIL_F	4		OPRFRNDSVINA#	2				
DG-POWERFTRA#	11		GE_CW_COR_FAIL_F	8		OPRFRNDSVINA#	12				
DG-POWERFTSA#	11		GE_CW_INLET_F	10		OPRFSJCRACLA#	1				
EXHCANYNBFLA#	11		GE_CW_MAIN_F	8		OPRFSJETACLA#	1				
EXMTK---CRIF+	1		GE_CW_MAIN_F	9		OPRFSPG-ACNA#	4				
FPW-----BFLA#	6		GE_CW_MAIN_F	13		OPRFTEMPMCNA#	3				
FPW-----BFLA#	10		GE_CW_TO_TANK_F	4		OPRFTEMPVRHA#	2				
FPW-----BFLA#	11		GE_CW_UNCORR_F	4		PERBETEMTWOA#	7				
GE-AVCW-TANK-F	13		GE_CW_UNCORR_F	10		PERFBEMATHEA#	9				
GE-F-AGIT-F	4		GE_CW_UNCORR_F	13		PERFTCALHLFA#	3				
GE-F-CALIB-F	3		GE_F_CANCW_F	4		PNVBECWSFCLF#	10				
GE-F-ELEC-F	4		GE_F_CAN_F	4		RAHRIVERSPRF#	10				
GE-F-ELEC-F	6		GE_F_CAN_F	11		SJ-FT125PREF+	1				
GE-F-ELEC-F	12		GE_F_CAN_F	13		SW-DG292BFLA#	11				
GE-F-MECH-F	4		GE_F_ELEC_F	11		TA-F----BFLA#	2				
GE-F-MECH-F	5		GE_F_EMG_F	11		TA-F----BFLA#	12				
GE-F-MECH-F	12		GE_F_INAD_COOL_F	1		TBP3000-PR3F#	1				
GE-F-MECH-NOT-F	4		GE_F_INAD_COOL_F	4		TBPTK---PREF#	1				
GE-F-OPRCL-F	1		GE_F_INAD_COOL_F	14		TE-BETE-BFLF#	7				
GE-F-TEMPALM-F	2		GE_F_INAD_LIQ_F	4		TE-FT125BFLA#	3				
GE-F-TEMPIND-F	2		GI-F-UNTRAN-F	1							
GE-F-TEMPIND-F	3		GI_F_HEAT_F	1							
GE-F-TEMPIND-F	12		GI_F_TOP_F	1							
GE-F-TEMPOPR-F	1		GI_F_TRAN_F	1							
GE-F-TEMPOPR-F	2		GI_F_TRAN_PLAN-F	1							
GE-F-UNAGIT-F	12		GI_F_UNREAC_F	1							
GE-F-UNAV-COOL-F	12		GI_F_UNREAC_F	14							
GE-F-UNCANCW-F	12		HCVBECWSFCLF#	10							
GE-F-UNCANCW-F	13		HX-BETUBLKSF#	10							
GE-F-UNOPR-F	1		HX-BETUBPLGF#	10							
GE-F-UNOPR-F	12		NACF125-XS-F+	1							
GE-F-UNTEMP-F	12		NCW-----BFLA#	10							
GE-F-UNTOPR-F	12		OPR-----TEHA+	1							

RED OIL EXPLOSION IN FEED TANK	.\REDOIL\FE125.CAF	5-24-94	Page 15

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	GI_F_TOP_F					5.84E-07
1.	EXMTK---CRIF+	Criticality provides heat for runaway TBP reaction	4	1H 2.0E-07H	2.00E-07	3.36E-07
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
2.	CHMCELL-FIRF+	Large fire in cell heats tank contents and causes pyrolysis of TBP	4	1H 1.0E-7H	1.00E-07	1.68E-07
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
3.	OPRFRNDSVINA#	Operator Fails to Notice Temperature Increase in 12.5 During Rounds Check	1	1N 1.0E-1N	1.00E-01N	3.72E-08
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	OPRFTEMPVRHA#	Operator Fails to Notice Temperature Increase During Transfer to 12.5	1	1N 5.0E-2N	5.00E-02N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TA-F----BFLA#	Temperature Alarm for 12.5 Fails	5	6M 3.0E-05H	6.21E-02	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
4.	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	1.44E-08
	OPRFPOW-ACHA#	Operator Fails to Stop Transfer During Power Failure	1	1N 5.0E-2N	5.00E-02N	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
5.	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	8.62E-09
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	TBP3000-PR3F# TBPTK---PREF#	TBP Present in Feed Exceeds 3000 Pounds Process upset causes excess organic in feed	3	0.1N 7D 0.1Y	1.00E-01 1.92E-03	
6.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	3.22E-09
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRFPOW-ACHA#	Operator Fails to Stop Transfer During Power Failure	1	1N 5.0E-2N	5.00E-02N	
	TBP3000-PR3F# TBPTK---PREF#	TBP Present in Feed Exceeds 3000 Pounds Process upset causes excess organic in feed	3	0.1N 7D 0.1Y	1.00E-01 1.92E-03	
7.	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	3.00E-09
	OPRFTEMPMCNA#	Miscalibration of Temperature Sensor for 12.5	1	1N 5.0E-3N	5.00E-03N	
	PERFTCALHLFA#	Temperature Sensor for 12.5 Calibrated Just Before Required	1	1N 0.005N	5.00E-03N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F# TBPTK---PREF#	TBP Present in Feed Exceeds 3000 Pounds Process upset causes excess organic in feed	3	0.1N 7D 0.1Y	1.00E-01 1.92E-03	
8.	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	2.88E-09
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F# TBPTK---PREF#	TBP Present in Feed Exceeds 3000 Pounds Process upset causes excess organic in feed	3	0.1N 7D 0.1Y	1.00E-01 1.92E-03	
	TE-FT125BFLA#	Temperature Sensor for Tank 12.5 Fails	3	24H 1.0E-06H	2.40E-05	
9.	DCSCC---INAF#	DCS Fails Causing Loss of Normal Cooling Water & Agitation	3	8H 3.0E-06H	2.40E-05	2.88E-0[illegible]
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F# TBPTK---PREF#	TBP Present in Feed Exceeds 3000 Pounds Process upset causes excess organic in feed	3	0.1N 7D 0.1Y	1.00E-01 1.92E-03	
10.	DG-POWERFTRA#	292 diesel generator fails to run	3	24H 3.0E-04H	7.17E-03	2.06E-09

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
11.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	1.93E-09
	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
12.	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	1.44E-09
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	SW-DG292BFLA#	switch gear failure causes failure of 292 diesel generator to supply power	1	1N 5E-3N	5.00E-03N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
13.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	6.44E-10
	DCSCC---INAF#	DCS Fails Causing Loss of Normal Cooling Water & Agitation	3	8H 3.0E-06H	2.40E-05	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
14.	DG-DG292MSCA#	misc./operator error causes failure of 292 diesel to supply power	1	1N 2E-3N	2.00E-03N	5.75E-10
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
15.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	4.62E-10
	DG-POWERFTRA#	292 diesel generator fails to run	3	24H 3.0E-04H	7.17E-03	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
16.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	3.22E-10
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	SW-DG292BFLA#	switch gear failure causes failure of 292 diesel generator to supply power	1	1N 5E-3N	5.00E-03N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
17.	AG-FT125BLAA#	Shaft/Blade Fails to Provide Mixing for Tank 12.5	3	1M 5.0E-07H	3.60E-04	2.16E-10
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	OPRFSPG-ACNA#	Operator Fails to Check for Fluctuation in SpG Instrument (Agitator Failure)	1	1N 5.0E-3N	5.00E-03N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
18.	OPR-----TEHA+	Transfer Error to Tank 12.5	1	1H 3.0E-5H	3.00E-05	1.56E-1[illegible]
	OPRFRNDSVINA#	Operator Fails to Notice Temperature Increase in 12.5 During Rounds Check	1	1N 1.0E-1N	1.00E-01N	
	OPRFSJCRACLA#	Operator in Control Room Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	TA-F----BFLA#	Temperature Alarm for 12.5 Fails	5	6M 3.0E-05H	6.21E-02	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
19.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	1.29E-10
	DG-DG292MSCA#	misc./operator error causes failure of 292 diesel to supply power	1	1N 2E-3N	2.00E-03N	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
20.	AG-FT125BFLA#	Agitator Motor on Tank 12.5 Fails	3	24H 5.0E-06H	1.20E-04	7.19E-11
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	OPRFSPG-ACNA#	Operator Fails to Check for Fluctuation in SpG Instrument (Agitator Failure)	1	1N 5.0E-3N	5.00E-03N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
21.	AG-FT125BLAA#	Shaft/Blade Fails to Provide Mixing for Tank 12.5	3	1M 5.0E-07H	3.60E-04	4.83E-11
	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	
	OPRFSPG-ACNA#	Operator Fails to Check for Fluctuation in SpG Instrument (Agitator Failure)	1	1N 5.0E-3N	5.00E-03N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
22.	EXHCANYNBFLA#	Canyon Exhaust System Fails	3	24H 0.03Y	8.22E-05	2.36E-11
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
23.	AG-FT125BFLA#	Agitator Motor on Tank 12.5 Fails	3	24H 5.0E-06H	1.20E-04	1.61E-11

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	
	OPRFSPG-ACNA#	Operator Fails to Check for Fluctuation in SpG Instrument (Agitator Failure)	1	1N 5.0E-3N	5.00E-03N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
24.	AG-FT125BLAA#	Shaft/Blade Fails to Provide Mixing for Tank 12.5	3	1M 5.0E-07H	3.60E-04	9.06E-12
	OPR-----TEHA+	Transfer Error to Tank 12.5	1	1H 3.0E-5H	3.00E-05	
	OPRFSJCRACLA#	Operator in Control Room Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
25.	CHMSOLEXUNRF+	Uncontrolled Chemical Reaction in Solvent Extraction	4	1H 1.6E-05H	1.60E-05	5.29E-12
	EXHCANYNBFLA#	Canyon Exhaust System Fails	3	24H 0.03Y	8.22E-05	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
26.	AG-FT125BFLA#	Agitator Motor on Tank 12.5 Fails	3	24H 5.0E-06H	1.20E-04	3.02E-12
	OPR-----TEHA+	Transfer Error to Tank 12.5	1	1H 3.0E-5H	3.00E-05	
	OPRFSJCRACLA#	Operator in Control Room Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
27.	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	3.02E-1[illegible]
	OPR-----TEHA+	Transfer Error to Tank 12.5	1	1H 3.0E-5H	3.00E-05	
	OPRFPOW-ACHA#	Operator Fails to Stop Transfer During Power Failure	1	1N 5.0E-2N	5.00E-02N	
	OPRFSJCRACLA#	Operator in Control Room Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	

Cutsets for Red Oil Explosions in Feed Tanks (Tank 12.5) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
28.	EXHCANYNBFLA#	Canyon Exhaust System Fails	3	24H 0.03Y	8.22E-05	2.46E-12
	OPRFBECWACNA#	Operator Fails to Turn Tank 12.5 Cooling Water On or Stop Addition	1	1N 5.0E-3N	5.00E-03N	
	OPRFBETEVRHA#	Operator Eails to Monitor Tank 12.5 Temperature During Cooling	1	1N 5.0E-2N	5.00E-02N	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
29.	EXHCANYNBFLA#	Canyon Exhaust System Fails	3	24H 0.03Y	8.22E-05	2.36E-12
	NCW-----BFLA#	"Normal" Cooling Water Lost at the Main Header Level	3	24H 1.0E-05H	2.40E-04	
	OPRFSJETACLA#	Operator in Gang Valve Corridor Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	SJ-FT125PREF+	Transfer to Tank 12.5 is Required	4	1H 4D	1.43E-01	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	
30.	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	1.81E-12
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPR-----TEHA+	Transfer Error to Tank 12.5	1	1H 3.0E-5H	3.00E-05	
	OPRFSJCRACLA#	Operator in Control Room Fails to Complete Transfer to 12.5	1	1N 5.0E-4N	5.00E-04N	
	TBP3000-PR3F#	TBP Present in Feed Exceeds 3000 Pounds		0.1N	1.00E-01	
	TBPTK---PREF#	Process upset causes excess organic in feed	3	7D 0.1Y	1.92E-03	

Appendix 4
Basic Event Data for Sump Receipt Tanks

Basic Event Report for Sump Receipt Tank 17.5 (S175-2.BE)

Event	C	Input	Calc.	Description	Source
AG-S----ON-A#	1	1N .5N	5.00E-01N	agitator for 17.5 is intentionally off	does not run during settling & transfers out of tank
AG-TK175BLAA#	3	14D 5.0E-07H	1.68E-04	agitator blade/shaft failure 17.5	14 days to detect (total failure rate from wsrc-tr-93-262 T1b)/10
AG-TK175FTSA#	3	14D 5.00E-06 H	1.68E-03	agitator motor failure 17.5	2 wks to detect use (total failure rate from wsrc-tr-93-262 T1b)
CHMTK175UNRS+	4	1H 5.0E-06H	5.00E-06	excessive chemical reaction in tank 17.5	a: temp>80 C (rxns:(nitrite,carbonate,NaOH,water)/ nitric)
DG-DG292MSCA#	1	1N 2E-3N	2.00E-03N	misc./operator error causes failure of 292 diesel to supply power	Demand Failure From Systems Analysis
DG-POWERFTRA#	3	24H 3.0E-04H	7.17E-03	292 diesel generator fails to run	must run 24 hrs
DG-POWERFTSA#	1	1N 3.0E-02N	3.00E-02N	292 emergency diesel generator fails to start	Demand Failure From Systems Analysis
EXHCANYNBFLA#	3	24H 0.03Y	8.22E-05	canyon exhaust system fails	24 hr mission fault tree ???.CAF
FPW-----BFLA#	3	24H 1.0E-04H	2.40E-03	utility power fails	a: Fails During 24 hour Cooling Period
GI-SR-ACID-S	4	1H 1E-32H	1.00E-32	strong nitric acid adjustment heats 17.5 tank contents	incredible <can only heat 10-20 C from acid add'n>
GI-SR-WATER-S	4	1H 1E-32H	1.00E-32	sump flush or process water addition heats 17.5	incredible <heat of dilution can only cause 10 C rise>
HCVS-CWSFCLA#	3	24H 3.0E-07H	7.20E-06	Manual Isolation Valve on Cooling Water Supply Line Fails Closed	Assumes Fails During 24 hr. Cooling Period
HX-S-TUBLKSA#	3	24H 1.0E-07H	2.40E-06	17.5 Cooling Coil Leaks	Assumes Fails During 24 hr. Cooling Period
HX-S-TUBPLGA#	3	24H 3.0E-08H	7.20E-07	17.5 Cooling Coil Plugs	Assumes Fails During 24 hr. Cooling Period
NCW-----BFLA#	3	24H 1.0E-05H	2.40E-04	"Normal" Cooling Water Lost at the Main Header Level	a: Fails During 24 hr Cooling Period
OPRPOWERACHA#	1	1N 5.0E-2N	5.00E-02N	operator fails to respond to power failure (shut down)	wsrc-tr-93-581 T4 #1 high (competing activities)
OPRS----TEHA+	4	1H 3.0E-5H	3.00E-05	transfer error to tank 17.5	freq. in TC file
OPRSAGITACNA#	1	1N 5.0E-3N	5.00E-03N	Operator fails to agitate tank 17.5	wsrc-tr-93-581 T4 #1 nominal
OPRSBEHSRMNA#	1	1N 5.0E-3N	5.00E-03N	Cooling Water Manual Supply Valve is Left Closed Following Maintenance	Assumes Discovered After Next Use The CW System
OPRSCW--ACNA#	1	1N 5.0E-3N	5.00E-03N	cooling water for tank 17.5 is not on during planned add'n -oper. error	<<add turn cw on to proc.>>
OPRSJ175ACLA#	1	1N 5.0E-4N	5.00E-04N	operator in GV corridor not attentive-SJ not turned off	wsrc-tr-93-581 T4 #1 low
OPRSRNDSVINA#	1	1N 1.0E-1N	1.00E-01N	operator fails to notice temp. increase in 17.5 during rounds check	wsrc-tr-93-581 T4 #31 nominal
OPRSSJ--VRNA#	1	1N 1.0E-2N	1.00E-02N	steam jet left on heats tank 17.5 (not verified in CR)	wsrc-tr-93-581 T4 #3 nominal

Basic Event Report for Sump Receipt Tank 17.5 (S175-2.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
OPRSSJCRACLA#	1	1N 5.0E-4N	5.00E-04N	oper. in CR fails to complete unintentional transfer to 17.5(SJ left on)	present throughout transfer so use low
OPRSSPG-ACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to read SpG indication (doesn't notice agitator failure)	wsrc-tr-93-581 T4 #1 nominal
OPRSTEMPMCNA#	1	1N 5.0E-3N	5.00E-03N	temp. sensor is miscalibrated for 17.5	wsrc-tr-93-581 T4 #12 nominal
OPRSTEMPVRHA#	1	1N 5.0E-2N	5.00E-02N	operator fails to notice temperature increase during addition to 17.5	wsrc-tr-93-581 T4 #3 high (no procedure)
PERCHMLK045A#	1	1N .45N	4.50E-01N	uncontrolled rxn is a result of transfer of sumps	assume 45% based on databank (10% for valving error, 1/2 remainder for trans)
PERS--MA038A#	1	1N 0.38N	3.80E-01N	17.5-Maintenance is Performed Just Before This Batch	Assumes 3 Maintenance Activities/Month and 8 Batches/Month
PERSCWON020A#	1	1N .2N	2.00E-01N	cooling water for tank 17.5 is not on during unplanned add'n	est not on 20% of time (on during & after transfers to cool down)
PERSTCALHLFA#	1	1N 5E-3N	5.00E-03N	temperature sensor for 17.5 calibrated just before required	est from calib. every 2 years & 200 batches in that time
PNVS-CWSFCLA#	5	7D 1.0E-06H	8.40E-05	Supply Control Valve on Cooling Water Fails Closed	Assumes Discovered within a week
RAHRIVERSPRS#	3	24H 5.0E-06H	1.20E-04	Spurious radiation alarms forces shut off cooling water	Fails during 24 hour cooling period
SJ-TK175PRES+	4	24H 1.19E-2H	2.22E-01	transfer to tank is required	tank remains hot for 1 day/2 transfer per week
SW-DG292BFLA#	1	1N 5E-3N	5.00E-03N	switch gear failure causes failure of 292 diesel generator to supply power	Demand Failure From Systems Analysis
TA-S----BFLA#	5	2Y 3E-5H	2.22E-01	temperature alarm for 17.5 fails	discovered at 2 year calibration interval
TBPTK175PRES#		2.0E-03N	2.00E-03	Suff. solvent from canyon leaks received in sump receipt tank 17.5 causes rxn	a: need > 3,000 lbs TBP-happens once in 5 years/500 batches in that time
TE-S----BFLA#	3	7D 1E-6H	1.68E-04	temperature sensor for 17.5 fails	1 week to discover

Type Codes for Sump Receipt Tank 17.5 (S175-2.TC)

Type Code	Rate	Description	Source	EF	D
AG- BLA A	5.0E-07H	agitator failure (blade/shaft)	(wsrc-tr-93-262 T1b agitator)/10		
AG- FTS A	5.00E-06 H	Agitator, Failure (Chemical)	WSRC-TR-93-262, AGI-FA-C	10	L
AG- ON- A	.5N	agitator not on at time of event	asuume 50% because not on during settling & transfers out of tank		
CHM UNR D	5.0E-06H	Uncontrolled chemical reaction-7.3	DPSTSY-200-1F T O-15 Unc. rxn in rerun		
CHM UNR S	5.0E-06H	Uncontrolled chemical reaction-17.5	DPSTSY-200-1F T O-15 Unc. rxn in rerun		
DG- FTR A	3.0E-04H	Emergency diesel fail run	DPSTSY-200-1F vol. 2 p P-32		
DG- FTS A	3.0E-02N	Emergency diesel fail start	DPSTSY-200-1F vol. 2 p P-32		
DG- MSC A	2E-3N	operator error/misc. causes diesel generator failure	DPSTSY-200-1F vol. 2 p P-32		
EXH BFL A	0.03Y	Failure of F-Canyon Ventilation System	SRT-SEP-93-009, Fault Tree Analysis of Diesel Generators in F-Canyon, 1/39yr		
FLT UNR D	3.81E-5H	ammonium nitrate rxn in PVV filter	takes 3 years to build up		
FPW BFL A	1.0E-04H	Failure of utility power	DPSTSY-200-1F		
GI- ID- D	1E-32H	acid add'n heats tank 17.5			
GI- ID- S	1E-32H	acid add'n heats tank 17.5			
GI- TER -	1E-32H	normal water addition heats tank	incredible		
HCV FCL A	3.0E-07H	Spurious Operation of Motor Operated Valve	WSRC-TR-93-262, page 12, MOV-OC-W, Spurious Operation of Motor Operated Valve		
HX- LKS A	1.0E-07H	Heat Exchanger Tube Leaks	WSRC-TR-93-262, page 15, HTX-LI-W, Heat Exchanger Tube Leakage		
HX- PLG A	3.0E-08H	Heat Exchanger Tube Plugs	WSRC-TR-93-262, page 15, HTX-PG-W, Heat Exchanger Tube Plugs		
NCW BFL A	1.0E-05H	"Normal" Cooling Water Fails at Header Level	DPSTSY-200-1F		
OPR ACH A	5.0E-2N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High		
OPR ACL A	5.0E-4N	Failure of Administrative Control	WSRC-TR-93-581, Table 4, Item 1, Low		
OPR ACN A	5.0E-3N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal		
OPR IRN A	1.0E-2N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal		
OPR MCN A	5.0E-3N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal		
OPR RMN A	5.0E-3N	Failure to restore following maintenance (Nominal)	WSRC-TR-93-581, Table 4, Item 14, Nominal		
OPR SVL A	1.0E-1N	Supervisor verification error	WSRC-TR-93-581, Table 4, Item 9, Low		
OPR TEH A	3.0E-5H	Transfer error (per Tank) (High)	WSRC-TR-93-581, Table 4, Item 17, High		
OPR VIN A	1.0E-1N	Failure of visual inspection (Nominal)	WSRC-TR-93-581, Table 4, Item 31, Nominal		
OPR VRH A	5.0E-2N	Failure to verify within control room (High)	WSRC-TR-93-581, Table 4, Item 3, High		
OPR VRN A	1.0E-2N	Failure to verify within control room (Nominal)	WSRC-TR-93-581, Table 4, Item 3, Nominal		
PDE FLO A	3.0E-06H	Differential Pressure Sensor Fails	WSRC-TR-93-262, page 30, DPS-FA-I, Differential Pressure Sensor Failure		
PDE PLG A	1.0E-08H	Differential Pressure Instrument Line Plugs (per foot)	WSRC-TR-93-262, page 22, TUB-PG-G, Tube Plugs		
PER 020 A	.2N	20% chance	Probability of occurrence		
PER 038 A	0.38N	38 % chance	Probability of occurrence		

Type Codes for Sump Receipt Tank 17.5 (S175-2.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
PER 045 A	.45N	45% chance	databank uncontrolled reactions caused intentional add'n (90%)/2		
PER HLF A	5E-3N	one half of one percent chance	prob. of occurrence		
PNV FCL A	1.0E-06H	Air-Operated Valve Fails Closed	WSRC-TR-93-262, page 12, AOV-CC-W, Air Operated Valve Spurious Operation		
RAH SPR S	5.0E-06H	SPURIOUS ALARM FAILURE	WSRC-TR-93-262, page 30, ALR-SO-I, Alarm/Annunciator Fails to AlarmInternal)		
SJ- PRE D	1.19E-2H	transfer to tank req	2/wk est		
SJ- PRE S	1.19E-2H	transfer to tank req	2/wk est		
SW- BFL A	5E-3N	switch gear failure	DPSTSY-200-1F vol. 2 p P-32		
TA- BFL A	3E-5H	alarm fails to alarm	wsrc-tr-93-262 T1f (ALR-NR-I)		
TE- BFL A	1E-6H	temp. sensor failure	wsrc-tr-93-262 T-1f		

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE)

Event	C	Input	Calc.	Description	Source
AG-D----ON-A#	1	1N .5N	5.00E-01N	agitator for 7.3 is intentionally off	does not run during settling & transfers out of tank
AG-S----ON-A#	1	1N .5N	5.00E-01N	agitator for 17.5 is intentionally off	does not run during settling & transfers out of tank
AG-TK-73BLAA#	3	14D 5.0E-07H	1.68E-04	7.3 agitator blade/shaft failure	14 days to detect (total failure rate from wsrc-tr-93-262 T1b)/10
AG-TK-73FTSA#	3	14D 5.00E-06 H	1.68E-03	agitator motor failure 7.3	2 wks to detect (total failure rate from wsrc-tr-93-262 T1b)
AG-TK175BLAA#	3	14D 5.0E-07H	1.68E-04	agitator blade/shaft failure 17.5	14 days to detect (total failure rate from wsrc-tr-93-262 T1b)/10
AG-TK175FTSA#	3	14D 5.00E-06 H	1.68E-03	agitator motor failure 17.5	2 wks to detect use (total failure rate from wsrc-tr-93-262 T1b)
AGITOFF		1N	1.00E+00	agitator off	
ANGEQLABBFLA#	3	24H 5.00E-05H	1.20E-03	Lab Equipment Malfunction, Sample Cannot be Run	a: 24hr restoration time
AQUDENS1PREA#	3	1M 1.0E-01Y	8.19E-03	Process upsets causes dilute 2AW or high density in 11.7S	estimated as 1/10yr - not discovered for 1 month
AQUDENS2PREA#	3	1M 1.0E-01Y	8.19E-03	Process upsets causes dilute 2W or high density in 11.7S	estimated as 1/10yr - not discovered for 1 month
BATB----PREB+	4	1H 5.71E-3H	5.68E-03	batch processed through 8.5	est. 50 times/year
BATE----PREE+	4	1H 5.71E-3H	5.68E-03	batch processed through 17.7	est., 50 times/yr
CHMCELL-FIRD+	4	1Y 1.0E-07H	8.75E-04	Large fire in 7.3 cell causes pyrolysis of TBP	Bounds frequency in PLF canyon fire study
CHMCELL-FIRS+	4	1Y 1.0E-07H	8.75E-04	Large fire in 17.5 cell causes pyrolysis of TBP	Bounds frequency in PLF canyon fire study
CHMTK-73UNRD+	4	1H 5.0E-06H	5.00E-06	excessive chemical reaction in tank 7.3	a: temp>80 C (rxns:(nitrite,carbonate,NaOH)/nitric ,HAN/FS)
CHMTK175UNRS+	4	1H 5.0E-06H	5.00E-06	excessive chemical reaction in tank 17.5	a: temp>80 C (rxns:(nitrite,carbonate,NaOH,water)/ nitric,HAN/FS)
DCS-CC--PREA#	3	72H 3.0E-06H	2.16E-04	Common cause DCS failure	WSRC-TR-93-262, Logic module failure 3 days to repair
DG-DG292MSCA#	1	1N 2E-3N	2.00E-03N	misc./operator error causes failure of 292 diesel to supply power	Demand Failure From Systems Analysis
DG-POWERFTRA#	3	24H 3.0E-04H	7.17E-03	292 diesel generator fails to run	must run 24 hrs
DG-POWERFTSA#	1	1N 3.0E-02N	3.00E-02N	292 emergency diesel generator fails to start	Demand Failure From Systems Analysis
EXCESSTBP		1.05e-5N	1.05E-05	excess TBP in 8.5BT	
EXHCANYNBFLA#	3	24H 0.03Y	8.22E-05	canyon exhaust system fails	24 hr mission fault tree ???.CA
EXMTK-73CRID+	4	1Y 1.8E-7H	1.57E-03	Criticality in 7.3 provides heat for runaway TBP reaction	F-Canyon SAR
EXMTK175CRIS+	4	1Y 1.8E-7H	1.57E-03	Criticality provides heat for runaway TBP reaction in 17.5	F-Canyon SAR

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
FLTRXN72UNRD+	4	24H 3.81E-5H	9.14E-04	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	takes 3 years
FPW-----BFLA#	3	24H 1.0E-04H	2.40E-03	utility power fails	a: Fails During 24 hour Cooling Period
GI-SR-ACID-D	4	1H 1E-32H	1.00E-32	strong nitric acid adjustment heats 7.3 tank contents	incredible
GI-SR-ACID-S	4	1H 1E-32H	1.00E-32	strong nitric acid adjustment heats 17.5 tank contents	incredible <can only heat 10-20 C from acid add'n>
GI-SR-WATER-D	4	1H 1E-32H	1.00E-32	normal water addition heats 7.3	incredible
GI-SR-WATER-S	4	1H 1E-32H	1.00E-32	sump flush or process water addition heats 17.5	incredible <heat of dilution can only cause 10 C rise>
GSK8WSECLKSG#	5	24H 1.0E-07H	1.20E-06	One of Two Gaskets in Section 8 of Warm Canyon Leaks	a: 24 hours to discover leak
HCV-10.8FTOG#	1	1N 1.0E-03N	1.00E-03N	Air jet valve fails to open & prevents organic air lift	a: Manual Valve Equivalent to being in a compressed gas system
HCV-11.7FTOG#	1	1N 1.0E-03N	1.00E-03N	Air jet valve fails to open & prevents organic air lift	a: Manual Valve Equivalent to that in a compressed gas system
HCVB-CWSFCLA#	3	24H 3.0E-07H	7.20E-06	Manual Isolation Valve on Cooling Water Supply Line Fails Closed	Assumes Fails During 24 hr. Cooling Period
HCVE-CWSFCLA#	3	24H 3.0E-07H	7.20E-06	Manual Isolation Valve on Cooling Water Supply Line Fails Closed	Assumes Fails During 24 hr. Cooling Period
HCVS-CWSFCLA#	3	24H 3.0E-07H	7.20E-06	Manual Isolation Valve on Cooling Water Supply Line Fails Closed	Assumes Fails During 24 hr. Cooling Period
HX-B-TUBLKSA#	3	24H 1.0E-07H	2.40E-06	8.5 bottoms tank Cooling Coil Leaks	Assumes Fails During 24 hr. Cooling Period
HX-B-TUBPLGA#	3	24H 3.0E-08H	7.20E-07	8.5 Cooling Coil Plugs	Assumes Fails During 24 hr. Cooling Period
HX-E-TUBLKSA#	3	24H 1.0E-07H	2.40E-06	17.7 bottoms tank Cooling Coil Leaks	Assumes Fails During 24 hr. Cooling Period
HX-E-TUBPLGA#	3	24H 3.0E-08H	7.20E-07	17.7 Cooling Coil Plugs	Assumes Fails During 24 hr. Cooling Period
HX-S-TUBLKSA#	3	24H 1.0E-07H	2.40E-06	17.5 Cooling Coil Leaks	Assumes Fails During 24 hr. Cooling Period
HX-S-TUBPLGA#	3	24H 3.0E-08H	7.20E-07	17.5 Cooling Coil Plugs	Assumes Fails During 24 hr. Cooling Period
INTTK108FHIG#	5	720H 3.0E-06H	1.08E-03	Interface Instrument in 10.8 Gives False high Reading	a: 1 week to restore
INTTK117FHIG#	5	720H 3.0E-06H	1.08E-03	Interface Instrument in 11.7 Gives False high Reading	a: 1 week to restore
LALA10.8BFLG#	5	1D 3.0E-05H	3.60E-04	10.8S level alarm instrumentation fails to detect low level	a: 24 hours restoration time
LALA11.7BFLG#	5	1D 3.0E-05H	3.60E-04	11.7S level alarm instrumentation fails to detect	a: 24 hours to restore
LALO10.8BFLG#	5	1D 3.0E-05H	3.60E-04	Failure of organic level alarm in decanter 10.8	a: 24 hours to restore
LALO11.7BFLG#	5	1D 3.0E-05H	3.60E-04	Failure of organic level alarm in decanter 11.7	a: 1 day to detect or correct

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
MOVGA137FTCG#	1	1N 3.0E-03N	3.00E-03N	Gang valve fails too close	Use TC Value
MOVGA175FTCG#	1	1N 3.0E-03N	3.00E-03N	Gang valve from 17.5 fails too close	Use TC Value
NCW-----BFLA#	3	24H 1.0E-05H	2.40E-04	"Normal" Cooling Water Lost at the Main Header Level	a: Fails During 24 hr Cooling Period
NCWTK-73BRKA#		1N	1.00E+00	cooling system for tank 7.3 is broken	no cooling for 7.3
NCWTK175INAS#		1N	1.00E+00	cooling water for tank 17.5 is not on	est not on 100% of time (not in procedure)
NOCOOL		1N	1.00E+00	no cooling	
NOVENT		1N	1.00E+00	no ventilation	
OPRAPDE-MCNA#	1	1N 5.0E-3N	5.00E-03N	Filter Pressure Differential Sensor is Miscalibrated	Assumes Nominal Calibration
OPRAPDE-VINA#	1	1N 1.0E-1N	1.00E-01N	Operator Fails to Monitor Filter Pressure Differential Sensor	High Pressure Difference is Easy to Observe
OPRBBEHSRMNA#	1	1N 5.0E-3N	5.00E-03N	Cooling Water Manual Supply Valve is Left Closed Following Maintenance	Assumes Discovered After Next Use of The CW System
OPRBCW--ACNA#	1	1N 5.0E-3N	5.00E-03N	cooling water for tank 8.5 is not on during planned add'n -oper. error	wsrc-tr-93-581 T4 #1 nominal
OPRBRNDSACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to notice temp. increase in 8.5 during rounds check	wsrc-tr-93-581 T4 #1 nominal (proceduralized on rounds sheet)
OPRBTEMPMCNA#	1	1N 5.0E-3N	5.00E-03N	temperature sensor for 8.5 miscalibrated	wsrc-tr-93-581 #12 nominal
OPRD----TEHA+	4	1H 3.0E-5H	3.00E-05	transfer error to tank 7.3	freq. in TC file
OPRDAGITACNA#	1	1N 5.0E-3N	5.00E-03N	Operator fails to agitate tank 7.3	wsrc-tr-93-581 T4 #1 nominal
OPRDCLN1ACLA#	1	1N 5.0E-4N	5.00E-04N	operator fails to flush NH4NO3 from 7.2 filter once detected	wsrc-tr-93-581 T4 #1 low
OPRDDET1IRNA#	1	1N 1.0E-2N	1.00E-02N	operator fails to detect NH4NO3 in 7.2 filter	wsrc-tr-93-581 T4 #11 nominal
OPRDFLUSACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to perform scheduled periodic filter flush	wsrc-tr-93-581 T4 #1 nominal
OPRDINS1ACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to inspect 7.2 PVV filter (monthly vacuum test)	wsrc-tr-93-581 T4 #1 nominal
OPRDSJ--ACLA#	1	1N 5.0E-4N	5.00E-04N	steam jet left on heats tank 7.3 (in control room)	wsrc-tr-93-581 T4 #1 low
OPRDSJ73SVLA#	1	1N 1.0E-1N	1.00E-01N	control room supervisor fails to stop transfer to 7.3 (key)	wsrc-tr-93-581 T4 #9 low
OPRDSJCRACLA#	1	1N 5.0E-4N	5.00E-04N	oper. in CR fails to complete unintentional transfer to 7.3 (SJ left on)	present throughout transfer so us low
OPRDSPG-ACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to read SpG indication (doesn't notice agitator failure)	wsrc-tr-93-581 T4 #1 nominal
OPRDTEMPMCNA#	1	1N 5.0E-3N	5.00E-03N	temp. sensor is miscalibrated for 7.3	wsrc-tr-93-581 T4 #12 nominal
OPRDTEMPVRHA#	1	1N 5.0E-2N	5.00E-02N	operator fails to notice temperature increase during addition to 7.3	wsrc-tr-93-581 T4 #3 high (no procedure)

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
OPRECLN-ACNA#	1	1N 5.0E-3N	5.00E-03N	Failure to clean causes accumulation and/or phase inversion of solvent	wsrc-tr-93-581 T4 #1 nominal old:notclean---f+
OPRECW--ACNA#	1	1N 5.0E-3N	5.00E-03N	cooling water for tank 17.7 is not on during planned add'n -oper. error	wsrc-tr-93-581 T4 #1 nominal
OPRERNDSACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to notice temp. increase in 17.7 during rounds check	wsrc-tr-93-581 T4 #1 nominal (proceduralized in rounds sheet)
OPRETEMPMCNA#	1	1N 5.0E-3N	5.00E-03N	error in calibration of 17.7 temp sensor	wsrc-tr-93-581 T4 #12 nominal
OPREU185VINA#	1	1N 1.0E-1N	1.00E-01N	operator fails to detect upset to 18.5 (1CU decanter)	wsrc-tr-93-581 T4 #31 nominal
OPRG-9.7CVNA#	1	1N 1.0E-1N	1.00E-01N	Operator fails to visually check sample for solvent	Use TC Value
OPRG-9.7SONA#	1	1N 1.0E-2N	1.00E-02N	Operator agitates tank	Use TC Value
OPRG10.8CSLA#	1	1N 3.0E-3N	3.00E-03N	Operator fails to shut down process (compelling signal)	Use TC Value
OPRG108-ACHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to jet out contents in 10.8 (overflow)	Use TC Value
OPRG108-MCHA#	1	1N 3.0E-2N	3.00E-02N	Calibration Error - Interface instrument is calibrated to give false reading	Use TC Value
OPRG11.7CSLA#	1	1N 3.0E-3N	3.00E-03N	Operator fails to shut down process (compelling signal)	Use TC Value
OPRG117-ACHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to jet out contents in 11.7 (overflow)	Use TC Value
OPRG1177MCHA#	1	1N 3.0E-2N	3.00E-02N	Calibration Error - interface instrument is Calibrated to Give False Reading	Use TC Value
OPRG13.8VRHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to verify temperature reading	Use TC Value
OPRG1361SRHA#	1	1N 3.0E-2N	3.00E-02N	Operator Selects Wrong Jet - TBP Transferred from 13.61S to 13.7	Use TC Value
OPRG1362SRHA#	1	1N 3.0E-2N	3.00E-02N	Operator Selects Wrong Jet - TBP Transferred from 13.62S to 13.7	Use TC Value
OPRG137-ACHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to settle tank contents prior to transferring out	Use TC Value
OPRG137-IRNA#	1	1N 1.0E-2N	1.00E-02N	Operator incorrectly reads spg display	Use TC Value
OPRG137-MCNA#	1	1N 5.0E-3N	5.00E-03N	Calibration Error - SPG Instrument is Calibrated to Give a False Reading	Use TC Value
OPRG137TACHA#	1	1N 5.0E-2N	5.00E-02N	Operator transfer too much organic to 7.8 (procedure violation)	Use TC Value
OPRG137VDEHA#	1	1N 1.0E-1N	1.00E-01N	Operator fails to recognize that too much TBP was transferred	Use TC Value
OPRG138-ACHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to settle tank contents prior to transferring out	Use TC Value
OPRG138-ACNA#	1	1N 5.0E-3N	5.00E-03N	Operator Fails To Check Temperature - Transfers Too Much	Use TC Value

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
OPRG138-MCHA#	1	1N 3.0E-2N	3.00E-02N	Calibration Error - Temp. Instrument is Calibrated to Give a False Reading	Use TC Value
OPRG175-ACHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to settle tank contents prior to tranferring out	Use TC Value
OPRG175-IRNA#	1	1N 1.0E-2N	1.00E-02N	Operator incorrectly reads spg display	Use TC Value
OPRG175-MCNA#	1	1N 5.0E-3N	5.00E-03N	Calibration Error - SPG Instrument is Calibrated to Give a False Reading	Use TC Value
OPRG175TACHA#	1	1N 5.0E-2N	5.00E-02N	Operator transfers too much TBP to 8.7	Use TC Value
OPRG175VDEHA#	1	1N 1.0E-1N	1.00E-01N	Operator fails to recognize that too much TBP was transferred to 8.7	Use TC Value
OPRG8.7-ACHA#	1	1N 5.0E-2N	5.00E-02N	Operator fails to settle tank contents prior to tranferring out	Use TC Value
OPRG8.7-IRNA#	1	1N 1.0E-2N	1.00E-02N	Operator incorrectly reads spg display	Use TC Value
OPRG8.7-MCNA#	1	1N 5.0E-3N	5.00E-03N	Calibration Error - SPG Instrument is Calibrated to Give a False Reading	Use TC Value
OPRG8.7TACHA#	1	1N 5.0E-2N	5.00E-02N	Operator transfers too much TBP to continous evaporator	Use TC Value
OPRG8.7VDEHA#	1	1N 1.0E-1N	1.00E-01N	Operator fails to recognize that too much TBP was transferred	Use TC Value
OPRGINSUACHA#	1	1N 5.0E-2N	5.00E-02N	Insufficient sample pulled	Use TC Value
OPRGLOSEILNA#	1	1N 5.0E-3N	5.00E-03N	Sample Accountability Error in Lab Causes Loss of Sample	Use TC Value
OPRGNOTRACHA#	1	1N 5.0E-2N	5.00E-02N	Sample Not Transported to Lab on a Timely Basis	Use TC Value
OPRGNROMCVLA#	1	1N 1.0E-2N	1.00E-02N	Operations Fails to Recognize/Correct Omission of Sample	Use TC Value
OPRGOPCOACHA#	1	1N 5.0E-2N	5.00E-02N	Operations Violates Procedure and Continues Without Lab results	Use TC Value
OPRGOPCOACNA#	1	1N 5.0E-3N	5.00E-03N	Operations Violates Procedure and Continues Without Lab results	Use TC Value
OPRGS137ACNA#	1	1N 5.0E-3N	5.00E-03N	Procedural violation results in no sample being taken for tank 13.7	Use TC Value
OPRGS137LANA#	1	1N 3.0E-4N	3.00E-04N	Routine analysis gives false TBP result for tank 13.7	Use TC Value
OPRGS175ACHA#	1	1N 5.0E-2N	5.00E-02N	Procedural violation results in sample being taken for tank 17.5	Use TC Value
OPRGS175LANA#	1	1N 3.0E-4N	3.00E-04N	Routine analysis gives false TBP results for tank 17.5	
OPRGS8.7ACHA#	1	1N 5.0E-2N	5.00E-02N	Procedural violation results in sample being taken for tank 8.7	Use TC Value
OPRGS8.7LANA#	1	1N 3.0E-4N	3.00E-04N	Routine analysis gives false TBP results for tank 8.7	
OPRGSEPSSVNA#	1	1N 3.0E-1N	3.00E-01N	Supervisor approves transfer from either separator	Use TC Value

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
OPRPOWERACHA#	1	1N 5.0E-2N	5.00E-02N	operator fails to respond to power failure (shut down)	wsrc-tr-93-581 T4 #1 high (competing activities)
OPRS----TEHA+	4	1H 3.0E-5H	3.00E-05	transfer error to tank 17.5	freq. in TC file
OPRSAGITACNA#	1	1N 5.0E-3N	5.00E-03N	Operator fails to agitate tank 17.5	wsrc-tr-93-581 T4 #1 nominal
OPRSBEHSRMNA#	1	1N 5.0E-3N	5.00E-03N	Cooling Water Manual Supply Valve is Left Closed Following Maintenance	Assumes Discovered After Next Use of The CW System
OPRSJ175ACLA#	1	1N 5.0E-4N	5.00E-04N	operator in GV corridor not attentive-SJ not turned off	wsrc-tr-93-581 T4 #1 low
OPRSRNDSVINA#	1	1N 1.0E-1N	1.00E-01N	operator fails to notice temp. increase in 17.5 during rounds check	wsrc-tr-93-581 T4 #31 nominal
OPRSSJ--VRNA#	1	1N 1.0E-2N	1.00E-02N	steam jet left on heats tank 17.5 (not verified in CR)	wsrc-tr-93-581 T4 #3 nominal
OPRSSJCRACLA#	1	1N 5.0E-4N	5.00E-04N	oper. in CR fails to complete unintentional transfer to 17.5(SJ left on)	present throughout transfer so use low
OPRSSPG-ACNA#	1	1N 5.0E-3N	5.00E-03N	operator fails to read SpG indication (doesn't notice agitator failure)	wsrc-tr-93-581 T4 #1 nominal
OPRSTEMPMCNA#	1	1N 5.0E-3N	5.00E-03N	temp. sensor is miscalibrated for 17.5	wsrc-tr-93-581 T4 #12 nominal
OPRSTEMPVRHA#	1	1N 5.0E-2N	5.00E-02N	operator fails to notice temperature increase during addition to 17.5	wsrc-tr-93-581 T4 #3 high (no procedure)
PDEFILT-FLOA#	5	1Y 3.0E-06H	1.30E-02	Filter Pressure Differential Sensor Fails Low	Assumes Tested Annually
PDEFILT-PLGA#	5	1Y 1.0E-08H	4.38E-05	Filter Pressure Differential Sensor Plugs	Assumes Tested Annually
PER-COLDTWFG#	1	1N 0.25N	2.50E-01N	Cold streams sent to 8.7	Use TC Value
PER138TBHUNA#	1	1N 1.0N	1.00E+00N	Excess TBP is received or stored in tank 13.8	a: always (cog)
PERB--MA006A#	1	1N .06N	6.00E-02N	8.5-Maintenance is Performed Just Before This Batch	Assumes 3 Maintenance Activities/year and 50 Batches/year
PERBTCAL001A#	1	1N .01N	1.00E-02N	temperature sensor for 8.5 calibrated just before required	est from calib. every 2 years & 100 batches in that time
PERCEMAXTENA#	1	1N 0.1N	1.00E-01N	Amount of TBP exceeds 3000 lbs	a: commitment to ensure < 3000 lbs of organic is present
PERCHMLK045A#	1	1N .45N	4.50E-01N	uncontrolled rxn is a result of transfer of sumps	assume 45% based on databank (10% for valving error, 1/2 remainder for trans)
PERCHMVL010A#	1	1N .1N	1.00E-01N	uncontrolled rxn is a result of valving error	assume 10% based on databank
PERCOL1F001G#	1	1N 1.0E-03N	1.00E-03N	10.8S contents are tranferred to 10.8A	a: 1/1000
PERCOLDF001G#	1	1N 1.0E-03N	1.00E-03N	11.7S contents are transferred to 11.7A	a: 1/1000
PERDTCALHLFA#	1	1N 5E-3N	5.00E-03N	temperature sensor for 7.3 calibrated just before required	est from calib. every 2 years & 200 batches in that time

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
PERE--MA006A#	1	1N .06N	6.00E-02N	17.7-Maintenance is Performed Just Before This Batch	Assumes 3 Maintenance Activities/year and 50 Batches/year
PEREDCSA090A#	1	1N .9N	9.00E-01N	DCS is in auto. mode	COG 90% in automatic mode
PEREDCSM010A#	1	1N .1N	1.00E-01N	DCS is in manual mode	COG 10% in manual DCS mode
PERETCAL001A#	1	1N .01N	1.00E-02N	temperature sensor for 17.7 calibrated just before required	est from calib. every 2 years & 100 batches in that time
PERGE108HUNA#	1	1N 1.0N	1.00E+00N	Operator fails to return organic content in 10.8A to 10.8S	a: alway true
PERGE117HUNA#	1	1N 1.0N	1.00E+00N	Operator fail to return solvent content in 11.7A to 11.7S	a: always true
PERS--MA038A#	1	1N 0.38N	3.80E-01N	17.5-Maintenance is Performed Just Before This Batch	Assumes 3 Maintenance Activities/Month and 8 Batches/Month
PERSAMLOTWEA#	1	1N 2.0E-01N	2.00E-01N	Lab does not request additional sample	Use TC Value (cog estimate)
PERSEPUS001G#	1	1N 1.0E-03N	1.00E-03N	Probability that the separators are used	a: 1/10 years - Use TC Value
PERSR137ONEA#	1	1N 1.0E-02N	1.00E-02N	Sample is Not Representative of 13.7 Tank Contents	a: commitment to improve sampling 1/100
PERSR175ONEA#	1	1N 1.0E-02N	1.00E-02N	Sample is Not Representative of Tank Contents	a: commitment to improve sampling 1/100
PERSR8.7ONEA#	1	1N 1.0E-02N	1.00E-02N	Sample is Not Representative of Tank Contents	a: commintment to improve sampling 1/100
PERSTCALHLFA#	1	1N 5E-3N	5.00E-03N	temperature sensor for 17.5 calibrated just before required	est from calib. every 2 years & 200 batches in that time
PERSUNRS045A#	1	1N .45N	4.50E-01N	uncontrolled reaction is due to addition of HAN/FS	assume 45% based on databank (10% for valve err.,1/2 remainder for HAN/FS)
PERTR175TWOA#	1	1N 0.02N	2.00E-02N	Material Is Being Received From 17.5	Received about 1 week total out of the year
PIP8WSECLKSG#	5	960H 3.0E-09H	1.44E-06	Pipe in Section 8 Warm Canyon Leaks	a: 24 Hours to Discover Leak, 40 ft.
PNVB-CWSFCLA#	5	7D 1.0E-06H	8.40E-05	Supply Control Valve on Cooling Water Fails Closed	Assumes Discovered within a week
PNVE-CWSFCLA#	5	7D 1.0E-06H	8.40E-05	Supply Control Valve on Cooling Water Fails Closed	Assumes Discovered within a week
PNVS-CWSFCLA#	5	7D 1.0E-06H	8.40E-05	Supply Control Valve on Cooling Water Fails Closed	Assumes Discovered within a week
RAHRIVERSPRS#	3	24H 5.0E-06H	1.20E-04	Spurious radiation alarms forces shut off cooling water	Fails during 24 hour cooling peri[od]
SAM-13.7BFLA#	5	1M 1.00E-05H	3.59E-03	Sampler malfunctions such that a sample can not be pulled (tank 13.7)	a: 1 month restoration time
SAM-8.7-BFLA#	5	1M 1.00E-05H	3.59E-03	Sampler malfunctions such that a sample can not be pulled (tank 8.7)	a: 1 month to restore
SAM_17.5BFLA#	5	1M 1.00E-05H	3.59E-03	Sampler malfunctions such that a sample can not be pulled (tank 17.5)	a: 1 month to restore
SJ-TK-73PRED+	4	24H 1.19E-2H	2.22E-01	transfer to tank 7.3 is required	tank remains hot for 1 day/2 transfe[rs] per week

Basic Event Report for Sump Receipt Tank 7.3 (S73-1.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
SJ-TK175PRES+	4	24H 1.19E-2H	2.22E-01	transfer to tank is required	tank remains hot for 1 day/2 transfer per week
SPGTK137FHIG#	5	720H 3.0E-06H	1.08E-03	SPG Instrument in 13.7 Gives False High Reading	a: 1 week to restore
SPGTK175FHIG#	5	3D 3.0E-06H	1.08E-04	SPG Instrument in 17.5 Gives False High Reading	Would Discover on Next Transfer - About 3 days
SPGTK8.7FHIG#	5	3D 3.0E-06H	1.08E-04	SPG Instrument in 8.7 Gives False High Reading	Would Discover on Next Transfer - About 3 days
SW-DG292BFLA#	1	1N 5E-3N	5.00E-03N	switch gear failure causes failure of 292 diesel generator to supply power	Demand Failure From Systems Analysis
SW-TK8.7BFLG#	3	5D 1.0E-06H	1.20E-04	Pump switch fails too close	a: 5 day mission time
TA-B----BFLA#	5	2Y 3E-5H	2.22E-01	temperature alarm for 8.5 fails	discovered at 2 year calibration interval
TA-D----BFLA#	5	2Y 3E-5H	2.22E-01	temperature alarm for 7.3 fails	discovered at 2 year calibration interval
TA-S----BFLA#	5	2Y 3E-5H	2.22E-01	temperature alarm for 17.5 fails	discovered at 2 year calibration interval
TBP-----PREA#	3	7D 0.1Y	1.92E-03	Process upset causes excess organic in feed	7 days to correct
TBPBLINEFHIA#	3	1H 0.1Y	1.14E-05	B-Line annual flush received in tank 9.7	a: tranfer from B-Line takes 1 hour
TBPROUBLPREG#	3	1H 0.1Y	1.14E-05	TBP is Received From Routine B-Line Flushes	Receive about 8,000 lbs/trans, 1 hr to feed to evaporator
TBPTK---PREA#	3	1M 0.1Y	8.19E-03	Process upset causes excess organic in feed	Estimated as 1/10years - Not detected for 1 month
TBPTK-73PRED#		2E-3N	2.00E-03	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx	a: need > 3,000 lbs TBP-happens once in five years=500 batches
TBPTK175PRES#		2E-3N	2.00E-03	Suff. solvent from canyon leaks received in sump receipt tank 17.5 causes rxn	a: need > 3,000 lbs TBP-happens once in five years=500 batches
TBPTK2BPPREA#	3	1M 0.1Y	8.19E-03	Process upset causes excess TBP in canyon product	a: process upset exists for 1 month
TE-B----BFLA#	3	7D 1E-6H	1.68E-04	high temp. sensor failure for 8.5	1 week to discover
TE-D----BFLA#	3	7D 1E-6H	1.68E-04	temperature sensor for 7.3 fails	1 week to discover
TE-E----BFLA#	3	7D 1E-6H	1.68E-04	high temp. sensor failure for tank 17.7	1 week to discover
TE-S----BFLA#	3	7D 1E-6H	1.68E-04	temperature sensor for 17.5 fails	1 week to discover
TE-TK138FLOG#	5	1M 1.0E-06H	3.60E-04	Temperature Instrument in 13.8 Gives False Low Reading	a: 1 month to restore
TNKTK185CLNE#	3	24H 3Y	8.19E-03	tank 18.5 is cleaned	a: 3/yr cleaning 1 day to clean

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC)

Type Code	Rate	Description	Source	EF	D
ACU FRH	3.00E-05 H	Air Conditioning Unit/, Chiller, Fails to run (HVAC)	WSRC-TR-93-262, ACU-FR-H	10	L
ACU FSH	1.00E-02 N	Air Conditioning Unit/, Chiller, Fails to start (HVAC)	WSRC-TR-93-262, ACU-FS-H	10	L
ADR FAG	5.00E-06 H	Air Dryer, Failure (Compressed Gas)	WSRC-TR-93-262, ADR-FA-G	10	L
AG- BFL G	5.0E-06H	Agitator basic failure	WSRC-TR-93-262, p.19 , AGI-FA-C		
AG- BLA A	5.0E-07H	agitator failure (blade/shaft)	(wsrc-tr-93-262 T1b agitator)/10		
AG- FTS A	5.00E-06 H	Agitator, Failure (Chemical)	WSRC-TR-93-262, AGI-FA-C	10	L
AG- ON- A	.5N	agitator not on at time of event	asuume 50% because not on during settling & transfers out of tank		
AGI FAC	5.00E-06 H	Agitator, Failure (Chemical)	WSRC-TR-93-262, AGI-FA-C	10	L
ALR NRI	3.00E-05 H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
ALR SOI	5.00E-06 H	Alarm/Annunciator, Spurious operation (Instr. & Control)	WSRC-TR-93-262, ALR-SO-I	10	L
AMP FAI	5.00E-06 H	Amplifier, Failure (Instr. & Control)	WSRC-TR-93-262, AMP-FA-I	10	L
ANA FAI	5.00E-06 H	Analyzer, Failure (Instr. & Control)	WSRC-TR-93-262, ANA-FA-I	10	L
ANG BFL A	5.00E-05H	Lab Equipment Malfunction	WSRC-TR-93-262, page 31, GCR-FA-I, Gas Chromatagraph Failure, Largest of Equip.		
AOD CCH	1.00E-02 N	Damper (Standby or Safety), Air-Operated, Fails to open/close (HVAC)	WSRC-TR-93-262, AOD-CC-H	30	L
AOD COH	1.00E-05 H	Damper (Standby or Safety), Air-Operated, Spurious operation (HVAC)	WSRC-TR-93-262, AOD-CO-H	10	L
AOD LEH	1.00E-07 H	Damper (Standby or Safety), Air-Operated, Leakage (external) (HVAC)	WSRC-TR-93-262, AOD-LE-H	10	L
AOD LIH	1.00E-05 H	Damper (Standby or Safety), Air-Operated, Leakage (internal) (HVAC)	WSRC-TR-93-262, AOD-LI-H	10	L
AOD OCH	1.00E-05 H	Damper (Standby or Safety), Air-Operated, Spurious operation (HVAC)	WSRC-TR-93-262, AOD-OC-H	10	L
AOD OOH	1.00E-02 N	Damper (Standby or Safety), Air-Operated, Fails to open/close (HVAC)	WSRC-TR-93-262, AOD-OO-H	30	L
AOD PGH	5.00E-07 H	Damper (Standby or Safety), Air-Operated, Plugs (HVAC)	WSRC-TR-93-262, AOD-PG-H	10	L
AOD REH	5.00E-09 H	Damper (Standby or Safety), Air-Operated, Rupture (external) (HVAC)	WSRC-TR-93-262, AOD-RE-H	30	L
AOD RIH	5.00E-07 H	Damper (Standby or Safety), Air-Operated, Rupture (internal) (HVAC)	WSRC-TR-93-262, AOD-RI-H	10	L
AOV CCC	1.00E-03 N	Valve (Standby or Safety), Air-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, AOV-CC-C	30	
AOV CCG	3.00E-03 N	Valve (Standby or Safety), Air-Operated, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, AOV-CC-G	30	
AOV CCW	1.00E-03 N	Valve (Standby or Safety), Air-Operated, Fails to open/close (Water)	WSRC-TR-93-262, AOV-CC-W	30	
AOV COC	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Spurious operation (Chemical)	WSRC-TR-93-262, AOV-CO-C	10	
AOV COG	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Spurious operation (Compressed Gas)	WSRC-TR-93-262, AOV-CO-G	10	
AOV COW	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Spurious operation (Water)	WSRC-TR-93-262, AOV-CO-W	5	L

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
AOV LEC	5.00E-07 H	Valve (Standby or Safety), Air-Operated, Leakage (external) (Chemical)	WSRC-TR-93-262, AOV-LE-C	10	L
AOV LEG	1.00E-07 H	Valve (Standby or Safety), Air-Operated, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, AOV-LE-G	10	L
AOV LEW	1.00E-08 H	Valve (Standby or Safety), Air-Operated, Leakage (external) (Water)	WSRC-TR-93-262, AOV-LE-W	10	L
AOV LIC	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Leakage (internal) (Chemical)	WSRC-TR-93-262, AOV-LI-C	10	L
AOV LIG	1.00E-05 H	Valve (Standby or Safety), Air-Operated, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, AOV-LI-G	10	L
AOV LIW	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Leakage (internal) (Water)	WSRC-TR-93-262, AOV-LI-W	10	L
AOV OCC	5.00E-08 H	Valve (Standby or Safety), Air-Operated, Plugs (Chemical)	WSRC-TR-93-262, AOV-OC-C	10	L
AOV OCG	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Spurious operation (Compressed Gas)	WSRC-TR-93-262, AOV-OC-G	10	L
AOV OCW	1.00E-06 H	Valve (Standby or Safety), Air-Operated, Spurious operation (Water)	WSRC-TR-93-262, AOV-OC-W	5	L
AOV OOC	1.00E-03 N	Valve (Standby or Safety), Air-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, AOV-OO-C	30	L
AOV OOG	3.00E-03 N	Valve (Standby or Safety), Air-Operated, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, AOV-OO-G	30	L
AOV OOW	1.00E-03 N	Valve (Standby or Safety), Air-Operated, Fails to open/close (Water)	WSRC-TR-93-262, AOV-OO-W	30	L
AOV PGG	5.00E-07 H	Valve (Standby or Safety), Air-Operated, Plugs (Compressed Gas)	WSRC-TR-93-262, AOV-PG-G	10	L
AOV PGW	5.00E-08 H	Valve (Standby or Safety), Air-Operated, Plugs (Water)	WSRC-TR-93-262, AOV-PG-W	10	L
AOV REC	3.00E-08 H	Valve (Standby or Safety), Air-Operated, Rupture (external) (Chemical)	WSRC-TR-93-262, AOV-RE-C	30	L
AOV REG	5.00E-09 H	Valve (Standby or Safety), Air-Operated, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, AOV-RE-G	30	L
AOV REW	5.00E-10 H	Valve (Standby or Safety), Air-Operated, Rupture (external) (Water)	WSRC-TR-93-262, AOV-RE-W	30	L
AOV RIC	5.00E-08 H	Valve (Standby or Safety), Air-Operated, Rupture (internal) (Chemical)	WSRC-TR-93-262, AOV-RI-C	30	L
AOV RIG	5.00E-07 H	Valve (Standby or Safety), Air-Operated, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, AOV-RI-G	30	L
AOV RIW	5.00E-08 H	Valve (Standby or Safety), Air-Operated, Rupture (internal) (Water)	WSRC-TR-93-262, AOV-RI-W	30	
AQU PRE A	1.0E-01Y	HIGH DENSITY AQUEOUS IN DECANTER	COG - AQUEOUS SITS TOO LONG IN TANK		
ATS CCE	1.00E-06 H	Switch, Automatic-Transfer, Fails to open/close (Electric Power)	WSRC-TR-93-262, ATS-CC-E	10	
ATS COE	1.00E-06 H	Switch, Automatic-Transfer, Spurious operation (Electric Power)	WSRC-TR-93-262, ATS-CO-E	10	
ATS NRE	1.00E-06 H	Switch, Automatic-Transfer, Fails to open/close (Electric Power)	WSRC-TR-93-262, ATS-NR-E	10	
ATS OCE	1.00E-06 H	Switch, Automatic-Transfer, Spurious operation (Electric Power)	WSRC-TR-93-262, ATS-OC-E	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
ATS OOE	1.00E-06 H	Switch, Automatic-Transfer, Fails to open/close (Electric Power)	WSRC-TR-93-262, ATS-OO-E	10	L
ATS SOE	1.00E-06 H	Switch, Automatic-Transfer, Spurious operation (Electric Power)	WSRC-TR-93-262, ATS-SO-E	10	L
AVO COC	5.00E-08 H	Valve (Standby or Safety), Air-Operated, Plugs (Chemical)	WSRC-TR-93-262, AVO-CO-C	10	L
BAG LIH	3.00E-05 H	Filter, Baghouse, Leakage (internal) (HVAC)	WSRC-TR-93-262, BAG-LI-H	10	L
BAG PGH	3.00E-05 H	Filter, Baghouse, Plugs (HVAC)	WSRC-TR-93-262, BAG-PG-H	10	L
BAG RIH	5.00E-06 H	Filter, Baghouse, Rupture (internal) (HVAC)	WSRC-TR-93-262, BAG-RI-H	10	L
BAT FAE	1.00E-05 H	Battery, Failure (Electric Power)	WSRC-TR-93-262, BAT-FA-E	3	L
BAT PRE B	5.71E-3H	batch through 8.5	50/yr est		
BAT PRE E	5.71E-3H	batch through 17.7	50/yr est		
BIS CCE	1.00E-05 N	Relay, Bistable, Fails to open/close (Electric Power)	WSRC-TR-93-262, BIS-CC-E	10	L
BIS COE	3.00E-07 H	Relay, Bistable, Spurious operation (Electric Power)	WSRC-TR-93-262, BIS-CO-E	10	L
BIS NRE	1.00E-05 N	Relay, Bistable, Fails to open/close (Electric Power)	WSRC-TR-93-262, BIS-NR-E	10	L
BIS OCE	3.00E-07 H	Relay, Bistable, Spurious operation (Electric Power)	WSRC-TR-93-262, BIS-OC-E	10	L
BIS OOE	1.00E-05 N	Relay, Bistable, Fails to open/close (Electric Power)	WSRC-TR-93-262, BIS-OO-E	10	L
BIS SOE	3.00E-07 H	Relay, Bistable, Spurious operation (Electric Power)	WSRC-TR-93-262, BIS-SO-E	10	L
BKR SPR G	3.0E-07H	Breaker fails open	WSRC-TR-93-262, p. 27 CBR-CO-E		
BLD BFL G	5.0E-07H	Agitator blades fall off	a: ten times less likely to fail than agitator basic failure		
BUB FAE	1.00E-06 H	Bus, Bare, Failure (Electric Power)	WSRC-TR-93-262, BUB-FA-E	10	L
BUM FAE	1.00E-07 H	Bus, Metal-Enclosed, Failure (Electric Power)	WSRC-TR-93-262, BUM-FA-E	5	L
CAD FCH	3.00E-06 H	Damper (Control), Air-Operated, Fails closed (HVAC)	WSRC-TR-93-262, CAD-FC-H	10	L
CAD FOH	3.00E-06 H	Damper (Control), Air-Operated, Fails open (HVAC)	WSRC-TR-93-262, CAD-FO-H	10	L
CAD LEH	1.00E-07 H	Damper (Control), Air-Operated, Leakage (external) (HVAC)	WSRC-TR-93-262, CAD-LE-H	10	L
CAD NRH	3.00E-06 H	Damper (Control), Air-Operated, Fails to respond (HVAC)	WSRC-TR-93-262, CAD-NR-H	10	
CAD PGH	5.00E-07 H	Damper (Control), Air-Operated, Plugs (HVAC)	WSRC-TR-93-262, CAD-PG-H	10	
CAD REH	5.00E-09 H	Damper (Control), Air-Operated, Rupture (external) (HVAC)	WSRC-TR-93-262, CAD-RE-H	30	
CAV FCC	3.00E-06 H	Valve (Control), Air-Operated, Fails closed (Chemical)	WSRC-TR-93-262, CAV-FC-C	10	
CAV FCG	3.00E-06 H	Valve (Control), Air-Operated, Fails closed (Compressed Gas)	WSRC-TR-93-262, CAV-FC-G	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
CAV FCW	3.00E-06 H	Valve (Control), Air-Operated, Fails closed (Water)	WSRC-TR-93-262, CAV-FC-W	10	L
CAV FOC	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Chemical)	WSRC-TR-93-262, CAV-FO-C	10	L
CAV FOG	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Compressed Gas)	WSRC-TR-93-262, CAV-FO-G	10	L
CAV FOW	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Water)	WSRC-TR-93-262, CAV-FO-W	10	L
CAV LEC	5.00E-07 H	Valve (Control), Air-Operated, Leakage (external) (Chemical)	WSRC-TR-93-262, CAV-LE-C	10	L
CAV LEG	1.00E-07 H	Valve (Control), Air-Operated, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, CAV-LE-G	10	L
CAV LEW	1.00E-08 H	Valve (Control), Air-Operated, Leakage (external) (Water)	WSRC-TR-93-262, CAV-LE-W	10	L
CAV NRC	3.00E-06 H	Valve (Control), Air-Operated, Fails to respond (Chemical)	WSRC-TR-93-262, CAV-NR-C	10	L
CAV NRG	3.00E-06 H	Valve (Control), Air-Operated, Fails to respond (Compressed Gas)	WSRC-TR-93-262, CAV-NR-G	10	L
CAV NRW	3.00E-06 H	Valve (Control), Air-Operated, Fails to respond (Water)	WSRC-TR-93-262, CAV-NR-W	10	L
CAV PGC	5.00E-08 H	Valve (Control), Air-Operated, Plugs (Chemical) (Chemical)	WSRC-TR-93-262, CAV-PG-C	10	L
CAV PGG	5.00E-07 H	Valve (Control), Air-Operated, Plugs (Compressed Gas)	WSRC-TR-93-262, CAV-PG-G	10	L
CAV PGW	5.00E-08 H	Valve (Control), Air-Operated, Plugs (Water)	WSRC-TR-93-262, CAV-PG-W	10	L
CAV REC	3.00E-08 H	Valve (Control), Air-Operated, Rupture (external) (Chemical)	WSRC-TR-93-262, CAV-RE-C	30	L
CAV REG	5.00E-09 H	Valve (Control), Air-Operated, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, CAV-RE-G	30	L
CAV REW	5.00E-10 H	Valve (Control), Air-Operated, Rupture (external) (Water)	WSRC-TR-93-262, CAV-RE-W	30	L
CBL FAE	3.00E-06 H	Termination/Jumper, Cable (Copper, 1000ft), Failure (Electric Power)	WSRC-TR-93-262, CBL-FA-E	3	L
CBR CCE	5.00E-04 N	Circuit Breaker, General, Fails to open/close (Electric Power)	WSRC-TR-93-262, CBR-CC-E	5	L
CBR COE	3.00E-07 H	Circuit Breaker, General, Spurious operation (Electric Power)	WSRC-TR-93-262, CBR-CO-E	10	L
CBR NRE	5.00E-04 N	Circuit Breaker, General, Fails to open/close (Electric Power)	WSRC-TR-93-262, CBR-NR-E	5	[illegible]
CBR OCE	3.00E-07 H	Circuit Breaker, General, Spurious operation (Electric Power)	WSRC-TR-93-262, CBR-OC-E	10	[illegible]
CBR OOE	5.00E-04 N	Circuit Breaker, General, Fails to open/close (Electric Power)	WSRC-TR-93-262, CBR-OO-E	5	[illegible]
CBR SOE	3.00E-07 H	Circuit Breaker, General, Spurious operation (Electric Power)	WSRC-TR-93-262, CBR-SO-E	10	[illegible]
CHM FHI G	1.0N	Acid concentration is normally high	assumed always high		
CHM FIR D	1.0E-07H	Large fire in cell causes pyrolysis of TBP	F-Canyon SAR		

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Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
CHM FIR S	1.0E-07H	Large fire in cell causes pyrolysis of TBP	F-Canyon SAR		
CHM UNR D	5.0E-06H	Uncontrolled chemical reaction-7.3	DPSTSY-200-1F T O-15 Unc. rxn in rerun		
CHM UNR S	5.0E-06H	Uncontrolled chemical reaction-17.5	DPSTSY-200-1F T O-15 Unc. rxn in rerun		
CKV CCC	5.00E-05 N	Valve (Standby or Safety), Check, Fails to open (Chemical)	WSRC-TR-93-262, CKV-CC-C	10	L
CKV CCG	1.00E-04 N	Valve (Standby or Safety), Check, Fails to open (Compressed Gas)	WSRC-TR-93-262, CKV-CC-G	10	L
CKV CCW	5.00E-05 N	Valve (Standby or Safety), Check, Fails to open (Water)	WSRC-TR-93-262, CKV-CC-W	10	L
CKV LEC	5.00E-07 H	Valve (Standby or Safety), Check, Leakage (external) (Chemical)	WSRC-TR-93-262, CKV-LE-C	10	L
CKV LEG	1.00E-07 H	Valve (Standby or Safety), Check, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, CKV-LE-G	10	L
CKV LEW	1.00E-08 H	Valve (Standby or Safety), Check, Leakage (external) (Water)	WSRC-TR-93-262, CKV-LE-W	10	L
CKV LIC	1.00E-06 H	Valve (Standby or Safety), Check, Leakage (internal) (Chemical)	WSRC-TR-93-262, CKV-LI-C	10	L
CKV LIG	1.00E-05 H	Valve (Standby or Safety), Check, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, CKV-LI-G	10	L
CKV LIW	1.00E-06 H	Valve (Standby or Safety), Check, Leakage (internal) (Water)	WSRC-TR-93-262, CKV-LI-W	10	L
CKV OOC	1.00E-03 N	Valve (Standby or Safety), Check, Fails to close (Chemical)	WSRC-TR-93-262, CKV-OO-C	10	L
CKV OOG	3.00E-03 N	Valve (Standby or Safety), Check, Fails to close (Compressed Gas)	WSRC-TR-93-262, CKV-OO-G	10	L
CKV OOW	1.00E-03 N	Valve (Standby or Safety), Check, Fails to close (Water)	WSRC-TR-93-262, CKV-00-W	5	L
CKV PGC	5.00E-08 H	Valve (Standby or Safety), Check, Plugs (Chemical)	WSRC-TR-93-262, CKV-PG-C	10	L
CKV PGG	5.00E-07 H	Valve (Standby or Safety), Check, Plugs (Compressed Gas)	WSRC-TR-93-262, CKV-PG-G	10	L
CKV PGW	5.00E-08 H	Valve (Standby or Safety), Check, Plugs (Water)	WSRC-TR-93-262, CKV-PG-W	10	L
CKV REC	3.00E-08 H	Valve (Standby or Safety), Check, Rupture (external) (Chemical)	WSRC-TR-93-262, CKV-RE-C	30	L
CKV REG	5.00E-09 H	Valve (Standby or Safety), Check, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, CKV-RE-G	30	L
CKV REW	5.00E-10 H	Valve (Standby or Safety), Check, Rupture (external) (Water)	WSRC-TR-93-262, CKV-RE-W	30	
CKV RIC	5.00E-08 H	Valve (Standby or Safety), Check, Rupture (internal) (Chemical)	WSRC-TR-93-262, CKV-RI-C	30	
CKV RIG	5.00E-07 H	Valve (Standby or Safety), Check, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, CKV-RI-G	30	
CKV RIW	5.00E-08 H	Valve (Standby or Safety), Check, Rupture (internal) (Water)	WSRC-TR-93-262, CKV-RI-W	30	
CMD FCH	3.00E-06 H	Damper (Control), Motor-Operated, Fails closed (HVAC)	WSRC-TR-93-262, CMD-FC-H	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
CMD FOH	3.00E-06 H	Damper (Control), Motor-Operated, Fails open (HVAC)	WSRC-TR-93-262, CMD-FO-H	10	L
CMD LEH	1.00E-07 H	Damper (Control), Motor-Operated, Leakage (external) (HVAC)	WSRC-TR-93-262, CMD-LE-H	10	L
CMD NRH	3.00E-06 H	Damper (Control), Motor-Operated, Fails to respond (HVAC)	WSRC-TR-93-262, CMD-NR-H	10	L
CMD PGH	5.00E-07 H	Damper (Control), Motor-Operated, Plugs (HVAC)	WSRC-TR-93-262, CMD-PG-H	10	L
CMD REH	5.00E-09 H	Damper (Control), Motor-Operated, Rupture (external) (HVAC)	WSRC-TR-93-262, CMD-RE-H	30	L
CMV FCC	3.00E-06 H	Valve (Control), Motor-Operated, Fails closed (Chemical)	WSRC-TR-93-262, CMV-FC-C	10	L
CMV FCG	3.00E-06 H	Valve (Control), Motor-Operated, Fails closed (Compressed Gas)	WSRC-TR-93-262, CMV-FC-G	10	L
CMV FCW	3.00E-06 H	Valve (Control), Motor-Operated, Fails closed (Water)	WSRC-TR-93-262, CMV-FC-W	10	L
CMV FOC	3.00E-06 H	Valve (Control), Motor-Operated, Fails open (Chemical)	WSRC-TR-93-262, CMV-FO-C	10	L
CMV FOG	3.00E-06 H	Valve (Control), Motor-Operated, Fails open (Compressed Gas)	WSRC-TR-93-262, CMV-FO-G	10	L
CMV FOW	3.00E-06 H	Valve (Control), Motor-Operated, Fails open (Water)	WSRC-TR-93-262, CMV-FO-W	10	L
CMV LEC	5.00E-07 H	Valve (Control), Motor-Operated, Leakage (external) (Chemical)	WSRC-TR-93-262, CMV-LE-C	10	L
CMV LEG	1.00E-07 H	Valve (Control), Motor-Operated, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, CMV-LE-G	10	L
CMV LEW	1.00E-08 H	Valve (Control), Motor-Operated, Leakage (external) (Water)	WSRC-TR-93-262, CMV-LE-W	10	L
CMV NRC	3.00E-06 H	Valve (Control), Motor-Operated, Fails to respond (Chemical)	WSRC-TR-93-262, CMV-NR-C	10	L
CMV NRG	3.00E-06 H	Valve (Control), Motor-Operated, Fails to respond (Compressed Gas)	WSRC-TR-93-262, CMV-NR-G	10	L
CMV NRW	3.00E-06 H	Valve (Control), Motor-Operated, Fails to respond (Water)	WSRC-TR-93-262, CMV-NR-W	10	L
CMV PGC	5.00E-08 H	Valve (Control), Motor-Operated, Plugs (Chemical)	WSRC-TR-93-262, CMV-PG-C	10	L
CMV PGG	5.00E-07 H	Valve (Control), Motor-Operated, Plugs (Compressed Gas)	WSRC-TR-93-262, CMV-PG-G	10	L
CMV PGW	5.00E-08 H	Valve (Control), Motor-Operated, Plugs (Water)	WSRC-TR-93-262, CMV-PG-W	10	[illegible]
CMV REC	3.00E-08 H	Valve (Control), Motor-Operated, Rupture (external) (Chemical)	WSRC-TR-93-262, CMV-RE-C	30	[illegible]
CMV REG	5.00E-09 H	Valve (Control), Motor-Operated, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, CMV-RE-G	30	[illegible]
CMV REW	5.00E-10 H	Valve (Control), Motor-Operated, Rupture (external) (Water)	WSRC-TR-93-262, CMV-RE-W	30	[illegible]
COC FAI	1.00E-04 H	Sensor/Transmit./, Transdu./Proc. Switch, CO2 Conc., Failure (Instr. & Control)	WSRC-TR-93-262, COC-FA-I	10	[illegible]

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
CRI PRE G	2.0E-07H	Heat from criticality causes secondary "red oil" reaction	DPSTSA-200-10, SUP-4, Table 5-7		
CSV FCC	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails closed (Chemical)	WSRC-TR-93-262, CSV-FC-C	10	L
CSV FCG	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails closed (Compressed Gas)	WSRC-TR-93-262, CSV-FC-G	10	L
CSV FCW	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails closed (Water)	WSRC-TR-93-262, CSV-FC-W	10	L
CSV FOC	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails open (Chemical)	WSRC-TR-93-262, CSV-FO-C	10	L
CSV FOG	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails open (Compressed Gas)	WSRC-TR-93-262, CSV-FO-G	10	L
CSV FOW	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails to respond (Water)	WSRC-TR-93-262, CSV-FO-W	10	L
CSV LEC	5.00E-07 H	Valve (Control), Solenoid-Operated, Leakage (external) (Chemical)	WSRC-TR-93-262, CSV-LE-C	10	L
CSV LEG	1.00E-07 H	Valve (Control), Solenoid-Operated, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, CSV-LE-G	10	L
CSV LEW	1.00E-08 H	Valve (Control), Solenoid-Operated, Leakage (external) (Water)	WSRC-TR-93-262, CSV-LE-W	10	L
CSV NRC	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails to respond (Chemical)	WSRC-TR-93-262, CSV-NR-C	10	L
CSV NRG	3.00E-06 H	Valve (Control), Solenoid-Operated, Fails to respond (Compressed Gas)	WSRC-TR-93-262, CSV-NR-G	10	L
CSV PGC	5.00E-08 H	Valve (Control), Solenoid-Operated, Plugs (Chemical)	WSRC-TR-93-262, CSV-PG-C	10	L
CSV PGG	5.00E-07 H	Valve (Control), Solenoid-Operated, Plugs (Compressed Gas)	WSRC-TR-93-262, CSV-PG-G	10	L
CSV PGW	5.00E-08 H	Valve (Control), Solenoid-Operated, Plugs (Water)	WSRC-TR-93-262, CSV-PG-W	10	L
CSV REC	3.00E-08 H	Valve (Control), Solenoid-Operated, Rupture (external) (Chemical)	WSRC-TR-93-262, CSV-RE-C	30	L
CSV REG	5.00E-09 H	Valve (Control), Solenoid-Operated, Rupture (external)	WSRC-TR-93-262, CSV-RE-G	30	L
CSV REW	5.00E-10 H	Valve (Control), Solenoid-Operated, Rupture (external) (Water)	WSRC-TR-93-262, CSV-RE-W	30	L
CTF FAC	5.00E-06 H	Centrifuge, Failure (Chemical)	WSRC-TR-93-262, CTF-FA-C	10	L
CYL LEG	1.00E-07 H	Cylinder (Pressurized), Leakage (external) (Compressed Gas)	WSRC-TR-93-262, CYL-LE-G	10	[illegible]
CYL REG	5.00E-09 H	Cylinder (Pressurized), Rupture (external) (Compressed Gas)	WSRC-TR-93-262, CYL-RE-G	30	[illegible]
DCS PRE A	3.0E-06H	Common cause failure of DCS temperature and agitation equipment	WSRC-TR-93-262		
DCT LEH	3.00E-07 H	Ducting, Leakage (per ft.) (external) (HVAC)	WSRC-TR-93-262, DCT-LE-H	10	[illegible]
DCT PGH	1.00E-08 H	Ducting, Plugs (per ft.) (HVAC)	WSRC-TR-93-262, DCT-PG-H	30	L
DCT REH	1.00E-08 H	Ducting, Rupture (per ft.) (external) (HVAC)	WSRC-TR-93-262, DCT-RE-H	30	[illegible]

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
DDF FRH	5.00E-03 H	Fan/Blower, Diesel-Driven, Fails to run (HVAC)	WSRC-TR-93-262, DDF-FR-H	10	L
DDF FSH	1.00E-02 N	Fan/Blower, Diesel-Driven, Fails to start (HVAC)	WSRC-TR-93-262, DDF-FS-H	10	L
DDF LEH	3.00E-07 H	Fan/Blower, Diesel-Driven, Leakage (external) (HVAC)	WSRC-TR-93-262, DDF-LE-H	10	L
DDF NSH	1.00E-02 N	Fan/Blower, Diesel-Driven, Fails to stop (HVAC)	WSRC-TR-93-262, DDF-NS-H	10	L
DDF OSH	1.00E-03 H	Fan/Blower, Diesel-Driven, Overspeed (HVAC)	WSRC-TR-93-262, DDF-OS-H	10	L
DDF REH	1.00E-08 H	Fan/Blower, Diesel-Driven, Rupture (external) (HVAC)	WSRC-TR-93-262, DDF-RE-H	10	L
DDG FRE	5.00E-03 H	Generator, Diesel-Driven, Fails to run (Electric Power)	WSRC-TR-93-262, DDG-FR-E	3	L
DDG FSE	1.00E-02 N	Generator, Diesel-Driven, Fails to start (Electric Power)	WSRC-TR-93-262, DDG-FS-E	3	L
DDP FRC	5.00E-03 H	Pump, Diesel-Driven, Fails to run (Chemical)	WSRC-TR-93-262, DDP-FR-C	10	L
DDP FRW	5.00E-03 H	Pump, Diesel-Driven, Fails to run (Water)	WSRC-TR-93-262, DDP-FR-W	5	L
DDP FSC	1.00E-02 N	Pump, Diesel-Driven, Fails to start (Chemical)	WSRC-TR-93-262, DDP-FS-C	10	L
DDP FSW	1.00E-02 N	Pump, Diesel-Driven, Fails to start (Water)	WSRC-TR-93-262, DDP-FS-W	5	L
DDP LEC	1.00E-06 H	Pump, Diesel-Driven, Leakage (external) (Chemical)	WSRC-TR-93-262, DDP-LE-C	10	L
DDP LEW	3.00E-08 H	Pump, Diesel-Driven, Leakage (external) (Water)	WSRC-TR-93-262, DDP-LE-W	10	L
DDP NSC	1.00E-02 N	Pump, Diesel-Driven, Fails to stop (Chemical)	WSRC-TR-93-262, DDP-NS-C	10	L
DDP NSW	1.00E-02 N	Pump, Diesel-Driven, Fails to stop (Water)	WSRC-TR-93-262, DDP-NS-W	5	L
DDP OSC	1.00E-03 H	Pump, Diesel-Driven, Overspeed (Chemical)	WSRC-TR-93-262, DDP-OS-C	10	L
DDP OSW	1.00E-03 H	Pump, Diesel-Driven, Overspeed (Water)	WSRC-TR-93-262, DDP-OS-W	5	L
DDP REC	5.00E-08 H	Pump, Diesel-Driven, Rupture (external) (Chemical)	WSRC-TR-93-262, DDP-RE-C	30	L
DDP REW	1.00E-09 H	Pump, Diesel-Driven, Rupture (external) (Water)	WSRC-TR-93-262, DDP-RE-W	30	L
DG- FTR A	3.0E-04H	Emergency diesel fail run	DPSTSY-200-1F vol. 2 p P-32		
DG- FTS A	3.0E-02N	Emergency diesel fail start	DPSTSY-200-1F vol. 2 p P-32		
DG- MSC A	2E-3N	operator error/misc. causes diesel generator failure	DPSTSY-200-1F vol. 2 p P-32		
DPS BFL G	3.0E-06H	Differential pressure sensor/transmitter/switch basic failure (high)	WSRC-TR-93-262 PAGE 30, DPS-FA-I		
DPS FAI	3.00E-06 H	Sensor/Transmit., Transdu./Proc. Sw., Differ. Pres., Failure (Instr. & Control)	WSRC-TR-93-262, DPS-FA-I	10	
EVP ON- G	8M	Batch evaporator is used	a: 8 times per month		
EVP ON1 G	52Y	Continous evaporator is used	a: run 52 times per year		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
EXH BFL A	0.03Y	Failure of F-Canyon Ventilation System	SRT-SEP-93-009, Fault Tree Analysis of Diesel Generators in F-Canyon, 1/39yr		
EXM CRI D	1.8E-7H	heat from criticality causes red oil rxn	F-Canyon SAR T5-7		
EXM CRI S	1.8E-7H	heat from criticality causes red oil rxn	F-Canyon SAR T5-7		
EXV CCC	1.00E-04 N	Valve (Standby or Safety), Explosive, Fails to open (Chemical)	WSRC-TR-93-262, EXV-CC-C	10	L
EXV CCW	1.00E-04 N	Valve (Standby or Safety), Explosive, Fails to open (Water)	WSRC-TR-93-262, EXV-CC-W	10	L
EXV LEC	5.00E-07 H,	Valve (Standby or Safety), Explosive, Leakage (external) (Chemical)	WSRC-TR-93-262, EXV-LE-C	10	L
EXV LEW	1.00E-08 H	Valve (Standby or Safety), Explosive, Leakage (external) (Water)	WSRC-TR-93-262, EXV-LE-W	10	L
EXV LIC	1.00E-06 H	Valve (Standby or Safety), Explosive, Leakage (internal) (Chemical)	WSRC-TR-93-262, EXV-LI-C	10	L
EXV LIW	1.00E-06 H	Valve (Standby or Safety), Explosive, Leakage (internal) (Water)	WSRC-TR-93-262, EXV-LI-W	10	L
EXV REC	3.00E-08 H	Valve (Standby or Safety), Explosive, Rupture (external) (Chemical)	WSRC-TR-93-262, EXV-RE-C	30	L
EXV REW	5.00E-10 H	Valve (Standby or Safety), Explosive, Rupture (external) (Water)	WSRC-TR-93-262, EXV-RE-W	30	L
EXV RIC	5.00E-08 H	Valve (Standby or Safety), Explosive, Rupture (internal) (Chemical)	WSRC-TR-93-262, EXV-RI-C	10	L
EXV RIW	5.00E-08 H	Valve (Standby or Safety), Explosive, Rupture (internal) (Water)	WSRC-TR-93-262, EXV-RI-W	30	L
FCU FRH	1.00E-05 H	Fan Cooler Unit, Fails to run (HVAC)	WSRC-TR-93-262, FCU-FR-H	3	L
FCU FSH	1.00E-02 N	Fan Cooler Unit, Fails to start (HVAC)	WSRC-TR-93-262, FCU-FS-H	5	L
FIR PRE G	1.0E-07H	Large fire in cell causes pyrolysis of TBP	Bounds DPSTSA-200-10, SUP-4		
FLG LEC	1.00E-07 H	Flange/Gasket, Leakage (external) (Chemical)	WSRC-TR-93-262, FLG-LE-C	10	L
FLG LEG	1.00E-07 H	Flange/Gasket, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, FLG-LE-G	10	L
FLG LEW	1.00E-08 H	Flange/Gasket, Leakage (external) (Water)	WSRC-TR-93-262, FLG-LE-W	10	L
FLG REC	1.00E-09 H	Flange/Gasket, Rupture (external) (Chemical)	WSRC-TR-93-262, FLG-RE-C	10	L
FLG REG	1.00E-09 H	Flange/Gasket, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, FLG-RE-G	10	L
FLG REW	1.00E-10 H	Flange/Gasket, Rupture (external) (Water)	WSRC-TR-93-262, FLG-RE-W	30	
FLL LIH	3.00E-06 H	Filter, Low-Efficiency, Leakage (internal) (HVAC)	WSRC-TR-93-262, FLL-LI-H	10	
FLL PGH	3.00E-06 H	Filter, Low-Efficiency, Plugs (HVAC)	WSRC-TR-93-262, FLL-PG-H	10	
FLL RIH	5.00E-07 H	Filter, Low-Efficiency, Rupture (internal) (HVAC)	WSRC-TR-93-262, FLL-RI-H	10	
FLS LIH	3.00E-06 H	Filter, Sand, Leakage (internal) (HVAC)	WSRC-TR-93-262, FLS-LI-H	10	
FLS PGH	3.00E-06 H	Filter, Sand, Plugs (HVAC)	WSRC-TR-93-262, FLS-PG-H	10	
FLS RIH	5.00E-07 H	Filter, Sand, Rupture (internal) (HVAC)	WSRC-TR-93-262, FLS-RI-H	10	
FLT LIC	3.00E-06 H	Filter/Strainer, Leakage (internal) (Chemical)	WSRC-TR-93-262, FLT-LI-C	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
FLT LIG	3.00E-06 H	Filter, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, FLT-LI-G	10	L
FLT LIH	3.00E-06 H	Filter, Normal, Leakage (internal) (HVAC)	WSRC-TR-93-262, FLT-LI-H	10	L
FLT LIW	3.00E-06 H	Filter/Strainer, Leakage (internal) (Water)	WSRC-TR-93-262, FLT-LI-W	10	L
FLT PGC	3.00E-06 H	Filter/Strainer, Plugs (Chemical)	WSRC-TR-93-262, FLT-PG-C	10	L
FLT PGG	3.00E-06 H	Filter, Plugs (Compressed Gas)	WSRC-TR-93-262, FLT-PG-G	10	L
FLT PGH	3.00E-06 H	Filter, Normal, Plugs (HVAC)	WSRC-TR-93-262, FLT-PG-H	10	L
FLT PGW	3.00E-06 H	Filter/Strainer, Plugs (Water)	WSRC-TR-93-262, FLT-PG-W	10	L
FLT RIC	5.00E-07 H	Filter/Strainer, Rupture (internal) (Chemical)	WSRC-TR-93-262, FLT-RI-C	10	L
FLT RIG	5.00E-07 H	Filter, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, FLT-RI-G	10	L
FLT RIH	5.00E-07 H	Filter, Normal, Rupture (internal) (HVAC)	WSRC-TR-93-262, FLT-RI-H	10	L
FLT RIW	5.00E-07 H	Filter/Strainer, Rupture (internal) (Water)	WSRC-TR-93-262, FLT-RI-W	10	L
FLT UNR D	3.81E-5H	ammonium nitrate rxn in PVV filter	takes 3 years to build up		
FPW BFL A	1.0E-04H	Failure of utility power	DPSTSY-200-1F		
FRE 1MO G	1.0Y	Frequency	a: adjusted once a month		
FRE 1WK G	4.0M	Frequency	a: adjusted 4 times a month (COG)		
FRE 2YR G	0.5Y	Frequency	a: every 2 years (COG)		
FRE 3MO G	3.0Y	Frequency	a: 3 times a year		
FRE 3YR G	0.333Y	Frequency	a: every 3 years		
FRE 5YR G	0.2Y	Frequency	a: every 5 yrs (cog)		
FRE 6MO G	2Y	Frequency	a: twice a year		
FST FAI	3.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Flow, Failure (Instr. & Control)	WSRC-TR-93-262, FST-FA-I	3	L
FUS CCE	1.00E-07 H	Fuse, Fail to open (Electric Power)	WSRC-TR-93-262, FUS-CC-E	10	L
FUS SOE	1.00E-08 H	Fuse, Premature opening (Electric Power)	WSRC-TR-93-262, FUS-SO-E	10	L
GCR FAI	5.00E-05 H	Gas Chromatograph, Failure (Instr. & Control)	WSRC-TR-93-262, GCR-FA-I	10	L
GI- ID- D	1E-32H	acid add'n heats tank 17.5			
GI- ID- S	1E-32H	acid add'n heats tank 17.5			
GI- TER -	1E-32H	normal water addition heats tank	incredible		
GSK LKS G	1.0E-07H	Gasket Leaks	WSRC-TR-93-262, page 19, FLG-LE-C, Flange/Gasket, Leakage		
GTG FRE	3.00E-04 H	Generator, Gas-Turbine-Driven, Fails to run (Electric Power)	WSRC-TR-93-262, GTG-FR-E	10	L
GTG FSE	3.00E-02 N	Generator, Gas-Turbine-Driven, Fails to start (Electric Power)	WSRC-TR-93-262, GTG-FS-E	1[illegible]	L
HCC FAI	1.00E-05 H	Sensor/Transmit./, Transdu./Proc. Sw., H2 Conc., Failure (Instr. & Con.)	WSRC-TR-93-262, HCC-FA-I	3	L
HCV FCL A	3.0E-07H	Spurious Operation of Motor Operated Valve	WSRC-TR-93-262, page 12, MOV-OC-W, Spurious Operation of Motor Operated Valve		
HCV FCL G	3.0E-07H	Spurious Operation of Motor Operated Valve	WSRC-TR-93-262, page 12, MOV-OC-W, Spurious Operation of Motor Operated Valve		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
HCV FTO G	1.0E-03N	Manual Valve Fails to Open	WSRC-TR-93-262, page 20, XMV-OO-G, Manual Valve Fails to Open		
HDG FRE	3.00E-04 H	Generator, Hydro-Turbine-Driven, Fails to run (Electric Power)	WSRC-TR-93-262, HDG-FR-E	10	L
HDG FSE	3.00E-03 N	Generator, Hydro-Turbine-Driven, Fails to start (Electric Power)	WSRC-TR-93-262, HDG-FS-E	10	L
HEC FAI	1.00E-05 H	Sensor/Transmit./, Transdu./Proc. Switch, He Conc., Failure (Instr. & Control)	WSRC-TR-93-262, HEC-FA-I	3	L
HOS LEC	1.00E-09 H	Hose, Leakage (external) (Chemical)	WSRC-TR-93-262, HOS-LE-C	10	L
HOS LEG	1.00E-08 H	Hose, Leakage (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, HOS-LE-G	10	L
HOS LEW	1.00E-09 H	Hose, Leakage (external) (per ft.) (Water)	WSRC-TR-93-262, HOS-LE-W	10	L
HOS PGC	1.00E-08 H	Hose, Plugs (Chemical)	WSRC-TR-93-262, HOS-PG-C	10	L
HOS PGG	1.00E-07 H	Hose, Plugs (per ft.) (Compressed Gas)	WSRC-TR-93-262, HOS-PG-G	10	L
HOS PGW	1.00E-08 H	Hose, Plugs (per ft.) (Water)	WSRC-TR-93-262, HOS-PG-W	10	L
HOS REC	1.00E-08 H	Hose, Rupture (external) (Chemical)	WSRC-TR-93-262, HOS-RE-C	10	L
HOS REG	1.00E-07 H	Hose, Rupture (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, HOS-RE-G	10	L
HOS REW	1.00E-08 H	Hose, Rupture (external) (per ft.) (Water)	WSRC-TR-93-262, HOS-RE-W	10	L
HPA LIH	3.00E-06 H	Filter, HEPA, Leakage (internal) (HVAC)	WSRC-TR-93-262, HPA-LI-H	10	L
HPA PGH	3.00E-06 H	Filter, HEPA, Plugs (HVAC)	WSRC-TR-93-262, HPA-PG-H	10	L
HPA RIH	5.00E-07 H	Filter, HEPA, Rupture (internal) (HVAC)	WSRC-TR-93-262, HPA-RI-H	10	L
HST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Process Switch, pH, Failure (Instr. & Control)	WSRC-TR-93-262, HST-FA-I	5	L
HTE FHC	1.00E-05 H	Heater (Electrical), Fails to heat (Chemical)	WSRC-TR-93-262, HTE-FH-C	10	L
HTE FHG	1.00E-06 H	Heater (Electrical), Fails to heat (Compressed Gas)	WSRC-TR-93-262, HTE-FH-G	10	L
HTE FHH	1.00E-06 H	Heater (Electrical), Fails to heat (HVAC)	WSRC-TR-93-262, HTE-FH-H	3	L
HTE FHW	1.00E-06 H	Heater (Electrical), Fails to heat (Water)	WSRC-TR-93-262, HTE-FH-W	10	L
HTE LEC	1.00E-06 H	Heater (Electrical), Leakage (external) (Chemical)	WSRC-TR-93-262, HTE-LE-C	10	L
HTE LEG	1.00E-06 H	Heater (Electrical), Leakage (external) (Compressed Gas)	WSRC-TR-93-262, HTE-LE-G	10	L
HTE LEW	1.00E-07 H	Heater (Electrical), Leakage (external) (Water)	WSRC-TR-93-262, HTE-LE-W	10	L
HTE OHC	3.00E-06 H	Heater (Electrical), Overheats (Chemical)	WSRC-TR-93-262, HTE-OH-C	10	L
HTE OHG	3.00E-07 H	Heater (Electrical), Overheats (Compressed Gas)	WSRC-TR-93-262, HTE-OH-G	10	L
HTE OHH	3.00E-07 H	Heater (Electrical), Overheats (HVAC)	WSRC-TR-93-262, HTE-OH-H	10	L
HTE OHW	3.00E-07 H	Heater (Electrical), Overheats (Water)	WSRC-TR-93-262, HTE-OH-W	10	L
HTE REC	5.00E-08 H	Heater (Electrical), Rupture (external) (Chemical)	WSRC-TR-93-262, HTE-RE-C	30	L
HTE REG	5.00E-08 H	Heater (Electrical), Rupture (external) (Compressed Gas)	WSRC-TR-93-262, HTE-RE-G	30	L

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
HTE REW	5.00E-09 H	Heater (Electrical), Rupture (external) (Water)	WSRC-TR-93-262, HTE-RE-W	30	L
HTG FHH	1.00E-03 H	Heater (Gas), Fails to heat (HVAC)	WSRC-TR-93-262, HTG-FH-H	10	L
HTG OHH	3.00E-04 H	Heater (Gas), Overheats (HVAC)	WSRC-TR-93-262, HTG-OH-H	10	L
HTX FLC	1.00E-06 H	Heat Exchanger, Shell/Tube, Fouling (tubes) (Chemical)	WSRC-TR-93-262, HTX-FL-C	10	L
HTX FLG	1.00E-05 H	Heat Exchanger, Shell/Tube, Fouling (tubes) (Compressed Gas)	WSRC-TR-93-262, HTX-FL-G	10	L
HTX FLW	1.00E-07 H	Heat Exchanger, Shell/Tube, Fouling (tubes) (Water)	WSRC-TR-93-262, HTX-FL-W	10	L
HTX LEC	1.00E-07 H	Heat Exchanger, Shell/Tube, Leakage (shell) (Chemical)	WSRC-TR-93-262, HTX-LE-C	10	L
HTX LEG	1.00E-06 H	Heat Exchanger, Shell/Tube, Leakage (shell) (Compressed Gas)	WSRC-TR-93-262, HTX-LE-G	10	L
HTX LEW	1.00E-08 H	Heat Exchanger, Shell/Tube, Leakage (shell) (Water)	WSRC-TR-93-262, HTX-LE-W	10	L
HTX LIC	1.00E-06 H	Heat Exchanger, Shell/Tube, Leakage (tubes) (Chemical)	WSRC-TR-93-262, HTX-LI-C	10	L
HTX LIG	1.00E-05 H	Heat Exchanger, Shell/Tube, Leakage (tubes) (Compressed Gas)	WSRC-TR-93-262, HTX-LI-G	10	L
HTX LIW	1.00E-07 H	Heat Exchanger, Shell/Tube, Leakage (tubes) (Water)	WSRC-TR-93-262, HTX-LI-W	10	L
HTX PGC	3.00E-07 H	Heat Exchanger, Shell/Tube, Plugs (tubes) (Chemical)	WSRC-TR-93-262, HTX-PG-C	10	L
HTX PGG	3.00E-06 H	Heat Exchanger, Shell/Tube, Plugs (tubes) (Compressed Gas)	WSRC-TR-93-262, HTX-PG-G	10	L
HTX PGW	3.00E-08 H	Heat Exchanger, Shell/Tube, Plugs (tubes) (Water)	WSRC-TR-93-262, HTX-PG-W	10	L
HTX REC	5.00E-09 H	Heat Exchanger, Shell/Tube, Rupture (shell) (Chemical)	WSRC-TR-93-262, HTX-RE-C	30	L
HTX REG	5.00E-08 H	Heat Exchanger, Shell/Tube, Rupture (shell) (Compressed Gas)	WSRC-TR-93-262, HTX-RE-G	30	L
HTX REW	5.00E-10 H	Heat Exchanger, Shell/Tube, Rupture (shell) (Water)	WSRC-TR-93-262, HTX-RE-W	30	L
HTX RIC	5.00E-08 H	Heat Exchanger, Shell/Tube, Rupture (tubes) (Chemical)	WSRC-TR-93-262, HTX-RI-C	30	L
HTX RIG	5.00E-07 H	Heat Exchanger, Shell/Tube, Rupture (tubes) (Compressed Gas)	WSRC-TR-93-262, HTX-RI-G	30	L
HTX RIW	5.00E-09 H	Heat Exchanger, Shell/Tube, Rupture (tubes) (Water)	WSRC-TR-93-262, HTX-RI-W	3[illegible]	[illegible]
HX- LKS A	1.0E-07H	Heat Exchanger Tube Leaks	WSRC-TR-93-262, page 15, HTX-LI-W, Heat Exchanger Tube Leakage		
HX- LKS G	1.0E-07H	Heat Exchanger Tube Leaks	WSRC-TR-93-262, page 15, HTX-LI-W, Heat Exchanger Tube Leakage		
HX- PLG A	3.0E-08H	Heat Exchanger Tube Plugs	WSRC-TR-93-262, page 15, HTX-PG-W, Heat Exchanger Tube Plugs		
HX- PLG G	3.0E-08H	Heat Exchanger Tube Plugs	WSRC-TR-93-262, page 15, HTX-PG-W, Heat Exchanger Tube Plugs		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
HYC FAI	1.00E-05 H	Sensor/Transmit./, Transdu./Proc. Sw., H2 Conc., Failure (Instr. & Contr.)	WSRC-TR-93-262, HYC-FA-I	3	L
IND FAI	1.00E-05 H	Indicator, Failure (Instr. & Control)	WSRC-TR-93-262, IND-FA-I	10	L
INT FHI G	3.0E-06H	DIFFERENTIAL PRESSURE INSTRUMENT FAILURE	WSRC-TR-93-262, page 30, DPS-FA-I		
INV FAE	1.00E-05 H	Inverter, Failure (Electric Power)	WSRC-TR-93-262, INV-FA-E	3	L
JNT FAE	3.00E-06 H	Joint (Copper), Failure (Electric Power)	WSRC-TR-93-262, JNT-FA-E	30	L
JPR FAE	5.00E-06 H	Jumper (Power), Failure (Electric Power)	WSRC-TR-93-262, JPR-FA-E	10	L
JPR LEC	1.00E-06 H	Jumper, Leakage (external) (Chemical)	WSRC-TR-93-262, JPR-LE-C	10	L
JPR LEG	1.00E-05 H	Jumper, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, JPR-LE-G	10	L
JPR LEW	1.00E-06 H	Jumper, Leakage (external) (Water)	WSRC-TR-93-262, JPR-LE-W	10	L
JPR PGC	5.00E-08 H	Jumper, Plugs (Chemical)	WSRC-TR-93-262, JPR-PG-C	10	L
JPR PGG	1.00E-07 H	Plugs (Compressed Gas)	WSRC-TR-93-262, JPR-PG-G	30	L
JPR PGW	5.00E-08 H	Jumper, Plugs (Water)	WSRC-TR-93-262, JPR-PG-W	10	L
JPR REC	1.00E-08 H	Jumper, Rupture (external) (Chemical)	WSRC-TR-93-262, JPR-RE-C	30	L
JPR REG	1.00E-07 H	Jumper, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, JPR-RE-G	30	L
JPR REW	1.00E-08 H	Jumper, Rupture (external) (Water)	WSRC-TR-93-262, JPR-RE-W	30	L
LAL BFL G	3.0E-05H		P.30 ALARM		
LMS CCE	1.00E-06 H	Switch, Limit, Fails to open/close (Electric Power)	WSRC-TR-93-262, LMS-CC-E	10	L
LMS COE	1.00E-06 H	Switch, Limit, Spurious operation (Electric Power)	WSRC-TR-93-262, LMS-CO-E	5	L
LMS NRE	1.00E-06 H	Switch, Limit, Fails to open/close (Electric Power)	WSRC-TR-93-262, LMS-NR-E	10	L
LMS OCE	1.00E-06 H	Switch, Limit, Spurious operation (Electric Power)	WSRC-TR-93-262, LMS-OC-E	5	L
LMS OOE	1.00E-06 H	Switch, Limit, Fails to open/close (Electric Power)	WSRC-TR-93-262, LMS-OO-E	10	L
LMS SOE	1.00E-06 H	Switch, Limit, Spurious operation (Electric Power)	WSRC-TR-93-262, LMS-SO-E	5	L
LOG FAI	3.00E-06 H	Logic Module, Failure (Instr. & Control)	WSRC-TR-93-262, LOG-FA-I	5	L
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
MDC FRG	5.00E-05 H	Compressor, Motor-Driven, Fails to run (Compressed Gas)	WSRC-TR-93-262, MDC-FR-G	3	L
MDC FSG	5.00E-03 N	Compressor, Motor-Driven, Fails to start (Compressed Gas)	WSRC-TR-93-262, MDC-FS-G	5	L
MDC LEG	3.00E-07 H	Compressor, Motor-Driven, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, MDC-LE-G	10	
MDC NSG	5.00E-03 N	Compressor, Motor-Driven, Fails to stop (Compressed Gas)	WSRC-TR-93-262, MDC-NS-G	5	
MDC OSG	1.00E-05 H	Compressor, Motor-Driven, Overspeed (Compressed Gas)	WSRC-TR-93-262, MDC-OS-G	5	
MDC REG	1.00E-08 H	Compressor, Motor-Driven, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, MDC-RE-G	30	
MDF FRH	3.00E-05 H	Fan/Blower, Motor-Driven, Fails to run (HVAC)	WSRC-TR-93-262, MDF-FR-H	3	

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Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
MDF FSH	5.00E-03 N	Fan/Blower, Motor-Driven, Fails to start (HVAC)	WSRC-TR-93-262, MDF-FS-H	5	L
MDF LEH	3.00E-07 H	Fan/Blower, Motor-Driven, Leakage (external) (HVAC)	WSRC-TR-93-262, MDF-LE-H	10	L
MDF NSH	5.00E-03 N	Fan/Blower, Motor-Driven, Fails to stop (HVAC)	WSRC-TR-93-262, MDF-NS-H	10	L
MDF OSH	5.00E-06 H	Fan/Blower, Motor-Driven, Overspeed (HVAC)	WSRC-TR-93-262, MDF-OS-H	10	L
MDF REH	1.00E-08 H	Fan/Blower, Motor-Driven, Rupture (external) (HVAC)	WSRC-TR-93-262, MDF-RE-H	30	L
MDG FRE	3.00E-05 H	Generator, Motor-Driven (ac to dc), Fails to run (Electric Power)	WSRC-TR-93-262, MDG-FR-E	10	L
MDG FSE	1.00E-05 H	Generator, Motor-Driven (ac to dc), Fails to start (Electric Power)	WSRC-TR-93-262, MDG-FS-E	10	L
MDP FRC	1.00E-04 H	Pump, Motor-Driven, Fails to run (Chemical)	WSRC-TR-93-262, MDP-FR-C	10	L
MDP FRW	3.00E-05 H	Pump, Motor-Driven, Fails to run (Water)	WSRC-TR-93-262, MDP-FR-W	10	L
MDP FSC	1.00E-02 N	Pump, Motor-Driven, Fails to start (Chemical)	WSRC-TR-93-262, MDP-FS-C	10	L
MDP FSW	3.00E-03 N	Pump, Motor-Driven, Fails to start (Water)	WSRC-TR-93-262, MDP-FS-W	5	L
MDP LEC	1.00E-06 H	Pump, Motor-Driven, Leakage (external) (Chemical)	WSRC-TR-93-262, MDP-LE-C	10	L
MDP LEW	3.00E-08 H	Pump, Motor-Driven, Leakage (external) (Water)	WSRC-TR-93-262, MDP-LE-W	10	L
MDP NSC	1.00E-02 N	Pump, Motor-Driven, Fails to stop (Chemical)	WSRC-TR-93-262, MDP-NS-C	10	L
MDP NSW	3.00E-03 N	Pump, Motor-Driven, Fails to stop (Water)	WSRC-TR-93-262, MDP-NS-W	5	L
MDP OSC	3.00E-05 H	Pump, Motor-Driven, Overspeed (Chemical)	WSRC-TR-93-262, MDP-OS-C	10	L
MDP OSW	5.00E-06 H	Pump, Motor-Driven, Overspeed (Water)	WSRC-TR-93-262, MDP-OS-W	10	L
MDP REC	5.00E-08 H	Pump, Motor-Driven, Rupture (external) (Chemical)	WSRC-TR-93-262, MDP-RE-C	30	L
MDP REW	1.00E-09 H	Pump, Motor-Driven, Rupture (external) (Water)	WSRC-TR-93-262, MDP-RE-W	30	L
MIX FAC	5.00E-06 H	Mixer/Blender, Failure (Chemical)	WSRC-TR-93-262, MIX-FA-C	10	L
MOD CCH	3.00E-02 N	Damper (Standby or Safety), Motor-Operated, Fails to open/close (HVAC)	WSRC-TR-93-262, MOD-CC-H	10	L
MOD COH	3.00E-06 H	Damper (Standby or Safety), Motor-Operated, Spurious operation (HVAC)	WSRC-TR-93-262, MOD-CO-H	10	
MOD LEH	1.00E-07 H	Damper (Standby or Safety), Motor-Operated, Leakage (external) (HVAC)	WSRC-TR-93-262, MOD-LE-H	10	
MOD LIH	1.00E-05 H	Damper (Standby or Safety), Motor-Operated, Leakage (internal) (HVAC)	WSRC-TR-93-262, MOD-LI-H	10	
MOD OCH	3.00E-06 H	Damper (Standby or Safety), Motor-Operated, Spurious operation (HVAC)	WSRC-TR-93-262, MOD-OC-H	10	
MOD OOH	3.00E-02 N	Damper (Standby or Safety), Motor-Operated, Fails to open/close (HVAC)	WSRC-TR-93-262, MOD-OO-H	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
MOD PGH	5.00E-07 H	Damper (Standby or Safety), Motor-Operated, Plugs (HVAC)	WSRC-TR-93-262, MOD-PG-H	10	L
MOD REH	5.00E-09 H	Damper (Standby or Safety), Motor-Operated, Rupture (external) (HVAC)	WSRC-TR-93-262, MOD-RE-H	30	L
MOD RIH	5.00E-07 H	Damper (Standby or Safety), Motor-Operated, Rupture (internal) (HVAC)	WSRC-TR-93-262, MOD-RI-H	10	L
MOV CCC	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, MOV-CC-C	10	L
MOV CCG	1.00E-02 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, MOV-CC-G	10	L
MOV CCW	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Water)	WSRC-TR-93-262, MOV-CC-W	5	L
MOV COC	3.00E-07 H	Valve (Standby or Safety), Motor-Operated, Spurious operation (Chemical)	WSRC-TR-93-262, MOV-CO-C	10	L
MOV COG	3.00E-07 H	Valve (Standby or Safety), Motor-Operated, Spurious operation (Compressed Gas)	WSRC-TR-93-262, MOV-CO-G	10	L
MOV COW	3.00E-07 H	Valve (Standby or Safety), Motor-Operated, Spurious operation (Water)	WSRC-TR-93-262, MOV-CO-W	5	L
MOV FTC G	3.0E-03N	Gang valve fails to close	WSRC-TR-93-262, page 16, MOV-OO-C, Mortor operated valve fails to close		
MOV LEC	5.00E-07 H	Valve (Standby or Safety), Motor-Operated, Leakage (external) (Chemical)	WSRC-TR-93-262, MOV-LE-C	10	L
MOV LEG	1.00E-07 H	Valve (Standby or Safety), Motor-Operated, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, MOV-LE-G	10	L
MOV LEW	1.00E-08 H	Valve (Standby or Safety), Motor-Operated, Leakage (external) (Water)	WSRC-TR-93-262, MOV-LE-W	10	L
MOV LIC	1.00E-06 H	Valve (Standby or Safety), Motor-Operated, Leakage (internal) (Chemical)	WSRC-TR-93-262, MOV-LI-C	10	L
MOV LIG	1.00E-05 H	Valve (Standby or Safety), Motor-Operated, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, MOV-LI-G	10	
MOV LIW	1.00E-06 H	Valve (Standby or Safety), Motor-Operated, Leakage (internal) (Water)	WSRC-TR-93-262, MOV-LI-W	10	
MOV OCC	3.00E-07 H	Valve (Standby or Safety), Motor-Operated, Spurious operation (Chemical)	WSRC-TR-93-262, MOV-OC-C	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
MOV OCG	3.00E-07 H	Valve (Standby or Safety), Motor-Operated, Spurious operation (Compressed Gas)	WSRC-TR-93-262, MOV-OC-G	10	L
MOV OCW	3.00E-07 H	Valve (Standby or Safety), Motor-Operated, Spurious operation (Water)	WSRC-TR-93-262, MOV-OC-W	5	L
MOV OOC	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, MOV-OO-C	10	L
MOV OOG	1.00E-02 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, MOV-OO-G	10	L
MOV OOW	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Water)	WSRC-TR-93-262, MOV-OO-W	5	L
MOV PGC	5.00E-08 H	Valve (Standby or Safety), Motor-Operated, Plugs (Chemical)	WSRC-TR-93-262, MOV-PG-C	10	L
MOV PGG	5.00E-07 H	Valve (Standby or Safety), Motor-Operated, Plugs (Compressed Gas)	WSRC-TR-93-262, MOV-PG-G	10	L
MOV PGW	5.00E-08 H	Valve (Standby or Safety), Motor-Operated, Plugs (Water)	WSRC-TR-93-262, MOV-PG-W	10	L
MOV REC	3.00E-08 H	Valve (Standby or Safety), Motor-Operated, Rupture (external) (Chemical)	WSRC-TR-93-262, MOV-RE-C	30	L
MOV REG	5.00E-09 H	Valve (Standby or Safety), Motor-Operated, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, MOV-RE-G	30	L
MOV REW	5.00E-10 H	Valve (Standby or Safety), Motor-Operated, Rupture (external) (Water)	WSRC-TR-93-262, MOV-RE-W	30	L
MOV RIC	5.00E-08 H	Valve (Standby or Safety), Motor-Operated, Rupture (internal) (Chemical)	WSRC-TR-93-262, MOV-RI-C	10	L
MOV RIG	5.00E-07 H	Valve (Standby or Safety), Motor-Operated, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, MOV-RI-G	30	L
MOV RIW	5.00E-08 H	Valve (Standby or Safety), Motor-Operated, Rupture (internal) (Water)	WSRC-TR-93-262, MOV-RI-W	30	L
MRA FRE	5.00E-06 H	Motor, AC, Fails to run (Electric Power)	WSRC-TR-93-262, MRA-FR-E	[illegible]	[illegible]
MRA FSE	3.00E-04 N	Motor, AC, Fails to start (Electric Power)	WSRC-TR-93-262, MRA-FS-E	[illegible]	[illegible]
MRD FRE	1.00E-05 H	Motor, DC, Fails to run (Electric Power)	WSRC-TR-93-262, MRD-FR-E	3	[illegible]
MRD FSE	3.00E-04 N	DC Motor, DC, Fails to start (Electric Power)	WSRC-TR-93-262, MRD-FS-E	3	[illegible]
MTE FAH	1.00E-04 H	Mist Eliminator, Failure (HVAC)	WSRC-TR-93-262, MTE-FA-H	10	[illegible]
NCW BFL A	1.0E-05H	"Normal" Cooling Water Fails at Header Level	DPSTSY-200-1F	-	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
NIC FAI	1.00E-05 H	Sensor/Transmit./, Transdu./Proc. Sw., Nitro. Conc., Failure (Instr. & Control)	WSRC-TR-93-262, NIC-FA-I	3	L
OPR AAH	1.0E-5 N	Single vehicle accident (per mile) (High)	WSRC-TR-93-581, Table 4, Item 23, High	10	L
OPR AAL	1.0E-7 N	Single vehicle accident (per mile)	WSRC-TR-93-581, Table 4, Item 23, Low	10	L
OPR AAN	1.0E-6 N	Single vehicle accident (per mile) (Nominal)	WSRC-TR-93-581, Table 4, Item 23, Nominal	10	L
OPR ACH	5.0E-2 N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High	5	L
OPR ACH A	5.0E-2N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High		
OPR ACL	5.0E-4 N	Failure of Administrative Control	WSRC-TR-93-581, Table 4, Item 1, Low	10	L
OPR ACL A	5.0E-4N	Failure of Administrative Control	WSRC-TR-93-581, Table 4, Item 1, Low		
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR ACN A	5.0E-3N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal		
OPR AMH	1.0E-5 N	Vehicle collision with another moving vehicle (per mile) (High)	WSRC-TR-93-581, Table 4, Item 24, High	10	L
OPR AML	1.0E-7 N	Vehicle collision with another moving vehicle (per mile)	WSRC-TR-93-581, Table 4, Item 24, Low	10	L
OPR AMN	1.0E-6 N	Vehicle collision with another moving vehicle (per mile) (Nominal)	WSRC-TR-93-581, Table 4, Item 24, Nominal	10	L
OPR AOH	1.0E-5 N	Vehicle collision with stationary object (per mile) (High)	WSRC-TR-93-581, Table 4, Item 22, High	10	L
OPR AOL	1.0E-7 N	Vehicle collision with stationary object (per mile)	WSRC-TR-93-581, Table 4, Item 22, Low	10	L
OPR AON	1.0E-6 N	Vehicle collision with stationary object (per mile) (Nominal)	WSRC-TR-93-581, Table 4, Item 22, Nominal	10	L
OPR ARH	1.0E-1 N	Failure of long-term accident recovery (High)	WSRC-TR-93-581, Table 4, Item 35, High	3	L
OPR ARL	3.0E-5 N	Failure of long-term accident recovery	WSRC-TR-93-581, Table 4, Item 35, Low	10	L
OPR ARN	3.0E-3 N	Failure of long-term accident recovery (Nominal)	WSRC-TR-93-581, Table 4, Item 35, Nominal	10	L
OPR CAH	3.0E-2 N	Chemical addition or elution error (High)	WSRC-TR-93-581, Table 4, Item 16, High	5	L
OPR CAL	3.0E-4 N	Chemical addition or elution error	WSRC-TR-93-581, Table 4, Item 16, Low	10	L
OPR CAN	3.0E-3 N	Chemical addition or elution error (Nominal)	WSRC-TR-93-581, Table 4, Item 16, Nominal	10	L
OPR CDH	1.0E-3 N	Dropping of load when using crane/hoist (per operation) (High)	WSRC-TR-93-581, Table 4, Item 27, High	10	L
OPR CDL	3.0E-5 N	Dropping of load when using crane/hoist (per operation)	WSRC-TR-93-581, Table 4, Item 27, Low	10	
OPR CDN	1.0E-4 N	Dropping of load when using crane/hoist (per operation) (Nominal)	WSRC-TR-93-581, Table 4, Item 27, Nominal	10	
OPR CEH	5.0E-1 N	Communication error (High)	WSRC-TR-93-581, Table 4, Item 7, High	2	
OPR CEL	1.0E-3 N	Communication error	WSRC-TR-93-581, Table 4, Item 7, Low	10	
OPR CEN	5.0E-2 N	Communication error (Nominal)	WSRC-TR-93-581, Table 4, Item 7, Nominal	5	
OPR CEN A	5.0E-2N	Communication error (Nominal)	WSRC-TR-93-581, Table 4, Item 7, Nominal		
OPR COH	3.0E-3 N	Crane/hoist strikes stationary object (per operation) (High)	WSRC-TR-93-581, Table 4, Item 28, High	10	
OPR COL	3.0E-5 N	Crane/hoist strikes stationary object (per operation)	WSRC-TR-93-581, Table 4, Item 28, Low	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
OPR CON	3.0E-4 N	Crane/hoist strikes stationary object (per operation) (Nominal)	WSRC-TR-93-581, Table 4, Item 28, Nominal	10	L
OPR CSH	1.0E-1 N	Failure to respond to compelling signal (High)	WSRC-TR-93-581, Table 4, Item 2, High	3	L
OPR CSL	3.0E-3 N	Failure to respond to compelling signal	WSRC-TR-93-581, Table 4, Item 2, Low	10	L
OPR CSL A	3.0E-3N	Failure to respond to compelling signal	WSRC-TR-93-581, Table 4, Item 2, Low		
OPR CSN	1.0E-2 N	Failure to respond to compelling signal (Nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal	5	L
OPR CSN A	1.0E-2N	Failure to respond to compelling signal (Nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal		
OPR CVH	3.0E-1 N	Checker verification error (High)	WSRC-TR-93-581, Table 4, Item 8, High	3	L
OPR CVL	1.0E-2 N	Checker verification error	WSRC-TR-93-581, Table 4, Item 8, Low	5	L
OPR CVL A	1.0E-2N	Checker verification error	WSRC-TR-93-581, Table 4, Item 8, Low		
OPR CVN	1.0E-1 N	Checker verification error (Nominal)	WSRC-TR-93-581, Table 4, Item 8, Nominal	3	L
OPR CVN A	1.0E-1N	Checker verification error (Nominal)	WSRC-TR-93-581, Table 4, Item 8, Nominal		
OPR DEH	1.0E-1 N	Diagnosis error (High)	WSRC-TR-93-581, Table 4, Item 30, High	3	L
OPR DEH A	1.0E-1N	Diagnosis error (High)	WSRC-TR-93-581, Table 4, Item 30, High		
OPR DEL	1.0E-3 N	Diagnosis error	WSRC-TR-93-581, Table 4, Item 30, Low	10	L
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR DFH	5.0E-4 N	Dropping of load when using forklift (per operation) (High)	WSRC-TR-93-581, Table 4, Item 25, High	10	L
OPR DFL	1.0E-5 N	Dropping of load when using forklift (per operation)	WSRC-TR-93-581, Table 4, Item 25, Low	10	L
OPR DFN	5.0E-5 N	Dropping of load when using forklift (per operation) (Nominal)	WSRC-TR-93-581, Table 4, Item 25, Nominal	10	L
OPR EEH	1.0E-1 N	Excavation error (per excavation) (High)	WSRC-TR-93-581, Table 4, Item 29, High	3	L
OPR EEL	1.0E-3 N	Excavation error (per excavation)	WSRC-TR-93-581, Table 4, Item 29, Low	10	L
OPR EEN	1.0E-2 N	Excavation error (per excavation) (Nominal)	WSRC-TR-93-581, Table 4, Item 29, Nominal	5	L
OPR FMH	5.0E-1 N	Failure of manual fire (High)	WSRC-TR-93-581, Table 4, Item 32, High	2	L
OPR FML	1.0E-2 N	Failure of manual fire	WSRC-TR-93-581, Table 4, Item 32, Low	5	L
OPR FMN	1.0E-1 N	Failure of manual fire (Nominal)	WSRC-TR-93-581, Table 4, Item 32, Nominal	3	L
OPR FNH	3.0E-1 N	Failure of manual Fire Suppression by non-occupant (High)	WSRC-TR-93-581, Table 4, Item 34, High	3	L
OPR FNL	3.0E-2 N	Failure of manual Fire Suppression by non-occupant (Low)	WSRC-TR-93-581, Table 4, Item 34, Low	5	L
OPR FNN	1.0E-1 N	Failure of manual Fire Suppression by non-occupant (Nominal)	WSRC-TR-93-581, Table 4, Item 34, Nominal	3	L
OPR FOH	5.0E-1 N	Failure of manual fire suppression by occupant (High)	WSRC-TR-93-581, Table 4, Item 33, High		
OPR FOL	1.0E-1 N	Failure of manual fire suppression by occupant	WSRC-TR-93-581, Table 4, Item 33, Low		
OPR FON	3.0E-1 N	Failure of manual fire suppression by occupant (Nominal)	WSRC-TR-93-581, Table 4, Item 33, Nominal	3	L
OPR ILH	3.0E-2 N	Incorrect labeling or tagging (High)	WSRC-TR-93-581, Table 4, Item 10, High	5	L
OPR ILL	1.0E-3 N	Incorrect labeling or tagging	WSRC-TR-93-581, Table 4, Item 10, Low	10	L
OPR ILN	5.0E-3 N	Incorrect labeling or tagging (Nominal)	WSRC-TR-93-581, Table 4, Item 10, Nominal	10	L
OPR ILN A	5.0E-3N	Incorrect labeling or tagging (Nominal)	WSRC-TR-93-581, Table 4, Item 10, Nominal		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate		Description	Source	EF	D
OPR IRH	5.0E-1	N	Incorrect reading or recording of data (High)	WSRC-TR-93-581, Table 4, Item 11, High	2	L
OPR IRL	3.0E-3	N	Incorrect reading or recording of data	WSRC-TR-93-581, Table 4, Item 11, Low	10	L
OPR IRN	1.0E-2	N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal	5	L
OPR IRN A	1.0E-2	N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal		
OPR LAH	1.0E-3	N	Laboratory analysis error (High)	WSRC-TR-93-581, Table 4, Item 19, High	10	L
OPR LAL	3.0E-5	N	Laboratory analysis error	WSRC-TR-93-581, Table 4, Item 19, Low	10	L
OPR LAN	3.0E-4	N	Laboratory analysis error (Nominal)	WSRC-TR-93-581, Table 4, Item 19, Nominal	10	L
OPR LAN A	3.0E-4	N	Laboratory analysis error (Nominal)	WSRC-TR-93-581, Table 4, Item 19, Nominal		
OPR LOH	5.0E-3	N	Failure to lock out (High)	WSRC-TR-93-581, Table 4, Item 15, High	10	L
OPR LOL	1.0E-4	N	Failure to lock out	WSRC-TR-93-581, Table 4, Item 15, Low	10	L
OPR LON	5.0E-4	N	Failure to lock out (Nominal)	WSRC-TR-93-581, Table 4, Item 15, Nominal	10	L
OPR MCH	3.0E-2	N	Miscalibration (High)	WSRC-TR-93-581, Table 4, Item 12, High	5	L
OPR MCH A	3.0E-2	N	Miscalibration (High)	WSRC-TR-93-581, Table 4, Item 12, High		
OPR MCL	3.0E-3	N	Miscalibration	WSRC-TR-93-581, Table 4, Item 12, Low	10	L
OPR MCN	5.0E-3	N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	L
OPR MCN A	5.0E-3	N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal		
OPR NCH	1.0E-1	N	Failure to verify parameter with calculation (High)	WSRC-TR-93-581, Table 4, Item 20, High	3	L
OPR NCL	5.0E-3	N	Failure to verify parameter with calculation	WSRC-TR-93-581, Table 4, Item 20, Low	10	L
OPR NCN	3.0E-2	N	Failure to verify parameter with calculation (Nominal)	WSRC-TR-93-581, Table 4, Item 20, Nominal	5	L
OPR OVH	5.0E-5	H	Overfilling of a tank (per Tank) (High)	WSRC-TR-93-581, Table 4, Item 18, High	10	L
OPR OVL	5.0E-7	H	Overfilling of a tank (per Tank)	WSRC-TR-93-581, Table 4, Item 18, Low	10	L
OPR OVN	5.0E-6	H	Overfilling of a tank (per Tank) (Nominal)	WSRC-TR-93-581, Table 4, Item 18, Nominal	10	L
OPR PFH	3.0E-4	N	Puncturing of load when using forklift (per operation) (High)	WSRC-TR-93-581, Table 4, Item 26, High	10	L
OPR PFL	5.0E-6	N	Puncturing of load when using forklift (per operation)	WSRC-TR-93-581, Table 4, Item 26, Low	10	L
OPR PFN	3.0E-5	N	Puncturing of load when using forklift (per operation) (Nominal)	WSRC-TR-93-581, Table 4, Item 26, Nominal	10	L
OPR RAH	5.0E-5	H	Random actuation/ shutdown of system (High)	WSRC-TR-93-581, Table 4, Item 21, High	10	L
OPR RAL	5.0E-7	H	Random actuation/ shutdown of system	WSRC-TR-93-581, Table 4, Item 21, Low	10	L
OPR RAN	5.0E-6	H	Random actuation/ shutdown of system (Nominal)	WSRC-TR-93-581, Table 4, Item 21, Nominal	10	
OPR RMH	5.0E-2	N	Failure to restore following maintenance (High)	WSRC-TR-93-581, Table 4, Item 14, High	5	
OPR RML	3.0E-3	N	Failure to restore following maintenance	WSRC-TR-93-581, Table 4, Item 14, Low	10	
OPR RMN	5.0E-3	N	Failure to restore following maintenance (Nominal)	WSRC-TR-93-581, Table 4, Item 14, Nominal	10	
OPR RMN A	5.0E-3	N	Failure to restore following maintenance (Nominal)	WSRC-TR-93-581, Table 4, Item 14, Nominal		
OPR RTH	3.0E-2	N	Failure to restore following test (High)	WSRC-TR-93-581, Table 4, Item 13, High	5	
OPR RTL	5.0E-3	N	Failure to restore following test	WSRC-TR-93-581, Table 4, Item 13, Low	10	L

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
OPR RTN	1.0E-2 N	Failure to restore following test (Nominal)	WSRC-TR-93-581, Table 4, Item 13, Nominal	5	L
OPR SOH	5.0E-2 N	Error in selecting control outside control room (High)	WSRC-TR-93-581, Table 4, Item 6, High	5	L
OPR SOL	3.0E-3 N	Error in selecting control outside control room	WSRC-TR-93-581, Table 4, Item 6, Low	10	L
OPR SON	1.0E-2 N	Error in selecting control outside control room (Nominal)	WSRC-TR-93-581, Table 4, Item 6, Nominal	5	L
OPR SON A	1.0E-2N	Error in selecting control outside control room (Nominal)	WSRC-TR-93-581, Table 4, Item 6, Nominal		
OPR SRH	3.0E-2 N	Error in selecting control within control room (High)	WSRC-TR-93-581, Table 4, Item 5, High	5	L
OPR SRH A	3.0E-2N	Error in selecting control within control room (High)	WSRC-TR-93-581, Table 4, Item 5, High		
OPR SRL	1.0E-3 N	Error in selecting control within control room	WSRC-TR-93-581, Table 4, Item 5, Low	10	L
OPR SRL A	1.0E-3N	Error in selecting control within control room	WSRC-TR-93-581, Table 4, Item 5, Low		
OPR SRN	1.0E-2 N	Error in selecting control within control room (Nominal)	WSRC-TR-93-581, Table 4, Item 5, Nominal	5	L
OPR SVH	5.0E-1 N	Supervisor verification error (High)	WSRC-TR-93-581, Table 4, Item 9, High	2	L
OPR SVL	1.0E-1 N	Supervisor verification error	WSRC-TR-93-581, Table 4, Item 9, Low	3	L
OPR SVL A	1.0E-1N	Supervisor verification error	WSRC-TR-93-581, Table 4, Item 9, Low		
OPR SVN	3.0E-1 N	Supervisor verification error (Nominal)	WSRC-TR-93-581, Table 4, Item 9, Nominal	3	L
OPR SVN A	3.0E-1N	Supervisor verification error (Nominal)	WSRC-TR-93-581, Table 4, Item 9, Nominal		
OPR TEH	3.0E-5 H	Transfer error (per Tank) (High)	WSRC-TR-93-581, Table 4, Item 17, High	10	L
OPR TEH A	3.0E-5H	Transfer error (per Tank) (High)	WSRC-TR-93-581, Table 4, Item 17, High		
OPR TEL	3.0E-7 H	Transfer error (per Tank)	WSRC-TR-93-581, Table 4, Item 17, Low	10	L
OPR TEN	3.0E-6 H	Transfer error (per Tank) (Nominal)	WSRC-TR-93-581, Table 4, Item 17, Nominal	10	L
OPR VIH	5.0E-1 N	Failure of visual inspection (High)	WSRC-TR-93-581, Table 4, Item 31, High	2	L
OPR VIL	1.0E-2 N	Failure of visual inspection	WSRC-TR-93-581, Table 4, Item 31, Low	5	L
OPR VIN	1.0E-1 N	Failure of visual inspection (Nominal)	WSRC-TR-93-581, Table 4, Item 31, Nominal	3	L
OPR VIN A	1.0E-1N	Failure of visual inspection (Nominal)	WSRC-TR-93-581, Table 4, Item 31, Nominal		
OPR VOH	1.0E-1 N	Failure to verify outside control room (High)	WSRC-TR-93-581, Table 4, Item 4, High	3	L
OPR VOH A	1.0E-1N	Failure to verify outside control room (High)	WSRC-TR-93-581, Table 4, Item 4, High		
OPR VOL	1.0E-2 N	Failure to verify outside control room	WSRC-TR-93-581, Table 4, Item 4, Low		
OPR VON	3.0E-2 N	Failure to verify outside control room (Nominal)	WSRC-TR-93-581, Table 4, Item 4, Nominal		
OPR VRH	5.0E-2 N	Failure to verify within control room (High)	WSRC-TR-93-581, Table 4, Item 3, High		
OPR VRH A	5.0E-2N	Failure to verify within control room (High)	WSRC-TR-93-581, Table 4, Item 3, High		
OPR VRL	3.0E-3 N	Failure to verify within control room	WSRC-TR-93-581, Table 4, Item 3, Low	10	
OPR VRN	1.0E-2 N	Failure to verify within control room (Nominal)	WSRC-TR-93-581, Table 4, Item 3, Nominal	5	
OPR VRN A	1.0E-2N	Failure to verify within control room (Nominal)	WSRC-TR-93-581, Table 4, Item 3, Nominal		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
ORF PGC	1.00E-06 H	Orifice, Plugs (Chemical)	WSRC-TR-93-262, ORF-PG-C	10	L
ORF PGG	1.00E-06 H	Orifice, Plugs (Compressed Gas)	WSRC-TR-93-262, ORF-PG-G	10	L
ORF PGW	1.00E-06 H	Orifice, Plugs (Water)	WSRC-TR-93-262, ORF-PG-W	3	L
OXC FAI	1.00E-05 H	Sensor/Transmitter/, Transducer/Proc. Sw., O2 Conc., Failure (Instr. & Control)	WSRC-TR-93-262, OXC-FA-I	10	L
PCP FAH	5.00E-05 H	Precipitator, Failure (HVAC)	WSRC-TR-93-262, PCP-FA-H	10	L
PDE FLO A	3.0E-06H	Differential Pressure Sensor Fails	WSRC-TR-93-262, page 30, DPS-FA-I, Differential Pressure Sensor Failure		
PDE PLG A	1.0E-08H	Differential Pressure Instrument Line Plugs (per foot)	WSRC-TR-93-262, page 22, TUB-PG-G, Tube Plugs		
PE- BFL G	1.0E-06H	Pressure Sensor Failure	WSRC-TR-93-262, page 30, PST-FA-I, Pressure Sensor Failure		
PER 001 A	.01N	1% chance			
PER 001 G	1.0E-03N	Probability of occurrence	Prob of occurrence = (2/yr)/ (12 batches/day * 5 days/week * 35 weeks/yr)		
PER 002 G	2.0E-03N	Probability of occurrence	= 1 / (100 batches/yr * 5 yrs)		
PER 003 G	3.0E-03N	Probability of occurrence	= 1 / (100 batches/yr * 3 yrs)		
PER 005 G	5.0E-03N	Probability of occurrence	= 1 / (100 batches/yr * 2 yrs)		
PER 006 A	.06N	6% chance			
PER 010 A	.1N	10% chance			
PER 038 A	0.38N	38 % chance	Probability of occurrence		
PER 045 A	.45N	45% chance	databank uncontrolled reactions caused intentional add'n (90%)/2		
PER 090 A	.9N	90% chance			
PER HLF A	5E-3N	one half of one percent chance	prob. of occurrence		
PER HUN A	1.0N	One Hundred Percent Chance (It Occurs)	Probability of Occurrence		
PER ONE A	1.0E-02N	1% of time	Probability of occurrence		
PER SMP A	.45N	percentage uncontrolled rxn caused by leaks to sump	databank uncontrolled reactions caused intentional add'n (90%)/2		
PER TEN A	0.1N	Ten Percent Chance	Probability of Occurrence		
PER THE A	0.38N	38 %	Probability of occurrence		
PER TWE A	2.0E-01N	Twenty Percent Chance	Probability of Occurrence		
PER TWF G	0.25N	25%	COG		
PER TWO A	0.02N	Two Percent Chance	Probability of Occurrence		
PER VLV A	.1N	percentage uncontrolled rxn caused by valving errors	databank uncontrolled reactions caused by unintentional add'ns in rerun		
PIP LEC	3.00E-09 H	Piping, Leakage (external) (Chemical)	WSRC-TR-93-262, PIP-LE-C	10	L
PIP LEG	3.00E-08 H	Piping, Leakage (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, PIP-LE-G	10	
PIP LEW	3.00E-09 H	Piping, Leakage (external) (per ft.) (Water)	WSRC-TR-93-262, PIP-LE-W	10	
PIP LKS G	3.0E-09H	Piping Leaks (per foot)	WSRC-TR-93-262, page 18, PIP-LE-C, Piping, Leakage		
PIP PFW	1.00E-10 H	Piping, Plugs (per ft.) (Water)	WSRC-TR-93-262, PIP-PF-W	30	
PIP PGC	1.00E-10 H	Piping, Plugs (Chemical)	WSRC-TR-93-262, PIP-PG-C	30	
PIP PGG	1.00E-09 H	Piping, Plugs (per ft.) (Compressed Gas)	WSRC-TR-93-262, PIP-PG-G	30	
PIP REC	1.00E-10 H	Piping, Rupture (external) (Chemical)	WSRC-TR-93-262, PIP-RE-C	30	
PIP REG	1.00E-09 H	Piping, Rupture (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, PIP-RE-G	30	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
PIP REW	1.00E-10 H	Piping, Rupture (external) (per ft.) (Water)	WSRC-TR-93-262, PIP-RE-W	30	L
PLC FAI	3.00E-05 H	Programmable Logic Controller, Failure (Instr. & Control)	WSRC-TR-93-262, PLC-FA-I	10	L
PNV FCL A	1.0E-06H	Air-Operated Valve Fails Closed	WSRC-TR-93-262, page 12, AOV-CC-W, Air Operated Valve Spurious Operation		
PNV FCL G	3.0E-06H	Air-Operated Valve Fails Closed	WSRC-TR-93-262, page 13, CAV-FC-W, Air Operated Control Valve Fails Closed		
PNV FOP G	3.0E-06H	Air-Operated steam control valve fails open	WSRC-TR-93-262, page 13, CAV-FO-W, Air Operated Control Valve Fails Open		
PNV FTC G	1.0E-03N	Air-Operated Valve Fails to Open/Close	WSRC-TR-93-262, page 12, AOV-OO-W, Air Operated Valve Fails to Open/Close		
PNV LKS G	1.0E-06H	Air-Operated Valve Fails Has Through Leakage	WSRC-TR-93-262, page 12, AOV-LI-W, Air Operated Valve has Leakage (Internal)		
PST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Press., Failure (Instr. & Control)	WSRC-TR-93-262, PST-FA-I	3	L
RAH SPR G	5.0E-06H	SPURIOUS ALARM FAILURE	WSRC-TR-93-262, page 30, ALR-SO-I, Alarm/Annunciator Fails to AlarmInternal)		
RAH SPR S	5.0E-06H	SPURIOUS ALARM FAILURE	WSRC-TR-93-262, page 30, ALR-SO-I, Alarm/Annunciator Fails to AlarmInternal)		
RCT FAE	1.00E-05 H	Charger, Rectifier, Failure (Electric Power)	WSRC-TR-93-262, RCT-FA-E	3	L
REC FAI	3.00E-05 H	Recorder, Failure (Instr. & Control)	WSRC-TR-93-262, REC-FA-I	30	L
RLC CCE	1.00E-04 N	Relay, Control, Fails to open/close (Electric Power)	WSRC-TR-93-262, RLC-CC-E	10	L
RLC COE	3.00E-07 H	Relay, Control, Spurious operation (Electric Power)	WSRC-TR-93-262, RLC-CO-E	30	L
RLC NRE	1.00E-04 N	Relay, Control, Fails to open/close (Electric Power)	WSRC-TR-93-262, RLC-NR-E	10	L
RLC OCE	3.00E-07 H	Relay, Control, Spurious operation (Electric Power)	WSRC-TR-93-262, RLC-OC-E	30	L
RLC OOE	1.00E-04 N	Relay, Control, Fails to open/close (Electric Power)	WSRC-TR-93-262, RLC-OO-E	10	L
RLC SOE	3.00E-07 H	Relay, Control, Spurious operation (Electric Power)	WSRC-TR-93-262, RLC-SO-E	30	L
RLP CCE	1.00E-03 N	Relay, Protective, Fails to open/close (Electric Power)	WSRC-TR-93-262, RLP-CC-E	10	L
RLP COE	1.00E-07 H	Relay, Protective, Spurious operation (Electric Power)	WSRC-TR-93-262, RLP-CO-E	10	
RLP NRE	1.00E-03 N	Relay, Protective, Fails to open/close (Electric Power)	WSRC-TR-93-262, RLP-NR-E	10	
RLP OCE	1.00E-07 H	Relay, Protective, Spurious operation (Electric Power)	WSRC-TR-93-262, RLP-OC-E	10	
RLP OOE	1.00E-03 N	Relay, Protective, Fails to open/close (Electric Power)	WSRC-TR-93-262, RLP-OO-E	10	
RLP SOE	1.00E-07 H	Relay, Protective, Spurious operation (Electric Power)	WSRC-TR-93-262, RLP-SO-E	10	
RST FAI	5.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Radiation, Failure (Instr. & Contr.)	WSRC-TR-93-262, RST-FA-I	5	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
RTB CCE	5.00E-03 N	Circuit Breaker, Reactor Trip, Fails to open (Electric Power)	WSRC-TR-93-262, RTB-CC-E	5	L
RTB COE	3.00E-06 H	Circuit Breaker, Reactor Trip, Spurious operation (Electric Power)	WSRC-TR-93-262, RTB-CO-E	10	L
SAM BFL A	1.00E-05H	Sampler Failure	WSRC-TR-93-262, Page 30, SAM-FA-I, Sampler Failure		
SAM FAI	1.00E-05 H	Sampler, Failure (Instr. & Control)	WSRC-TR-93-262, SAM-FA-I	10	L
SBR FAH	1.00E-06 H	Scrubber, Failure (HVAC)	WSRC-TR-93-262, SBR-FA-H	10	L
SCR FAI	3.00E-07 H	Modifier/Signal Conditioner, Failure (Instr. & Control)	WSRC-TR-93-262, SCR-FA-I	3	L
SET FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Seismic, Failure (Instr. & Control)	WSRC-TR-93-262, SET-FA-I	5	L
SJ- PRE D	1.19E-2H	transfer to tank req	2/wk est		
SJ- PRE S	1.19E-2H	transfer to tank req	2/wk est		
SOV CCC	1.00E-03 N	Valve (Standby or Safety), Solenoid-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, SOV-CC-C	10	L
SOV CCG	3.00E-03 N	Valve (Standby or Safety), Solenoid-Oper., Fails to open/close (Compressed Gas)	WSRC-TR-93-262, SOV-CC-G	10	L
SOV CCW	1.00E-03 N	Valve (Standby or Safety), Solenoid--Operated, Fails to open/close (Water)	WSRC-TR-93-262, SOV-CC-W	10	L
SOV COC	5.00E-07 H	Valve (Standby or Safety), Solenoid-Operated, Spurious operation (Chemical)	WSRC-TR-93-262, SOV-CO-C	10	L
SOV COG	5.00E-07 H	Valve (Standby or Safety), Solenoid-Oper., Spurious operation (Compressed Gas)	WSRC-TR-93-262, SOV-CO-G	10	L
SOV COW	5.00E-07 H	Valve (Standby or Safety), Solenoid--Operated, Spurious operation (Water)	WSRC-TR-93-262, SOV-CO-W	10	L
SOV LEC	5.00E-07 H	Valve (Standby or Safety), Solenoid-Operated, Leakage (external) (Chemical)	WSRC-TR-93-262, SOV-LE-C	10	L
SOV LEG	1.00E-07 H	Valve (Standby or Safety), Solenoid-Oper., Leakage (external) (Compressed Gas)	WSRC-TR-93-262, SOV-LE-G	10	L
SOV LEW	1.00E-08 H	Valve (Standby or Safety), Solenoid--Operated, Leakage (external) (Water)	WSRC-TR-93-262, SOV-LE-W	10	
SOV LIC	1.00E-06 H	Valve (Standby or Safety), Solenoid-Operated, Leakage (internal) (Chemical)	WSRC-TR-93-262, SOV-LI-C	10	
SOV LIG	1.00E-05 H	Valve (Standby or Safety), Solenoid-Oper., Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, SOV-LI-G	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
SOV LIW	1.00E-06 H	Valve (Standby or Safety), Solenoid--Operated, Leakage (internal) (Water)	WSRC-TR-93-262, SOV-LI-W	10	L
SOV OCC	5.00E-07 H	Valve (Standby or Safety), Solenoid-Operated, Spurious operation (Chemical)	WSRC-TR-93-262, SOV-OC-C	10	L
SOV OCG	5.00E-07 H	Valve (Standby or Safety), Solenoid-Oper., Spurious operation (Compressed Gas)	WSRC-TR-93-262, SOV-OC-G	10	L
SOV OCW	5.00E-07 H	Valve (Standby or Safety), Solenoid--Operated, Spurious operation (Water)	WSRC-TR-93-262, SOV-OC-W	10	L
SOV OOC	1.00E-03 N	Valve (Standby or Safety), Solenoid-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, SOV-OO-C	10	L
SOV OOG	3.00E-03 N	Valve (Standby or Safety), Solenoid-Oper., Fails to open/close (Compressed Gas)	WSRC-TR-93-262, SOV-OO-G	10	L
SOV OOW	1.00E-03 N	Valve (Standby or Safety), Solenoid--Operated, Fails to open/close (Water)	WSRC-TR-93-262, SOV-OO-W	10	L
SOV PGC	5.00E-08 H	Valve (Standby or Safety), Solenoid-Operated, Plugs (Chemical)	WSRC-TR-93-262, SOV-PG-C	10	L
SOV PGG	5.00E-07 H	Valve (Standby or Safety), Solenoid-Oper., Plugs (Compressed Gas)	WSRC-TR-93-262, SOV-PG-G	10	L
SOV PGW	5.00E-08 H	Valve (Standby or Safety), Solenoid--Operated, Plugs (Water)	WSRC-TR-93-262, SOV-PG-W	10	L
SOV REC	3.00E-08 H	Valve (Standby or Safety), Solenoid-Operated, Rupture (external) (Chemical)	WSRC-TR-93-262, SOV-RE-C	30	L
SOV REG	5.00E-09 H	Valve (Standby or Safety), Solenoid-Oper., Rupture (external) (Compressed Gas)	WSRC-TR-93-262, SOV-RE-G	30	L
SOV REW	5.00E-10 H	Valve (Standby or Safety), Solenoid--Operated, Rupture (external) (Water)	WSRC-TR-93-262, SOV-RE-W	30	L
SOV RIC	5.00E-08 H	Valve (Standby or Safety), Solenoid-Operated, Rupture (internal) (Chemical)	WSRC-TR-93-262, SOV-RI-C	30	L
SOV RIG	5.00E-07 H	Valve (Standby or Safety), Solenoid-Oper., Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, SOV-RI-G	30	L
SOV RIW	5.00E-08 H	Valve (Standby or Safety), Solenoid--Operated, Rupture (internal) (Water)	WSRC-TR-93-262, SOV-RI-W	30	[illegible]
SPG BFL G	3.0E-06H	SPG transmitter spuriously signals (basic failure)	WSRC-TR-93-262, p.30 DPS-FA-I		
SPG FHI G	3.0E-06H	Density Instrumet (all failures)	WSRC-TR-93-262, page 30, DPS-FA-I		
SPG FLO G	3.0E-06H	DIFFERENTIAL PRESSURE INSTRUMENT FAILURE	WSRC-TR-93-262, page 30, DPS-FA-I		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
SPG LKS G	1.0E-08H	TUBE LEAKS (/HR-FT)	WSRC-TR-93-262, page 22, TUB-LE-G		
SPG PLG G	1.0E-06H	TUBE PLUGS (/HR-FT)	WSRC-TR-93-262, page 22, TUB-PG-G - 1.0E-08 * 100 (evap. plugs frequently)		
SRV CCC	3.00E-03 N	Valve (Standby or Safety), Safety/Relief, Fails to open (Chemical)	WSRC-TR-93-262, SRV-CC-C	10	L
SRV CCG	1.00E-02 N	Valve (Standby or Safety), Safety/Relief, Fails to open (Compressed Gas)	WSRC-TR-93-262, SRV-CC-G	10	L
SRV CCW	3.00E-03 N	Valve (Standby or Safety), Safety/Relief, Fails to open (Water)	WSRC-TR-93-262, SRV-CC-W	3	L
SRV LEC	5.00E-07 H	Valve (Standby or Safety), Safety/Relief, Leakage (external) (Chemical)	WSRC-TR-93-262, SRV-LE-C	10	L
SRV LEG	1.00E-07 H	Valve (Standby or Safety), Safety/Relief, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, SRV-LE-G	10	L
SRV LEW	1.00E-08 H	Valve (Standby or Safety), Safety/Relief, Leakage (external) (Water)	WSRC-TR-93-262, SRV-LE-W	10	L
SRV LIC	1.00E-06 H	Valve (Standby or Safety), Safety/Relief, Leakage (internal) (Chemical)	WSRC-TR-93-262, SRV-LI-C	10	L
SRV LIG	1.00E-05 H	Valve (Standby or Safety), Safety/Relief, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, SRV-LI-G	10	L
SRV LIW	1.00E-06 H	Valve (Standby or Safety), Safety/Relief, Leakage (internal) (Water)	WSRC-TR-93-262, SRV-LI-W	10	L
SRV OOC	3.00E-03 N	Valve (Standby or Safety), Safety/Relief, Fails to reclose (Chemical)	WSRC-TR-93-262, SRV-OO-C	10	L
SRV OOG	1.00E-02 N	Valve (Standby or Safety), Safety/Relief, Fails to reclose (Compressed Gas)	WSRC-TR-93-262, SRV-OO-G	10	L
SRV OOW	3.00E-03 N	Valve (Standby or Safety), Safety/Relief, Fails to reclose (Water)	WSRC-TR-93-262, SRV-OO-W	3	L
SRV REC	3.00E-08 H	Valve (Standby or Safety), Safety/Relief, Rupture (external) (Chemical)	WSRC-TR-93-262, SRV-RE-C	30	L
SRV REG	5.00E-09 H	Valve (Standby or Safety), Safety/Relief, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, SRV-RE-G	30	L
SRV REW	5.00E-10 H	Valve (Standby or Safety), Safety/Relief, Rupture (external) (Water)	WSRC-TR-93-262, SRV-RE-W	30	L
SRV RIC	5.00E-08 H	Valve (Standby or Safety), Safety/Relief, Rupture (internal) (Chemical)	WSRC-TR-93-262, SRV-RI-C	30	L
SRV RIG	5.00E-07 H	Valve (Standby or Safety), Safety/Relief, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, SRV-RI-G	30	L
SRV RIW	5.00E-08 H	Valve (Standby or Safety), Safety/Relief, Rupture (internal) (Water)	WSRC-TR-93-262, SRV-RI-W	3[illegible]	
SST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Process Sw., Speed, Failure (Instr. & Control)	WSRC-TR-93-262, SST-FA-I	1[illegible]	
STM BFL A	1.9Y	Failure to supply steam to header	DWPF SAR 9.A		
STM FCL G	1.0E-03N	Steam trap on cooling line fails closed	COG		
STM FCL X	0.1Y	Steam trap fails closed once every 1000 batches => 10 yrs	COG		
SW- BFL A	5E-3N	switch gear failure	DPSTSY-200-1F vol. 2 p P-32		
SW- BFL G	1.0E-06H	PRESSURE SWITCH FAILS	WSRC-TR-93-262, page 30, PST-FA-I, PRESSURE SENSOR/TRAN/SWITCH FAILURE		

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
SW- FTC G	1.0E-06H	PRESSURE SWITCH FAILS	WSRC-TR-93-262, page 30, PST-FA-I, PRESSURE SENSOR/TRAN/SWITCH FAILURE		
SW- SPR G	1.0E-06H	PRESSURE SWITCH FAILS	WSRC-TR-93-262, page 30, PST-FA-I, PRESSURE SENSOR/TRAN/SWITCH FAILURE		
SYN FAE	1.00E-05 H	Motor, Synchro, Failure (Electric Power)	WSRC-TR-93-262, SYN-FA-E	10	L
TA- BFL A	3E-5H	alarm fails to alarm	wsrc-tr-93-262 T1f (ALR-NR-I)		
TBP DEC G	1.0N	TBP does not decompose during evaporation process	a: Any TBP from continous evaporator is always available to react		
TBP FHI A	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TBP PRE A	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TBP PRE G	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TDP FRC	1.00E-04 H	Pump, Turbine-Driven, Fails to run (Chemical)	WSRC-TR-93-262, TDP-FR-C	30	L
TDP FRW	1.00E-04 H	Pump, Turbine-Driven, Fails to run (Water)	WSRC-TR-93-262, TDP-FR-W	30	L
TDP FSC	3.00E-02 N	Pump, Turbine-Driven, Fails to start (Chemical)	WSRC-TR-93-262, TDP-FS-C	10	L
TDP FSW	3.00E-02 N	Pump, Turbine-Driven, Fails to start (Water)	WSRC-TR-93-262, TDP-FS-W	3	L
TDP LEC	1.00E-06 H	Pump, Turbine-Driven, Leakage (external) (Chemical)	WSRC-TR-93-262, TDP-LE-C	10	L
TDP LEW	3.00E-08 H	Pump, Turbine-Driven, Leakage (external) (Water)	WSRC-TR-93-262, TDP-LE-W	10	L
TDP NSC	3.00E-02 N	Pump, Turbine-Driven, Fails to stop (Chemical)	WSRC-TR-93-262, TDP-NS-C	10	L
TDP NSW	3.00E-02 N	Pump, Turbine-Driven, Fails to stop (Water)	WSRC-TR-93-262, TDP-NS-W	3	L
TDP OSC	3.00E-05 H	Pump, Turbine-Driven, Overspeed (Chemical)	WSRC-TR-93-262, TDP-OS-C	10	L
TDP OSW	3.00E-05 H	Pump, Turbine-Driven, Overspeed (Water)	WSRC-TR-93-262, TDP-OS-W	10	L
TDP REC	5.00E-08 H	Pump, Turbine-Driven, Rupture (external) (Chemical)	WSRC-TR-93-262, TDP-RE-C	30	L
TDP REW	1.00E-09 H	Pump, Turbine-Driven, Rupture (external) (Water)	WSRC-TR-93-262, TDP-RE-W	30	L
TE- BFL A	1E-6H	temp. sensor failure	wsrc-tr-93-262 T-1f		
TE- BFL G	1.0E-06H	Temperature Sensor Fails	WSRC-TR-93-262, page 30, TST-FA-I, Temperature Sensor Failure		
TE- FLO G	1.0E-06H	Temperature sensor/trasmitter/transducer/process switch failure	WSRC-TR-93-262, Table 1f, TST-FA-I, p.30		
TFI FAE	1.00E-06 H	Transformer, Instrumentation/Control, Failure (Electric Power)	WSRC-TR-93-262, TFI-FA-E	10	
TFP FAE	1.00E-06 H	Transformer, Power, Failure (Electric Power)	WSRC-TR-93-262, TFP-FA-E	10	
TKP LEC	1.00E-07 H	Tank (Pressurized), Leakage (external) (Chemical)	WSRC-TR-93-262, TKP-LE-C	10	

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
TKP LEG	1.00E-07 H	Tank (Pressurized), Leakage (external) (Compressed Gas)	WSRC-TR-93-262, TKP-LE-G	10	L
TKP LEW	1.00E-08 H	Tank (Pressurized), Leakage (external) (Water)	WSRC-TR-93-262, TKP-LE-W	10	L
TKP REC	5.00E-09 H	Tank (Pressurized), Rupture (external) (Chemical)	WSRC-TR-93-262, TKP-RE-C	30	L
TKP REG	5.00E-09 H	Tank (Pressurized), Rupture (external) (Compressed Gas)	WSRC-TR-93-262, TKP-RE-G	30	L
TKP REW	5.00E-10 H	Tank (Pressurized), Rupture (external) (Water)	WSRC-TR-93-262, TKP-RE-W	30	L
TKU LEC	1.00E-07 H	Tank (Unpressurized), Leakage (external) (Chemical)	WSRC-TR-93-262, TKU-LE-C	10	L
TKU LEW	1.00E-08 H	Tank (Unpressurized), Leakage (external) (Water)	WSRC-TR-93-262, TKU-LE-W	10	L
TKU REC	5.00E-09 H	Tank (Unpressurized), Rupture (external) (Chemical)	WSRC-TR-93-262, TKU-RE-C	30	L
TKU REW	5.00E-10 H	Tank (Unpressurized), Rupture (external) (Water)	WSRC-TR-93-262, TKU-RE-W	30	L
TMN FAE	3.00E-07 H	Termination (Copper), Failure (Electric Power)	WSRC-TR-93-262, TMN-FA-E	10	L
TMR FAI	5.00E-06 H	Timer, Failure (Instr. & Control)	WSRC-TR-93-262, TMR-FA-I	10	L
TNK CLN E	3Y	Failure to clean system causes accumulation and/or phase inversion of solvent	a: estimate on frequency of cleaning * 0.1 prob. fail to clean		
TRD FAI	1.00E-06 H	Transducer, Failure (Instr. & Control)	WSRC-TR-93-262, TRD-FA-I	10	L
TRM FAI	3.00E-06 H	Transmitter, Failure (Instr. & Control)	WSRC-TR-93-262, TRM-FA-I	10	L
TRS PGW	5.00E-07 H	Screen, Travelling, Plugs (Water)	WSRC-TR-93-262, TRS-PG-W	10	L
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L
TUB LEG	3.00E-07 H	Tube, Leakage (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, TUB-LE-G	10	L
TUB PGG	1.00E-08 H	Tube, Plugs (per ft.) (Compressed Gas)	WSRC-TR-93-262, TUB-PG-G	30	L
TUB REG	1.00E-08 H	Tube, Rupture (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, TUB-RE-G	30	L
UNC PRE A	1.0E-04H	UNCONTROLLED CHEMICAL REACTION IN AN EVAPORATOR	BOUNDS DPSTSY-200-1F		
UST FAI	1.00E-05 H	Sensor/Transmitter/, Transducer/Proc. Sw., Humidity, Failure (Instr. & Control)	WSRC-TR-93-262, UST-FA-I	10	L
VAP FAG	1.00E-04 H	Vaporizer, Failure (Compressed Gas)	WSRC-TR-93-262, VAP-FA-G	10	L
VBV CCC	1.00E-02 N	Valve (Standby or Safety), Vacuum-Breaker, Fails to open (Chemical)	WSRC-TR-93-262, VBV-CC-C	10	L
VBV CCG	3.00E-02 N	Valve (Standby or Safety), Vacuum-Breaker, Fails to open (Compressed Gas)	WSRC-TR-93-262, VBV-CC-G	10	L
VBV CCW	1.00E-02 N	Valve (Standby or Safety), Vacuum-Breaker, Fails to open (Water)	WSRC-TR-93-262, VBV-CC-W	10	L
VBV LEC	5.00E-07 H	Valve (Standby or Safety), Vacuum-Breaker, Leakage (external) (Chemical)	WSRC-TR-93-262, VBV-LE-C	10	L

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

Type Code	Rate	Description	Source	EF	D
VBV LEG	1.00E-07 H	Valve (Standby or Safety), Vacuum-Breaker, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, VBV-LE-G	10	L
VBV LEW	1.00E-08 H	Valve (Standby or Safety), Vacuum-Breaker, Leakage (external) (Water)	WSRC-TR-93-262, VBV-LE-W	10	L
VBV LIC	1.00E-06 H	Valve (Standby or Safety), Vacuum-Breaker, Leakage (internal) (Chemical)	WSRC-TR-93-262, VBV-LI-C	10	L
VBV LIG	1.00E-05 H	Valve (Standby or Safety), Vacuum-Breaker, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, VBV-LI-G	10	L
VBV LIW	1.00E-06 H	Valve (Standby or Safety), Vacuum-Breaker, Leakage (internal) (Water)	WSRC-TR-93-262, VBV-LI-W	10	L
VBV OOC	1.00E-02 N	Valve (Standby or Safety), Vacuum-Breaker, Fails to reclose (Chemical)	WSRC-TR-93-262, VBV-OO-C	10	L
VBV OOG	3.00E-02 N	Valve (Standby or Safety), Vacuum-Breaker, Fails to reclose (Compressed Gas)	WSRC-TR-93-262, VBV-OO-G	10	L
VBV OOW	1.00E-02 N	Valve (Standby or Safety), Vacuum-Breaker, Fails to reclose (Water)	WSRC-TR-93-262, VBV-OO-W	10	L
VBV REC	3.00E-08 H	Valve (Standby or Safety), Vacuum-Breaker, Rupture (external) (Chemical)	WSRC-TR-93-262, VBV-RE-C	30	L
VBV REG	5.00E-09 H	Valve (Standby or Safety), Vacuum-Breaker, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, VBV-RE-G	30	L
VBV REW	5.00E-10 H	Valve (Standby or Safety), Vacuum-Breaker, Rupture (external) (Water)	WSRC-TR-93-262, VBV-RE-W	30	L
VBV RIC	5.00E-08 H	Valve (Standby or Safety), Vacuum-Breaker, Rupture (internal) (Chemical)	WSRC-TR-93-262, VBV-RI-C	30	L
VBV RIG	5.00E-07 H	Valve (Standby or Safety), Vacuum-Breaker, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, VBV-RI-G	30	L
VBV RIW	5.00E-08 H	Valve (Standby or Safety), Vacuum-Breaker, Rupture (internal) (Water)	WSRC-TR-93-262, VBV-RI-W	3[illegible]	[illegible]
VRG FAI	3.00E-06 H	Voltage Regulator, Failure (Instr. & Control)	WSRC-TR-93-262, VRG-FA-I	10	[illegible]
XDM CCH	3.00E-03 N	Damper (Standby or Safety), Manual, Fails to open/close (HVAC)	WSRC-TR-93-262, XDM-CC-H	10	[illegible]
XDM LEH	1.00E-07 H	Damper (Standby or Safety), Manual, Leakage (external) (HVAC)	WSRC-TR-93-262, XDM-LE-H	10	[illegible]
XDM LIH	1.00E-05 H	Damper (Standby or Safety), Manual, Leakage (internal) (HVAC)	WSRC-TR-93-262, XDM-LI-H	10	[illegible]

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

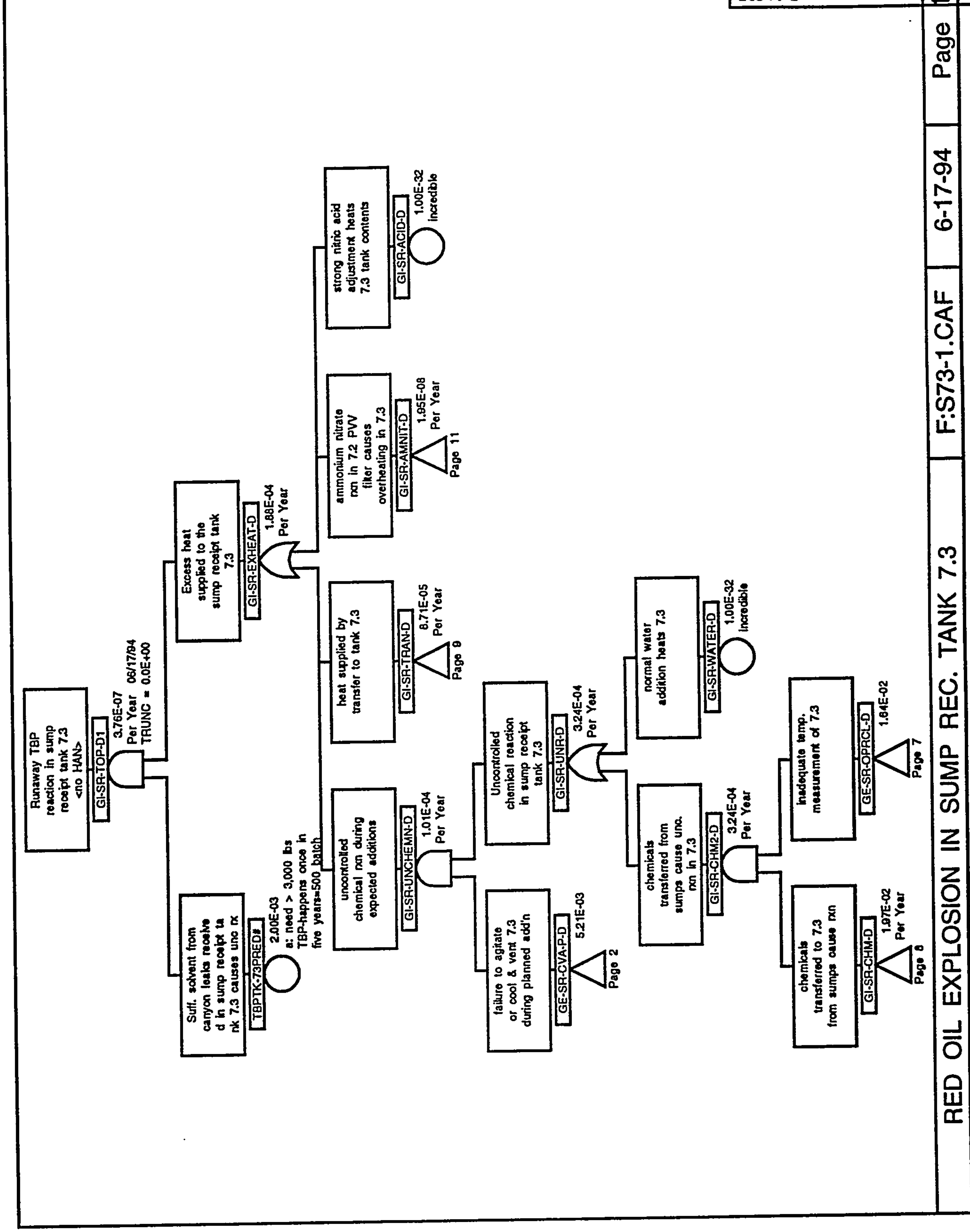
Type Code	Rate	Description	Source	EF	D
XDM OOH	3.00E-03 N	Damper (Standby or Safety), Manual, Fails to open/close (HVAC)	WSRC-TR-93-262, XDM-OO-H	10	L
XDM PGH	5.00E-07 H	Damper (Standby or Safety), Manual, Plugs (HVAC)	WSRC-TR-93-262, XDM-PG-H	10	L
XDM REH	5.00E-09 H	Damper (Standby or Safety), Manual, Rupture (external) (HVAC)	WSRC-TR-93-262, XDM-RE-H	30	L
XDM RIH	5.00E-07 H	Damper (Standby or Safety), Manual, Rupture (internal) (HVAC)	WSRC-TR-93-262, XDM-RI-H	30	L
XSK CCE	3.00E-07 H	Switch, Key-Operated (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSK-CC-E	10	L
XSK COE	1.00E-06 H	Switch, Key-Operated (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSK-CO-E	10	L
XSK NRE	3.00E-07 H	Switch, Key-Operated (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSK-NR-E	10	L
XSK OCE	1.00E-06 H	Switch, Key-Operated (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSK-OC-E	10	L
XSK OOE	3.00E-07 H	Switch, Key-Operated (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSK-OO-E	10	L
XSK SOE	1.00E-06 H	Switch, Key-Operated (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSK-SO-E	10	L
XSP CCE	1.00E-06 H	Switch, Push-Button (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSP-CC-E	10	L
XSP COE	1.00E-06 H	Switch, Push-Button (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSP-CO-E	10	L
XSP NRE	1.00E-06 H	Switch, Push-Button (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSP-NR-E	10	L
XSP OCE	1.00E-06 H	Switch, Push-Button (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSP-OC-E	10	L
XSP OOE	1.00E-06 H	Switch, Push-Button (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSP-OO-E	10	L
XSP SOE	1.00E-06 H	Switch, Push-Button (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSP-SO-E	10	L
XSR CCE	5.00E-08 H	Switch, Rotary (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSR-CC-E	10	L
XSR COE	5.00E-07 H	Switch, Rotary (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSR-CO-E	10	L
XSR NRE	5.00E-08 H	Switch, Rotary (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSR-NR-E	10	L
XSR OCE	5.00E-07 H	Switch, Rotary (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSR-OC-E	10	L
XSR OOE	5.00E-08 H	Switch, Rotary (Manual), Fails to open/close (Electric Power)	WSRC-TR-93-262, XSR-OO-E	10	L
XSR SOE	5.00E-07 H	Switch, Rotary (Manual), Spurious operation (Electric Power)	WSRC-TR-93-262, XSR-SO-E	10	L
XVM CCC	3.00E-04 N	Valve (Standby or Safety), Manual, Fails to open/close (Chemical)	WSRC-TR-93-262, XVM-CC-C	10	L
XVM CCG	1.00E-03 N	Valve (Standby or Safety), Manual, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, XVM-CC-G	10	L

Type Codes for Sump Receipt Tank 7.3 (S73-1.TC) (CONT.)

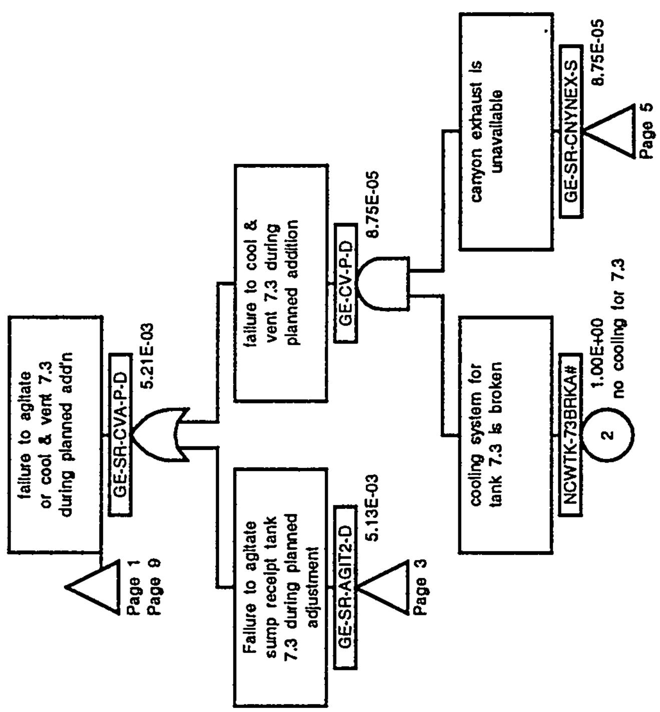
Type Code	Rate	Description	Source	EF	D
XVM CCW	3.00E-04 N	Valve (Standby or Safety), Manual, Fails to open/close (Water)	WSRC-TR-93-262, XVM-CC-W	10	L
XVM LEC	5.00E-07 H	Valve (Standby or Safety), Manual, Leakage (external) (Chemical)	WSRC-TR-93-262, XVM-LE-C	10	L
XVM LEG	1.00E-07 H	Valve (Standby or Safety), Manual, Leakage (external) (Compressed Gas)	WSRC-TR-93-262, XVM-LE-G	10	L
XVM LEW	1.00E-08 H	Valve (Standby or Safety), Manual, Leakage (external) (Water)	WSRC-TR-93-262, XVM-LE-W	10	L
XVM LIC	1.00E-06 H	Valve (Standby or Safety), Manual, Leakage (internal) (Chemical)	WSRC-TR-93-262, XVM-LI-C	10	L
XVM LIG	1.00E-05 H	Valve (Standby or Safety), Manual, Leakage (internal) (Compressed Gas)	WSRC-TR-93-262, XVM-LI-G	10	L
XVM LIW	1.00E-06 H	Valve (Standby or Safety), Manual, Leakage (internal) (Water)	WSRC-TR-93-262, XVM-LI-W	10	L
XVM OOC	3.00E-04 N	Valve (Standby or Safety), Manual, Fails to open/close (Chemical)	WSRC-TR-93-262, XVM-OO-C	10	L
XVM OOG	1.00E-03 N	Valve (Standby or Safety), Manual, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, XVM-OO-G	10	L
XVM OOW	3.00E-04 N	Valve (Standby or Safety), Manual, Fails to open/close (Water)	WSRC-TR-93-262, XVM-OO-W	10	L
XVM PGC	5.00E-08 H	Valve (Standby or Safety), Manual, Plugs (Chemical)	WSRC-TR-93-262, XVM-PG-C	10	L
XVM PGG	5.00E-07 H	Valve (Standby or Safety), Manual, Plugs (Compressed Gas)	WSRC-TR-93-262, XVM-PG-G	10	L
XVM PGW	5.00E-08 H	Valve (Standby or Safety), Manual, Plugs (Water)	WSRC-TR-93-262, XVM-PG-W	10	L
XVM REC	3.00E-08 H	Valve (Standby or Safety), Manual, Rupture (external) (Chemical)	WSRC-TR-93-262, XVM-RE-C	30	L
XVM REG	5.00E-09 H	Valve (Standby or Safety), Manual, Rupture (external) (Compressed Gas)	WSRC-TR-93-262, XVM-RE-G	30	L
XVM REW	5.00E-10 H	Valve (Standby or Safety), Manual, Rupture (external) (Water)	WSRC-TR-93-262, XVM-RE-W	30	L
XVM RIC	5.00E-08 H	Valve (Standby or Safety), Manual, Rupture (internal) (Chemical)	WSRC-TR-93-262, XVM-RI-C	30	L
XVM RIG	5.00E-07 H	Valve (Standby or Safety), Manual, Rupture (internal) (Compressed Gas)	WSRC-TR-93-262, XVM-RI-G	30	L
XVM RIW	5.00E-08 H	Valve (Standby or Safety), Manual, Rupture (internal) (Water)	WSRC-TR-93-262, XVM-RI-W	30	L

Appendix 5
Fault Trees & Cutsets for Sump Receipt Tanks

Calculation No. S-CLC-F-00100
Sheet No. 84 of 135
Rev. 1



Calculation No.
S-CLC-F-00100
Sheet No. 85 of 135
Rev. 1



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Calculation No. S-CLC-F-00100	
Sheet No. 86 of 135	
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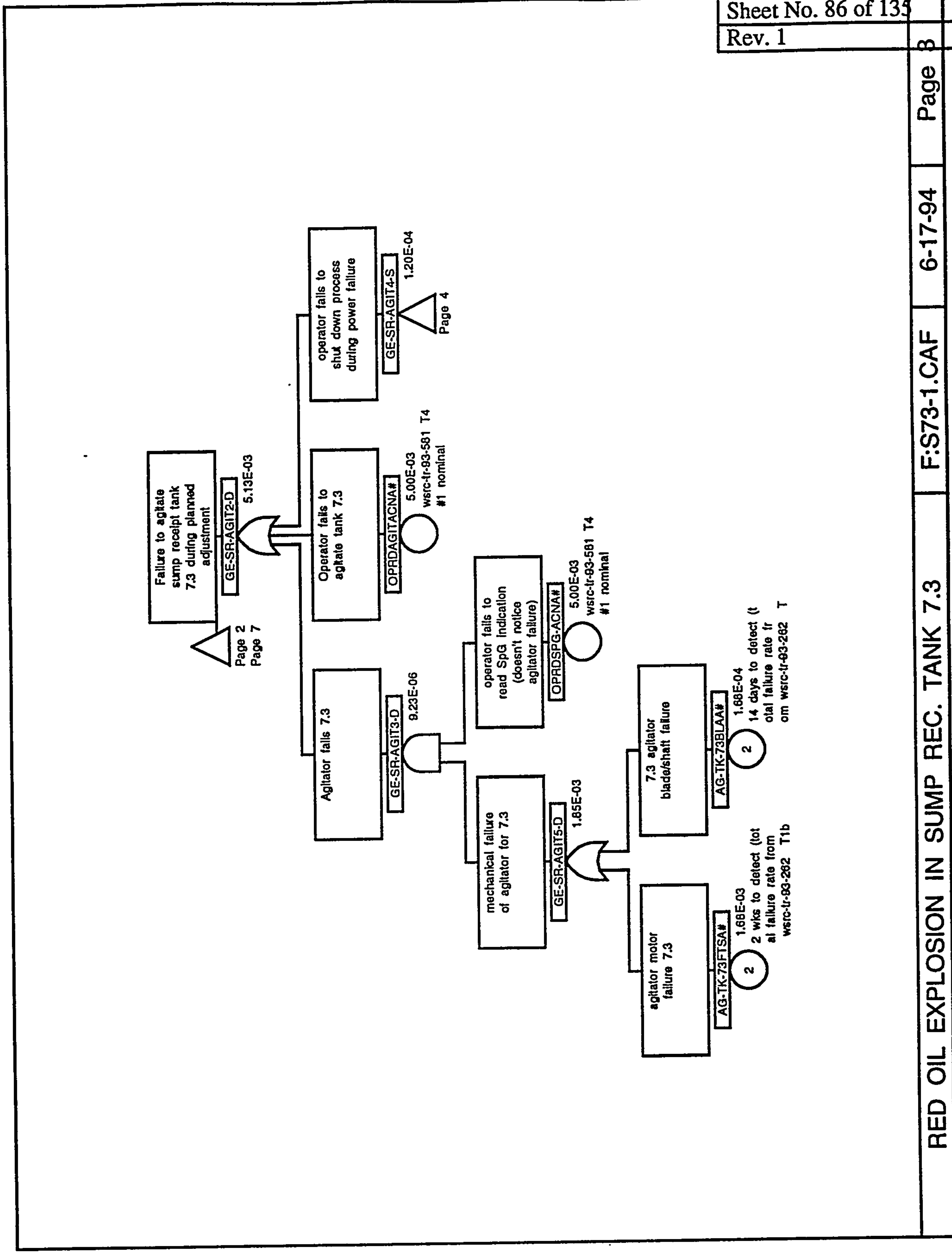

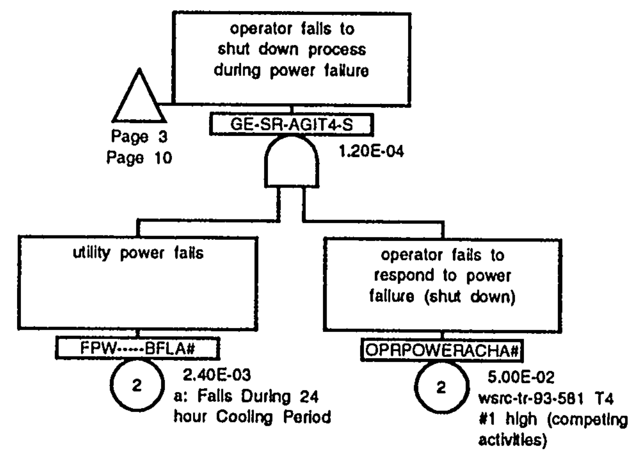

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Calculation No. S-CLC-F-00100	
Sheet No. 88 of 135	
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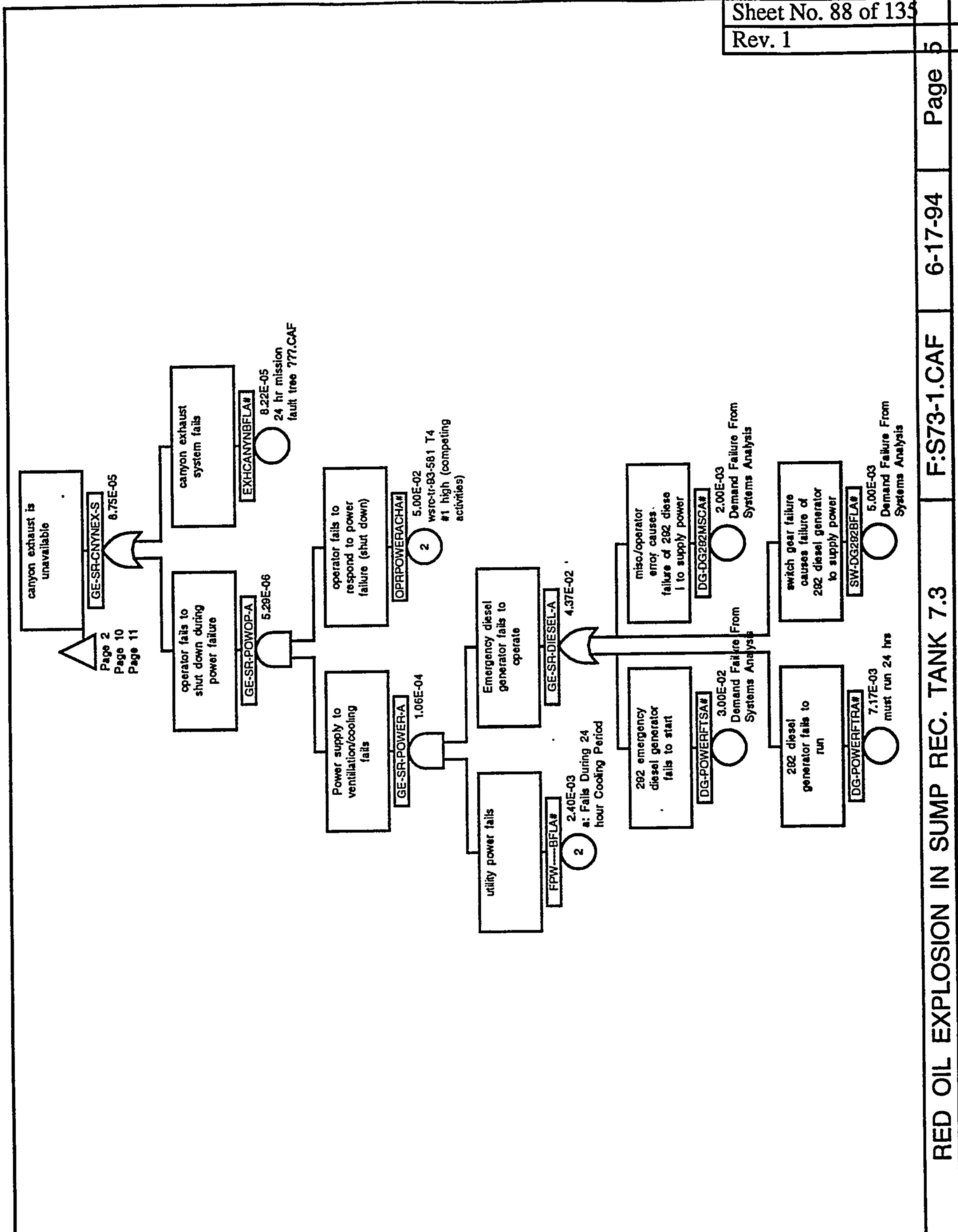
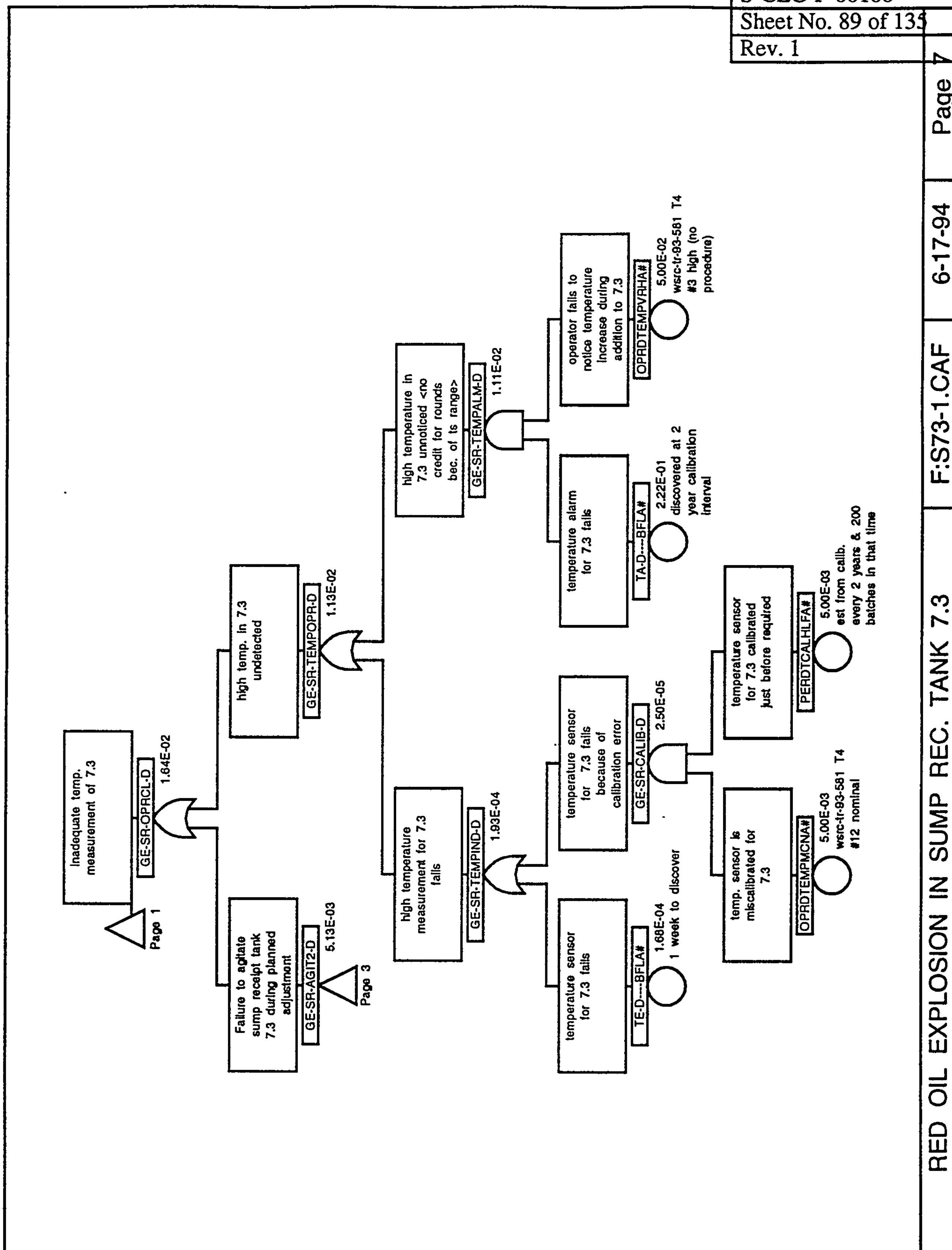
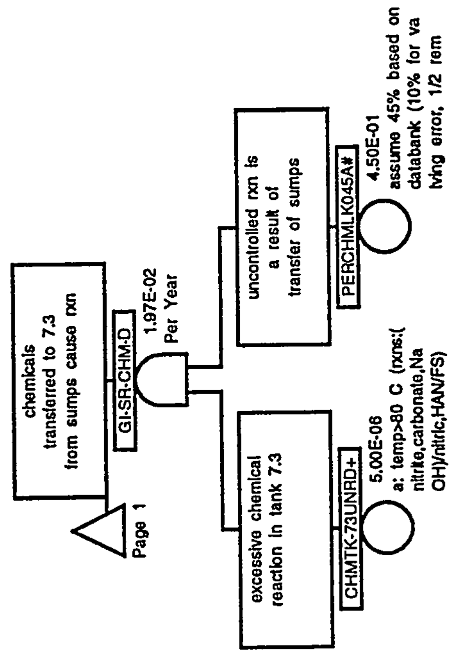


Calculation No. S-CLC-F-00100
Sheet No. 89 of 135
Rev. 1

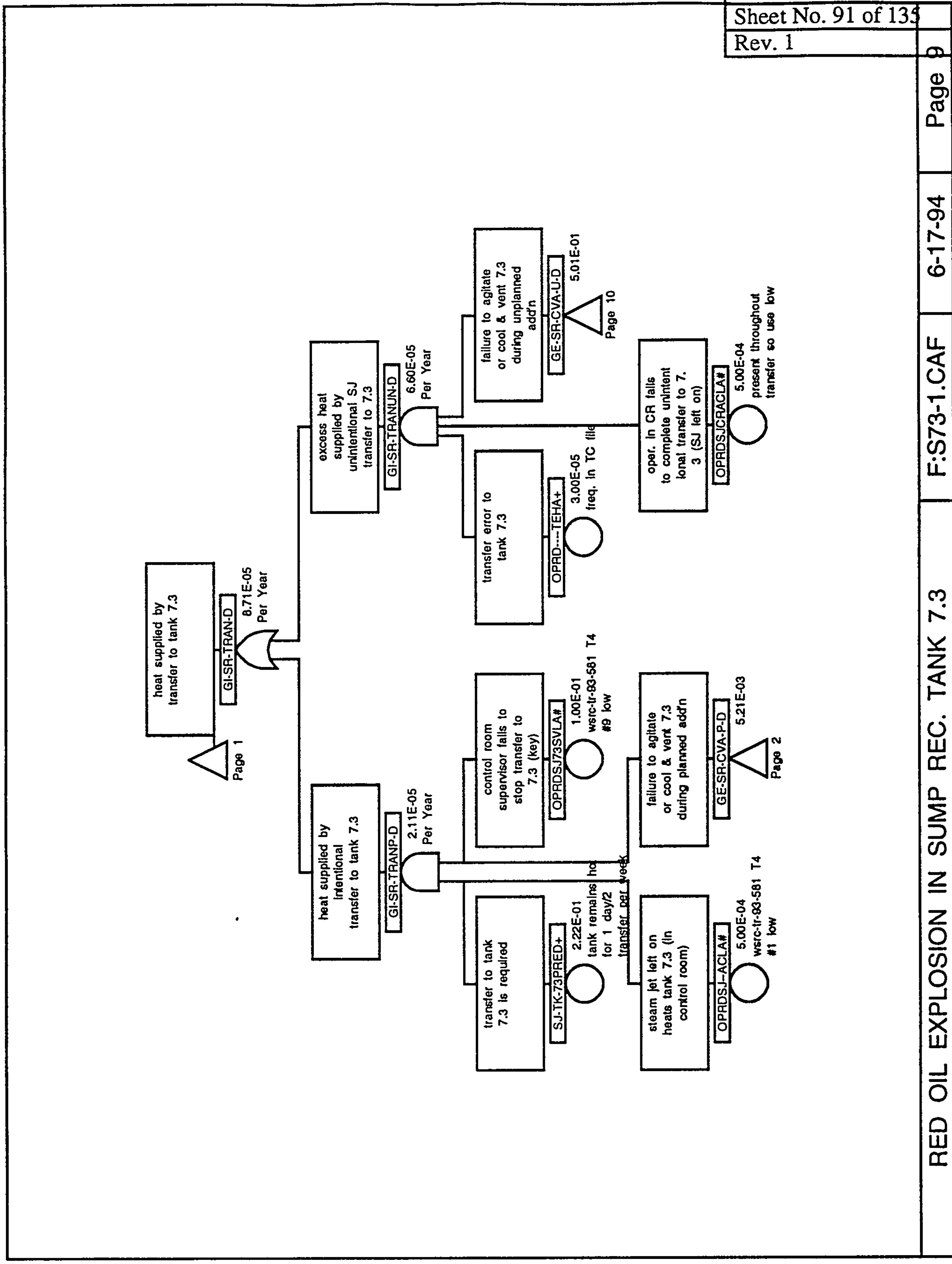


Calculation No. S-CLC-F-00100	
Sheet No. 90 of 135	
Rev. 1	

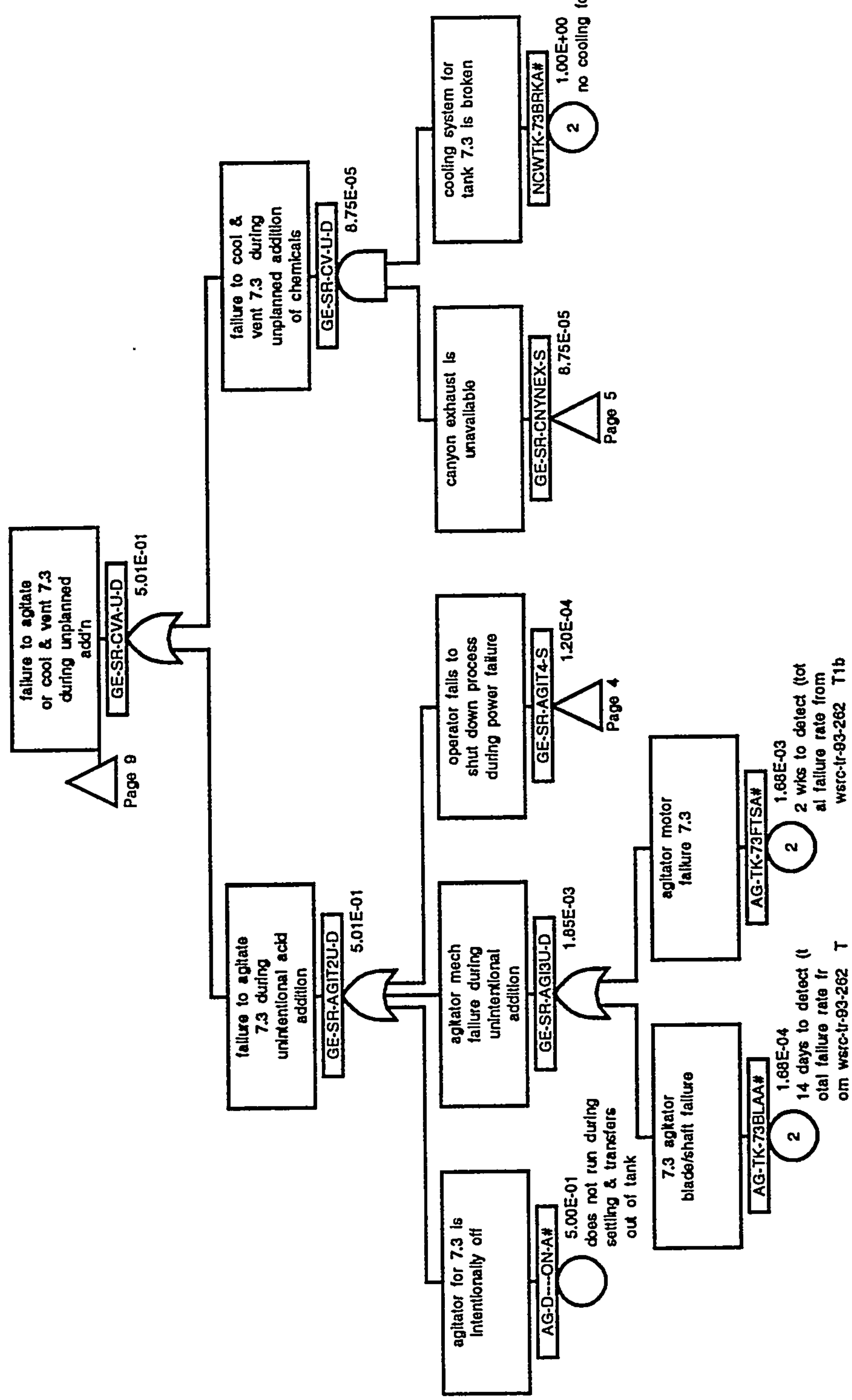


RED OIL EXPLOSION IN SUMP REC. TANK 7.3 | F:S73-1.CAF | 6-17-94 | Page 8

Calculation No. S-CLC-F-00100
Sheet No. 91 of 135
Rev. 1



Calculation No. S-CLC-F-00100	
Sheet No. 92 of 135	
Rev. 1	



RED OIL EXPLOSION IN SUMP REC. TANK 7.3	F:S73-1.CAF	6-17-94	Page 10

Calculation No. S-CLC-F-00100	
Sheet No. 93 of 135	
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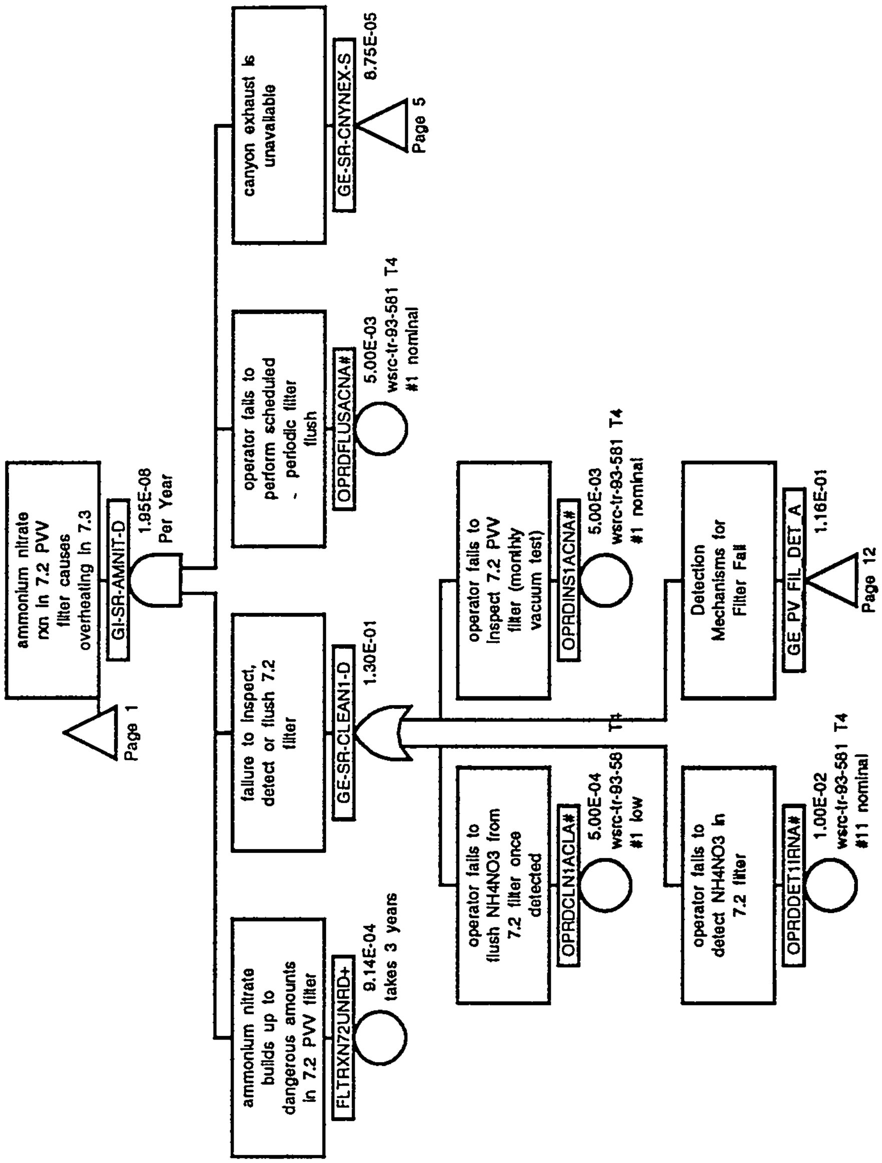

RED OIL EXPLOSION IN SUMP REC. TANK 7.3 | F:S73-1.CAF | 6-17-94 | Page 11

Calculation No. S-CLC-F-00100
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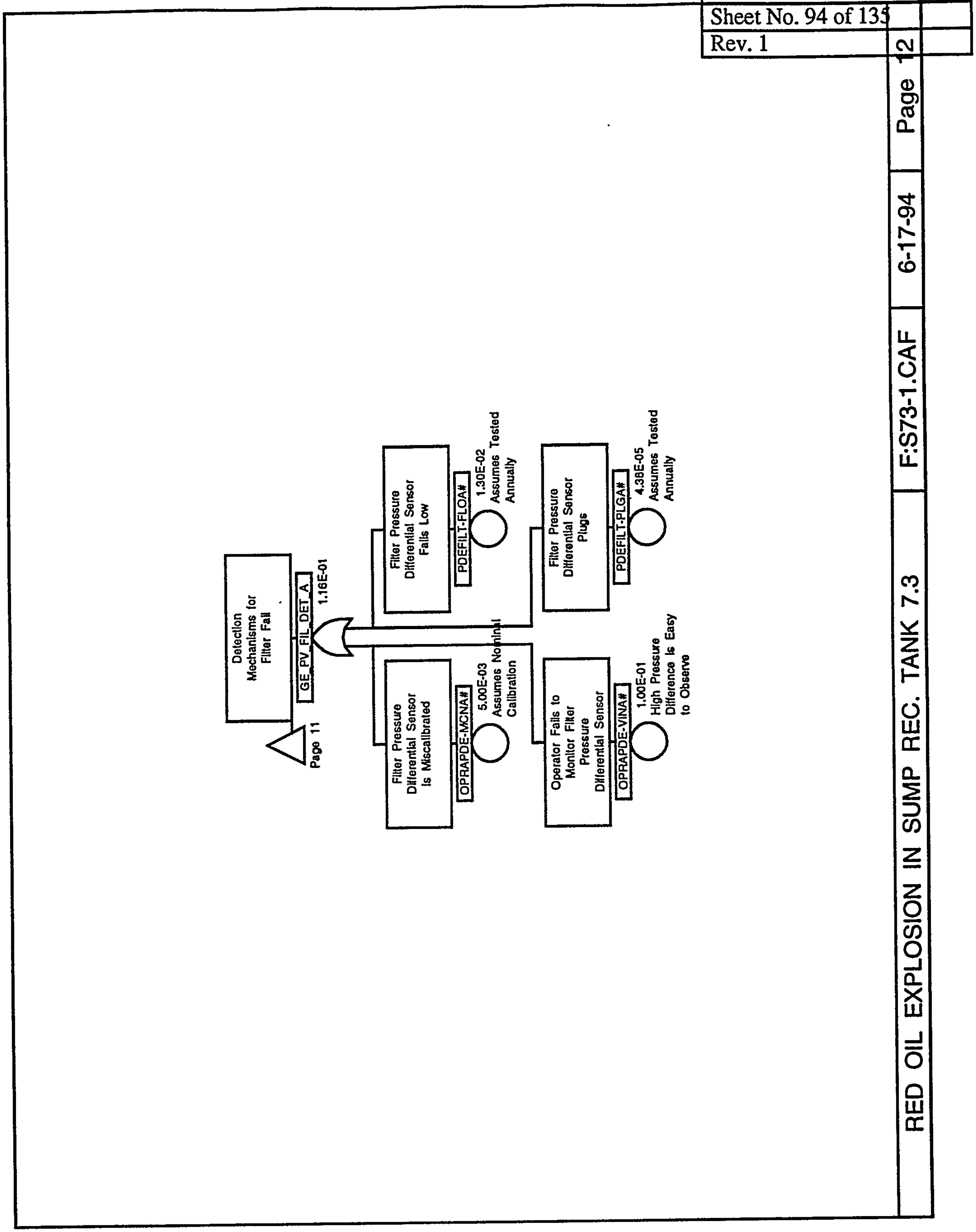

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AG-D----ON-A#	10		GE-SR-OPRCL-D	7		OPRDTEMPVRHA#	7				
AG-TK-73BLAA#	3		GE-SR-POWER-A	5		OPRPOWERACHA#	4				
AG-TK-73BLAA#	10		GE-SR-POWOP-A	5		OPRPOWERACHA#	5				
AG-TK-73FTSA#	3		GE-SR-TEMPALM-D	7		PDEFILT-FLOA#	12				
AG-TK-73FTSA#	10		GE-SR-TEMPIND-D	7		PDEFILT-PLGA#	12				
CHMTK-73UNRD+	8		GE-SR-TEMPOPR-D	7		PERCHMLK045A#	8				
DG-DG292MSCA#	5		GE_PV_FIL_DET_A	11		PERDTCALHLFA#	7				
DG-POWERFTRA#	5		GE_PV_FIL_DET_A	12		SJ-TK-73PRED+	9				
DG-POWERFTSA#	5		GI-SR-ACID-D	1		SW-DG292BFLA#	5				
EXHCANYNBFLA#	5		GI-SR-AMNIT-D	1		TA-D----BFLA#	7				
FLTRXN72UNRD+	11		GI-SR-AMNIT-D	11		TBPTK-73PRED#	1				
FPW-----BFLA#	4		GI-SR-CHM-D	1		TE-D----BFLA#	7				
FPW-----BFLA#	5		GI-SR-CHM-D	8							
GE-CV-P-D	2		GI-SR-CHM2-D	1							
GE-SR-AGI3U-D	10		GI-SR-EXHEAT-D	1							
GE-SR-AGIT2-D	2		GI-SR-TOP-D1	1							
GE-SR-AGIT2-D	3		GI-SR-TRAN-D	1							
GE-SR-AGIT2-D	7		GI-SR-TRAN-D	9							
GE-SR-AGIT2U-D	10		GI-SR-TRANP-D	9							
GE-SR-AGIT3-D	3		GI-SR-TRANUN-D	9							
GE-SR-AGIT4-S	3		GI-SR-UNCHEMN-D	1							
GE-SR-AGIT4-S	4		GI-SR-UNR-D	1							
GE-SR-AGIT4-S	10		GI-SR-WATER-D	1							
GE-SR-AGIT5-D	3		NCWTK-73BRKA#	2							
GE-SR-CALIB-D	7		NCWTK-73BRKA#	10							
GE-SR-CLEAN1-D	11		OPRAPDE-MCNA#	12							
GE-SR-CNYNEX-S	2		OPRAPDE-VINA#	12							
GE-SR-CNYNEX-S	5		OPRD----TEHA+	9							
GE-SR-CNYNEX-S	10		OPRDAGITACNA#	3							
GE-SR-CNYNEX-S	11		OPRDCLN1ACLA#	11							
GE-SR-CV-U-D	10		OPRDDET1IRNA#	11							
GE-SR-CVA-P-D	1		OPRDFLUSACNA#	11							
GE-SR-CVA-P-D	2		OPRDINS1ACNA#	11							
GE-SR-CVA-P-D	9		OPRDSJ--ACLA#	9							
GE-SR-CVA-U-D	9		OPRDSJ73SVLA#	9							
GE-SR-CVA-U-D	10		OPRDSJCRACLA#	9							
GE-SR-DIESEL-A	5		OPRDSPG-ACNA#	3							
GE-SR-OPRCL-D	1		OPRDTEMPMCNA#	7							

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	GI-SR-TOP-D1					3.76E-07
1.	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	1.97E-07
	OPRDAGITACNA#	Operator fails to agitate tank 7.3	1	1N 5.0E-3N	5.00E-03N	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
2.	AG-D----ON-A#	agitator for 7.3 is intentionally off	1	1N .5N	5.00E-01N	1.31E-07
	OPRD----TEHA+	transfer error to tank 7.3	4	1H 3.0E-5H	3.00E-05	
	OPRDSJCRACLA#	oper. in CR fails to complete unintentional transfer to 7.3 (SJ left on)	1	1N 5.0E-4N	5.00E-04N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
3.	OPRDAGITACNA#	Operator fails to agitate tank 7.3	1	1N 5.0E-3N	5.00E-03N	4.05E-08
	OPRDSJ--ACLA#	steam jet left on heats tank 7.3 (in control room)	1	1N 5.0E-4N	5.00E-04N	
	OPRDSJ73SVLA#	control room supervisor fails to stop transfer to 7.3 (key)	1	1N 1.0E-1N	1.00E-01N	
	SJ-TK-73PRED+	transfer to tank 7.3 is required	4	24H 1.19E-2H	2.22E-01	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
4.	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	4.72E-09
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
5.	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	9.72E-1[illegible]
	OPRDSJ--ACLA#	steam jet left on heats tank 7.3 (in control room)	1	1N 5.0E-4N	5.00E-04N	
	OPRDSJ73SVLA#	control room supervisor fails to stop transfer to 7.3 (key)	1	1N 1.0E-1N	1.00E-01N	

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	SJ-TK-73PRED+	transfer to tank 7.3 is required	4	24H 1.19E-2H	2.22E-01	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
6.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	6.66E-10
	NCWTK-73BRKA#	cooling system for tank 7.3 is broken		1N	1.00E+00	
	OPRDSJ--ACLA#	steam jet left on heats tank 7.3 (in control room)	1	1N 5.0E-4N	5.00E-04N	
	OPRDSJ73SVLA#	control room supervisor fails to stop transfer to 7.3 (key)	1	1N 1.0E-1N	1.00E-01N	
	SJ-TK-73PRED+	transfer to tank 7.3 is required	4	24H 1.19E-2H	2.22E-01	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
7.	AG-TK-73FTSA#	agitator motor failure 7.3	3	14D 5.00E-06 H	1.68E-03	4.41E-10
	OPRD----TEHA+	transfer error to tank 7.3	4	1H 3.0E-5H	3.00E-05	
	OPRDSJCRACLA#	oper. in CR fails to complete unintentional transfer to 7.3 (SJ left on)	1	1N 5.0E-4N	5.00E-04N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
8.	AG-TK-73FTSA#	agitator motor failure 7.3	3	14D 5.00E-06 H	1.68E-03	3.31E-10
	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	
	OPRDSPG-ACNA#	operator fails to read SpG indication (doesn't notice agitator failure)	1	1N 5.0E-3N	5.00E-03N	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
9.	AG-TK-73FTSA#	agitator motor failure 7.3	3	14D 5.00E-06 H	1.68E-03	6.81E[illegible]
	OPRDSJ--ACLA#	steam jet left on heats tank 7.3 (in control room)	1	1N 5.0E-4N	5.00E-04N	
	OPRDSJ73SVLA#	control room supervisor fails to stop transfer to 7.3 (key)	1	1N 1.0E-1N	1.00E-01N	
	OPRDSPG-ACNA#	operator fails to read SpG indication (doesn't notice agitator failure)	1	1N 5.0E-3N	5.00E-03N	

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	SJ-TK-73PRED+	transfer to tank 7.3 is required	4	24H 1.19E-2H	2.22E-01	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
10.	AG-TK-73BLAA#	7.3 agitator blade/shaft failure	3	14D 5.0E-07H	1.68E-04	4.41E-11
	OPRD----TEHA+	transfer error to tank 7.3	4	1H 3.0E-5H	3.00E-05	
	OPRDSJCRACLA#	oper. in CR fails to complete unintentional transfer to 7.3 (SJ left on)	1	1N 5.0E-4N	5.00E-04N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
11.	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	3.60E-11
	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	
	NCWTK-73BRKA#	cooling system for tank 7.3 is broken		1N	1.00E+00	
	OPRDTEMPVRHA#	operator fails to notice temperature increase during addition to 7.3	1	1N 5.0E-2N	5.00E-02N	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	TA-D----BFLA#	temperature alarm for 7.3 fails	5	2Y 3E-5H	2.22E-01	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
12.	AG-TK-73BLAA#	7.3 agitator blade/shaft failure	3	14D 5.0E-07H	1.68E-04	3.31E-11
	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	
	OPRDSPG-ACNA#	operator fails to read SpG indication (doesn't notice agitator failure)	1	1N 5.0E-3N	5.00E-03N	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
13.	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	3.15E
	OPRD----TEHA+	transfer error to tank 7.3	4	1H 3.0E-5H	3.00E-05	
	OPRDSJCRACLA#	oper. in CR fails to complete unintentional transfer to 7.3 (SJ left on)	1	1N 5.0E-4N	5.00E-04N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
14.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	2.74E-11
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	OPRAPDE-VINA#	Operator Fails to Monitor Filter Pressure Differential Sensor	1	1N 1.0E-1N	1.00E-01N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
15.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	2.16E-11
	NCWTK-73BRKA#	cooling system for tank 7.3 is broken		1N	1.00E+00	
	OPRD----TEHA+	transfer error to tank 7.3	4	1H 3.0E-5H	3.00E-05	
	OPRDSJCRACLA#	oper. in CR fails to complete unintentional transfer to 7.3 (SJ left on)	1	1N 5.0E-4N	5.00E-04N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
16.	AG-TK-73BLAA#	7.3 agitator blade/shaft failure	3	14D 5.0E-07H	1.68E-04	6.81E-12
	OPRDSJ--ACLA#	steam jet left on heats tank 7.3 (in control room)	1	1N 5.0E-4N	5.00E-04N	
	OPRDSJ73SVLA#	control room supervisor fails to stop transfer to 7.3 (key)	1	1N 1.0E-1N	1.00E-01N	
	OPRDSPG-ACNA#	operator fails to read SpG indication (doesn't notice agitator failure)	1	1N 5.0E-3N	5.00E-03N	
	SJ-TK-73PRED+	transfer to tank 7.3 is required	4	24H 1.19E-2H	2.22E-01	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
17.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	3.57E[illegible]
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	PDEFILT-FLOA#	Filter Pressure Differential Sensor Fails Low	5	1Y 3.0E-06H	1.30E-02	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
18.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	2.74E-12
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	OPRDDET1IRNA#	operator fails to detect NH4NO3 in 7.2 filter	1	1N 1.0E-2N	1.00E-02N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
19.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	1.37E-12
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRDINS1ACNA#	operator fails to inspect 7.2 PVV filter (monthly vacuum test)	1	1N 5.0E-3N	5.00E-03N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
20.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	1.37E-12
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	OPRAPDE-MCNA#	Filter Pressure Differential Sensor is Miscalibrated	1	1N 5.0E-3N	5.00E-03N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
21.	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	1.20E-12
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRAPDE-VINA#	Operator Fails to Monitor Filter Pressure Differential Sensor	1	1N 1.0E-1N	1.00E-01N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
22.	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	5.44E-13
	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	
	NCWTK-73BRKA#	cooling system for tank 7.3 is broken		1N	1.00E+00	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
	TE-D----BFLA#	temperature sensor for 7.3 fails	3	7D 1E-6H	1.68E-04	
23.	DG-POWERFTRA#	292 diesel generator fails to run	3	24H 3.0E-04H	7.17E-03	2.87E-13
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRAPDE-VINA#	Operator Fails to Monitor Filter Pressure Differential Sensor	1	1N 1.0E-1N	1.00E-01N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
24.	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	2.00E-13
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRAPDE-VINA#	Operator Fails to Monitor Filter Pressure Differential Sensor	1	1N 1.0E-1N	1.00E-01N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	SW-DG292BFLA#	switch gear failure causes failure of 292 diesel generator to supply power	1	1N 5E-3N	5.00E-03N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
25.	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	1.56E-13
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	

Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	PDEFILT-FLOA#	Filter Pressure Differential Sensor Fails Low	5	1Y 3.0E-06H	1.30E-02	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
26.	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	1.37E-13
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	OPRDCLN1ACLA#	operator fails to flush NH4NO3 from 7.2 filter once detected	1	1N 5.0E-4N	5.00E-04N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
27.	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	1.20E-13
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRDDET1IRNA#	operator fails to detect NH4NO3 in 7.2 filter	1	1N 1.0E-2N	1.00E-02N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
28.	CHMTK-73UNRD+	excessive chemical reaction in tank 7.3	4	1H 5.0E-06H	5.00E-06	8.10E[illegible]
	EXHCANYNBFLA#	canyon exhaust system fails	3	24H 0.03Y	8.22E-05	
	NCWTK-73BRKA#	cooling system for tank 7.3 is broken		1N	1.00E+00	
	OPRDTEMPMCNA#	temp. sensor is miscalibrated for 7.3	1	1N 5.0E-3N	5.00E-03N	
	PERCHMLK045A#	uncontrolled rxn is a result of transfer of sumps	1	1N .45N	4.50E-01N	
	PERDTCALHLFA#	temperature sensor for 7.3 calibrated just before required	1	1N 5E-3N	5.00E-03N	

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Cutsets for Sump Receipt Tank 7.3 (S73-1.caf) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
29.	DG-DG292MSCA#	misc./operator error causes failure of 292 diesel to supply power	1	1N 2E-3N	2.00E-03N	7.99E-14
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRAPDE-VINA#	Operator Fails to Monitor Filter Pressure Differential Sensor	1	1N 1.0E-1N	1.00E-01N	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	
30.	DG-POWERFTSA#	292 emergency diesel generator fails to start	1	1N 3.0E-02N	3.00E-02N	5.99E-14
	FLTRXN72UNRD+	ammonium nitrate builds up to dangerous amounts in 7.2 PVV filter	4	24H 3.81E-5H	9.14E-04	
	FPW-----BFLA#	utility power fails	3	24H 1.0E-04H	2.40E-03	
	OPRDFLUSACNA#	operator fails to perform scheduled periodic filter flush	1	1N 5.0E-3N	5.00E-03N	
	OPRDINS1ACNA#	operator fails to inspect 7.2 PVV filter (monthly vacuum test)	1	1N 5.0E-3N	5.00E-03N	
	OPRPOWERACHA#	operator fails to respond to power failure (shut down)	1	1N 5.0E-2N	5.00E-02N	
	TBPTK-73PRED#	Suff. solvent from canyon leaks received in sump receipt tank 7.3 causes unc rx		2E-3N	2.00E-03	

Appendix 6
Basic Event Data for 2nd Pu Mixer-Settler

Basic Event Report for Red Oil Explosions in Mixer Settler (2PU.BE)

Event	C	Input	Calc.	Description	Source
AG-2PU1-BFLA+	4	8H 1.24E-06H	9.92E-06	First Impeller Fails due to Motor Failure	Assumed 8 Hours to Detect Chemistry Upset in Bank Due to Motor Failure
AG-2PU1-BLAA+	4	8H 5.0E-06H	4.00E-05	First Impeller Fails Due to Blade/Shaft Failure	Assumed 8 Hours to Detect Chemistry Upset in Bank Due to Blade/Shaft Failure
AG-2PU2-BFLA+	4	8H 1.24E-06H	9.92E-06	Adjacent Impeller Fails Due to Motor Failure	Assumed 8 Hours to Detect Upset of Chemistry in Bank due to Motor Failure
AG-2PU2-BLAA+	4	8H 5.0E-06H	4.00E-05	Adjacent Impeller Fails Due to Blade/Shaft Failure	Assumed 8 Hours to Detect Upset of Chemistry in Bank due to Blade/Shaft Failure
CHM2PU--OVHC+	1	1H 1.0E-32H	1.00E-32	2nd PU Mixer Settler Overheated Due to Strong Acid Addition	Frequency Based on Information Obtained From M.L. Hyder
CHM2PU--UNRC+	1	1H 1.0E-32H	1.00E-32	Uncontrolled Reaction in 2nd Pu Mixer Settler Cause Pyrolysis of TBP	Estimate; See assumptions
DCS2AF--CRDC+	4	8H 3.0E-06H	2.40E-05	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	Assumed 8 Hours to Detect and Repair
DCS2AS--CRDC+	4	8H 3.0E-06H	2.40E-05	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	Assumed 8 Hours to Detect and Repair
DCS2AX--CRDC+	4	8H 3.0E-06H	2.40E-05	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	Assumed 8 Hours to Detect and to Repair
DG-DG292MSCC#	1	1N 2.00E-03N	2.00E-03N	Misc./Operator Error Causes Failure of 292 Diesel to Supply Power	Demand from F-Canyon System Analysis, page P-28
DG-POWERFTRC#	3	24H 3.0E-04H	7.17E-03	Emergency Diesel Generator Fails to Run	F-Canyon SAR Addendum One
DG-POWERFTSC#	1	1N 3.0E-2N	3.00E-02N	292 Emergency Diesel Generator Fails to Start	F and H-Canyon System Analysis, p P-28
EXHCANYNBFLC#	3	24H 2.7E-06H	6.48E-05	Canyon Exhaust System Fails	F-Canyon SAR Addendum One
FCM2AS--ADJC+	4	1H 1.25E-01M	1.74E-04	Number of Adjustments made to the Flow Meter	Estimate
FCM2AX--ADJC+	4	1H 1.25E-01M	1.74E-04	Number of Adjustments made to the Flow Meter	Estimate
FCV2AF--FOPC+	4	8H 3.00E-06H	2.40E-05	2AF Auto Wall Nozzle Fails Open	See TC File
FCV2AF--HFLC+	4	8H 3.13E-04H	2.50E-03	2AF Auto Wall Nozzle (Operated Manually) Held Open too Wide	See TC File
FPW-----BFLC#	3	24H 1.40E-03H	3.30E-02	Utility Power Fails	F and H-Canyon System Analysis, page P-28
GV-2AF--BFLC+	4	8H 1.67E-02H	1.18E-01	Gang Valve Fails	See TC File
GV-2AF--POSC+	4	8H 3.0E-06H	2.40E-05	Steam Valve Fails Open and Gang Valve Does Not Go to Airblow/Vent	See TC File
INT2AF--BFLC+	4	672H 1.3E-07H	8.74E-05	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	DP-1633, Page 26
INT2AF--STEC+	4	8H 3.0E-06H	2.40E-05	Steam Control Valve to Heat Exchanger Fails Open	WSRC-TR-93-262
INT2AS--BFLC+	4	672H 1.3E-07H	8.74E-05	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	See TC File

Basic Event Report for Red Oil Explosions in Mixer Settler (2PU.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
INT2AX--BFLC+	4	672H 1.3E-07H	8.74E-05	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	See TC File
INTFCV--FOPC+	4	8H 3.0E-06H	2.40E-05	Interlock Fails to Shut Off 2AS Flow due to Flow Control Valve Failing Open	See TC File
INTFCVAXFOPC+	4	8H 3.0E-06H	2.40E-05	Interlock Fails to Shut Off 2AX Flow Due to Flow Control Valve Failing Open	See TC File
OPR2AF--ACNC#	1	1N 5.0E-03N	5.00E-03N	Operator Fails to Stop Transfer	See TC File
OPR2AFTEMCNC#	1	1N 5.0E-03N	5.00E-03N	2AF Temperature Sensor is Miscalibrated	See TC File
OPR2ASTEMCNC#	1	1N 5.0E-03N	5.00E-03N	2AS Temperature Xmitter is Miscalibrated	See TC File
OPR2AXTEMCNC#	1	1N 5.0E-03N	5.00E-03N	2AX Temperature Sensor is Miscalibrated	See TC File
OPR2PU--RMNC#	1	1N 5.0E-3N	5.00E-03N	Impeller Drive (VFD) Not in "Normal" Position	See TC File
OPRSCV--ACNC#	1	1N 5.0E-03N	5.00E-03N	Operator Mistakenly Increases Steam Flow Rate	See TC File
OPRSCVAXACNC#	1	1N 5.0E-03N	5.00E-03N	Operator Mistakenly Increases Steam Flow Rate for the 2AX	See TC File
OPRSPC--VINC#	1	1N 1.0E-01N	1.00E-01N	Operator Fails to Detect Failure of VFD	See TC File
SFW2A---DISC+	1	1N 6.67E-03N	6.67E-03N	Software Interlock Failure - Interlock Operation Disabled	Assume Access Every 18 Months
SPC2PU--BFLC+	4	8H 1.24E-06H	9.92E-06	2nd Pu VFD Fails	See TC File
STE2AF--LFLC+	4	8H 3.0E-06H	2.40E-05	Sufficient Steam to Overheat the Water to the 2AF Heat Exchanger	Valve falure; See TC File
STE2AS--FOPC+	4	8H 3.0E-06H	2.40E-05	Steam Control Valve Fails Open	See TC File
STE2AX--FOPC+	4	8H 3.0E-06H	2.40E-05	Steam Control Valve for the 2AX HX Fails Open	See TC File
SW-DG292BFLC#	1	1N 5.00E-3N	5.00E-03N	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	F-Canyon SAR Addendum One
TE-2AF--FLOC+	4	8H 4.0E-05H	3.20E-04	2AF Temperature Sensor Fails Low	See TC File
TE-2AS--FLOC+	4	8H 4.0E-05H	3.20E-04	2AS Temperature Sensor Fails Low	See TC File
TE-2AX--FLOC+	4	8H 4.0E-05H	3.20E-04	2AX Temperature Sensor Fails Low	See TC File
TNK2AF--FLOC+	4	1H 1D	4.00E-02	Tank of material is nearly empty	Use Frequency in TC file(Down time assumed 1H to fill tank)
TSEN2AF-ADJC+	4	1H 1.25E-01M	1.74E-04	Number of Adjustments Made to the Temperature Sensor	Estimate
TSEN2AS-ADJC+	4	1H 1.25E-01M	1.74E-04	Number of Adjustments Made to the Temperature Sensor	Estimate
TSEN2AX-ADJC+	4	1H 1.25E-01M	1.74E-04	Number of Adjustments Made to the Temperature Sensor	Estimate

Basic Event Report for Red Oil Explosions in Mixer Settler (2PU.BE) (CONT.)

Event	C	Input	Calc.	Description	Source
WAT2AF--FLOC+	4	8H 3.0E-06H	2.40E-05	Sufficient Volumetric Flow of Water (To HX) to Heat 2AF	Valve Failure; See TC File

Type Codes for Red Oil Explosion in the Mixer Settler (2PU.TC)

Type Code	Rate	Description	Source
AG- BFL A	1.24E-06H	First Impeller Fails Due to Motor Failue	WSRC-TR-93-262, page 19, AGI-FA-C, Agitator Failure
AG- BLA A	5.0E-06H	Agitator Blades/Shaft Fail	WSRC-TR-93-262, page 19, AGI-FA-C, Agitator Failure, Less Likely /10
CHM OVH C	1.0E-32H	2nd Pu Mixer Settler Overheated Due to Strong Acid Addition	Estimate Based on Information Obtained From M.L. Hyder
CHM UNR C	1.0E-32H	Uncontrolled Reaction in 2nd Pu Mixer Settler Cause Pyrolysis of TBP	Estimate
DCS CRD C	3.0E-06H	Interlock/Loop Fails due to DCS card Failure	WSRC-TR-93-262 Page 187
DG- FTR C	3.0E-04H	292 Diesel Generator Fails to Run	F-Canyon SAR Addendum One
DG- FTS C	3.0E-2N	292 Diesel Generator Fails to Start	F-Canyon System Analysis
DG- MSC C	2.00E-03N	Misc./Operator Error Causes failure of 292 Diesel to Supply Power	F-Canyon System Analysis
EXH BFL C	2.7E-06H	Canyon Exhaust System Fails	F-Canyon SAR Addendum One
FCM ADJ C	1.25E-01M	Number of Adjustments Made to the Flow Meter	Estimate
FCV FOP C	3.00E-06H	Steam Valve Fails Open	WSRC-TR-93-262, Page 13
FCV HFL C	3.13E-04H	2AF Auto Wall Nozzle (Operated Manually) Held Open too Wide	Estimate: ACN Human Error x 50% Run in Manual Mode
FPW BFL C	1.40E-03H	Utility Power Fails	F and H-Canyon System Analysis, page P-28
GV- BFL C	1.67E-02H	Gang Valve Fails	DPSTSY-200-1H, Page 13
GV- POS C	3.0E-06H	Steam Valve Fails Open and Gang Valve Does Not Go to Airblow/Vent	WSRC-TR-93-262, Page 13
INT BFL C	1.3E-07H	Switch gear failure	DP 1633, Page 26
INT FOP C	3.0E-06H	Interlock Fails to Shut off 2AX Flow Due to Flow Control Valve Failing Open	WSRC-TR-93-262, page 13
INT STE C	3.0E-06H	2AF Auto Wall Nozzle Fails Open	WSRC-TR-93-262, page 13
OPR ACN C	5.0E-03N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal
OPR MCN C	5.0E-03N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal
OPR RMN C	5.0E-3N	Failure to restore following maintenance (Nominal)	WSRC-TR-93-581, Table 4, Item 14, Nominal
OPR VIN C	1.0E-01N	Failure of Visual Inspection (Nominal)	WSRC-TR-93-581, Table 4, Item 31, Nominal
SFW DIS C	6.67E-03N	Software Interlock Failure	Rate x Human Error(RTN), WSRC-TR-93-581
SPC BFL C	1.24E-06H	2nd Pu VDF Fails	DP-1633, Page 20
STE FOP C	3.0E-06H	Steam Control Valve Fails Open	WSRC-TR-93-262, Page 13
STE LFL C	3.0E-06H	Sufficient Steam to Heat the Water too Hot	WSRC-TR-93-262, Page 13
SW- BFL C	5.00E-3N	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	F-Canyon SAR Addendum One
TE- FLO C	4.0E-05H	Temperature measurements (Excluding pyrometers)	DP 1633, Page 28
TNK FLO C	1D	Transfer required to fill tank for 2AF stream	Conservative estimate
TSE ADJ C	1.25E-01M	Number of Times the Temperature Sensor is Calibrated	Estimate; 1/8 months
WAT FLO C	3.0E-06H	Sufficient Volumetric Flow of Water (From HX) to Heat 2AF	WSRC-TR-93-262, Page 13

Appendix 7
Fault Trees & Cutsets for 2nd Pu Mixer-Settler

Calculation No. S-CLC-F-00100
Sheet No. 110 of 135
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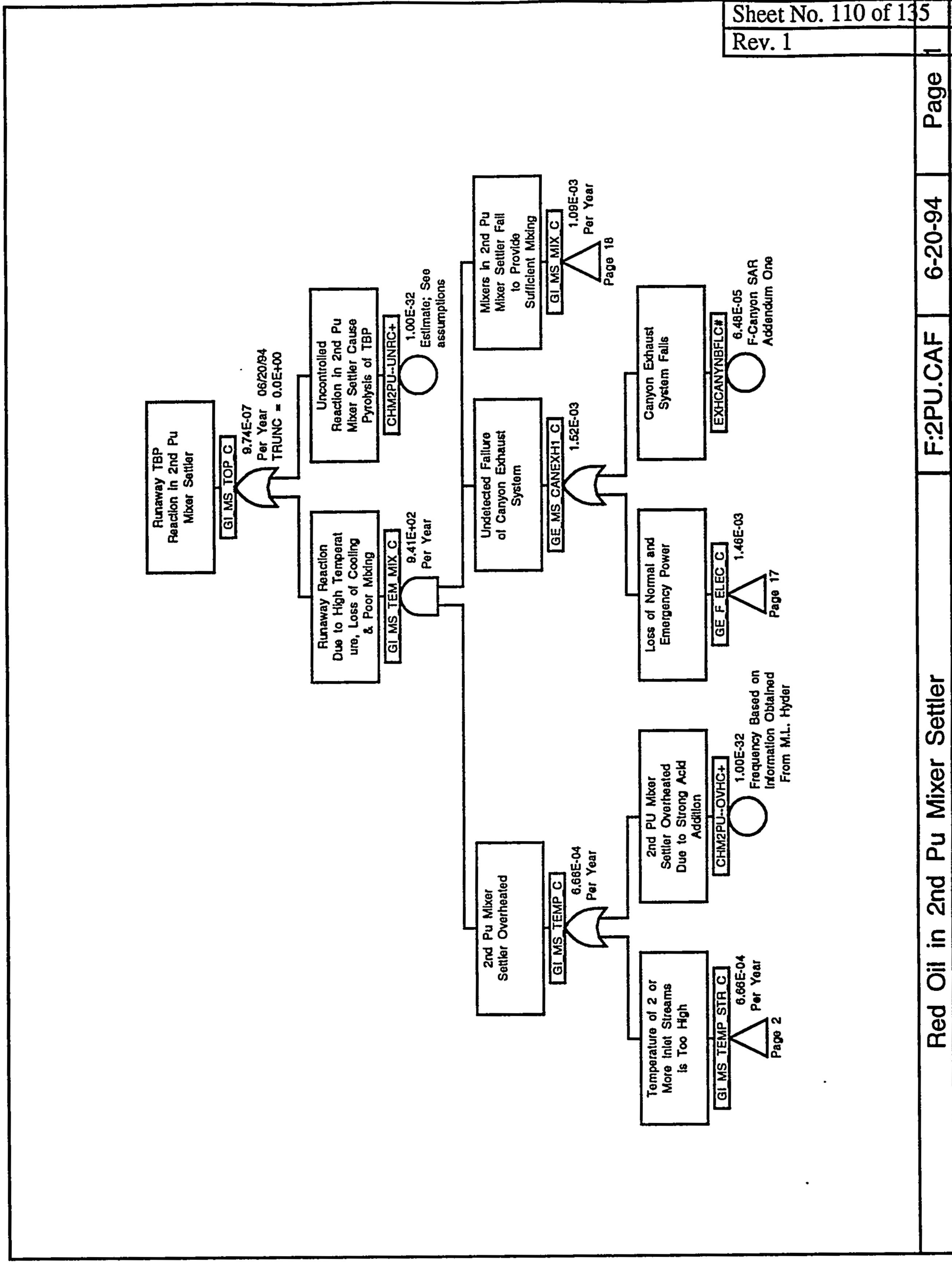

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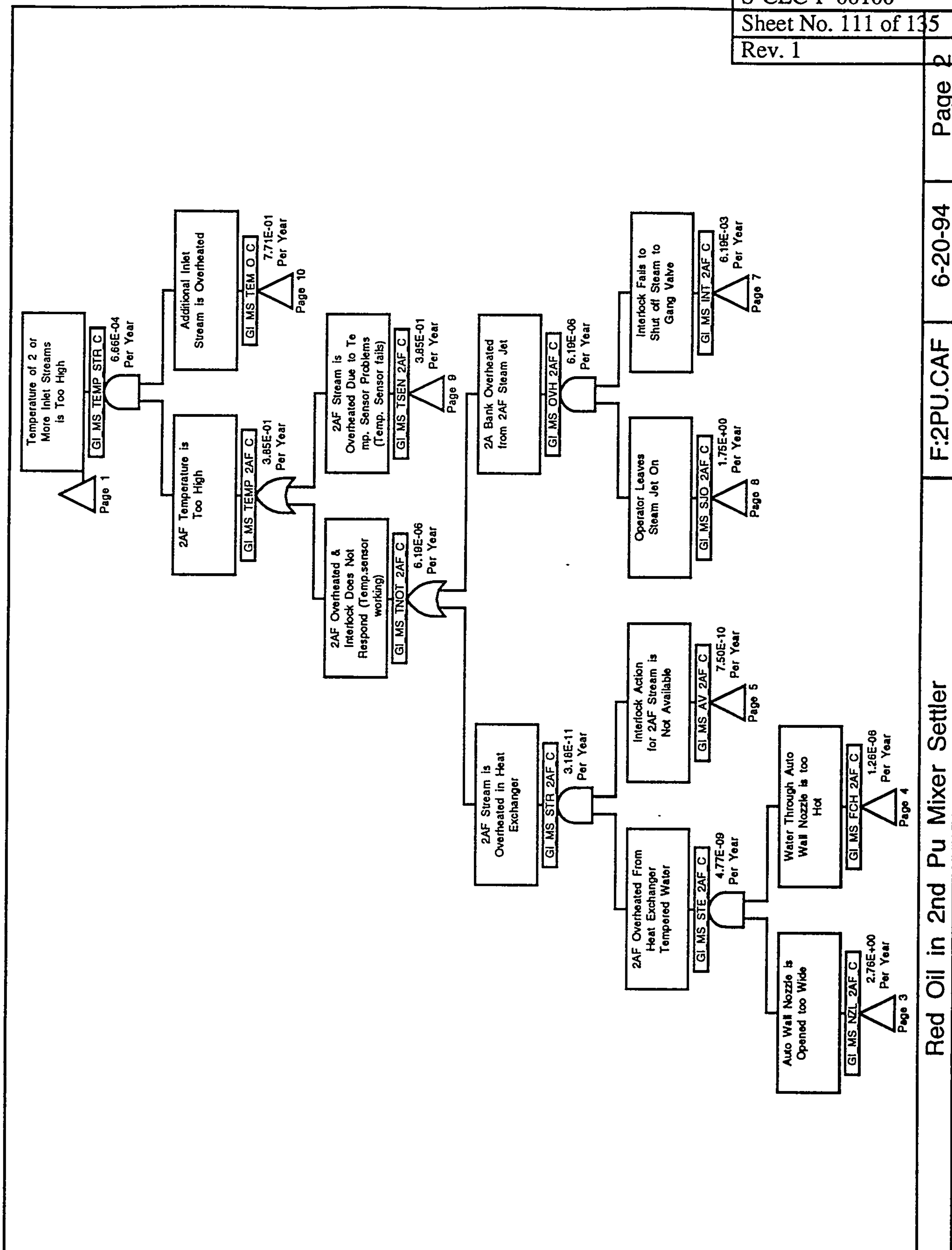

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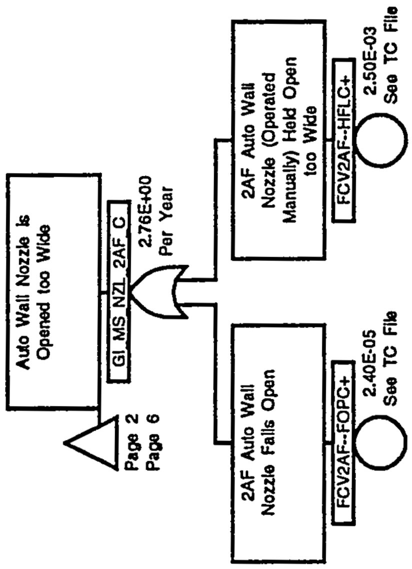

Red Oil in 2nd Pu Mixer Settler | F:2PU.CAF | 6-20-94 | Page 3

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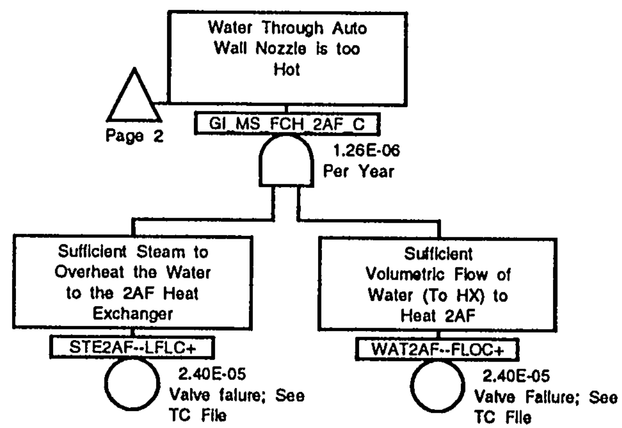

Red Oil in 2nd Pu Mixer Settler | F:2PU.CAF | 6-20-94 | Page 4

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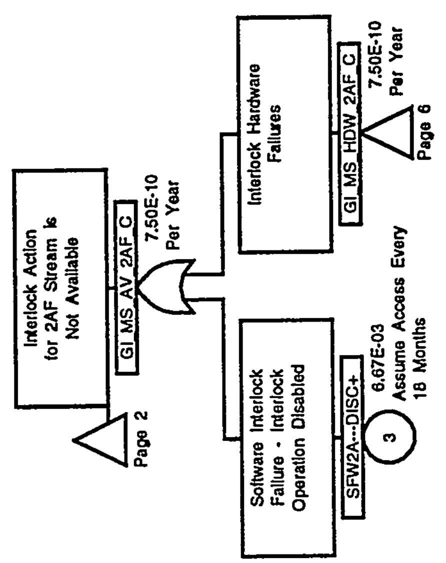

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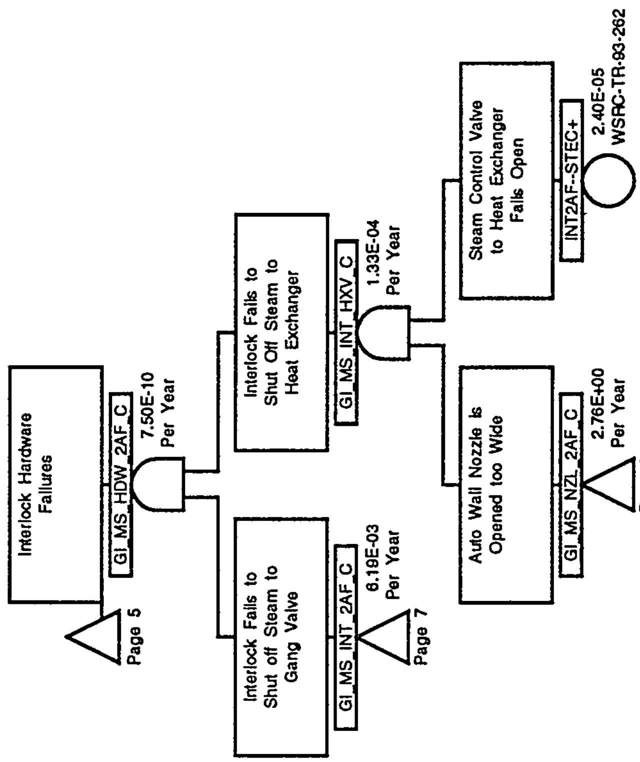

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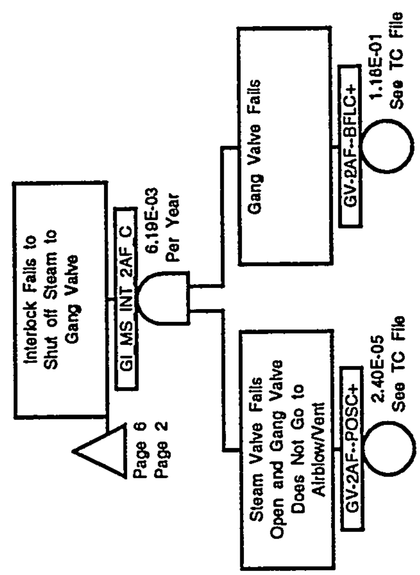

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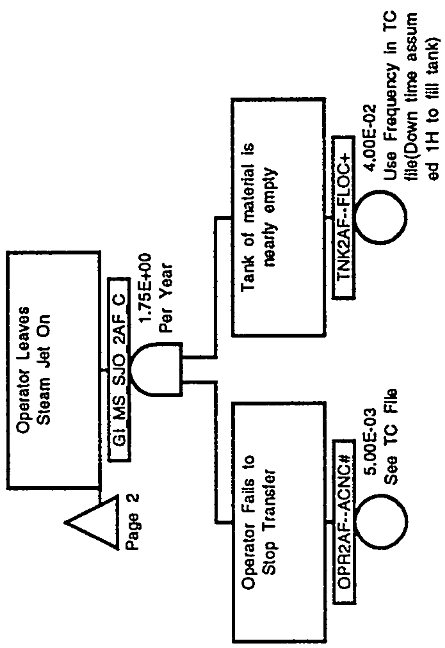

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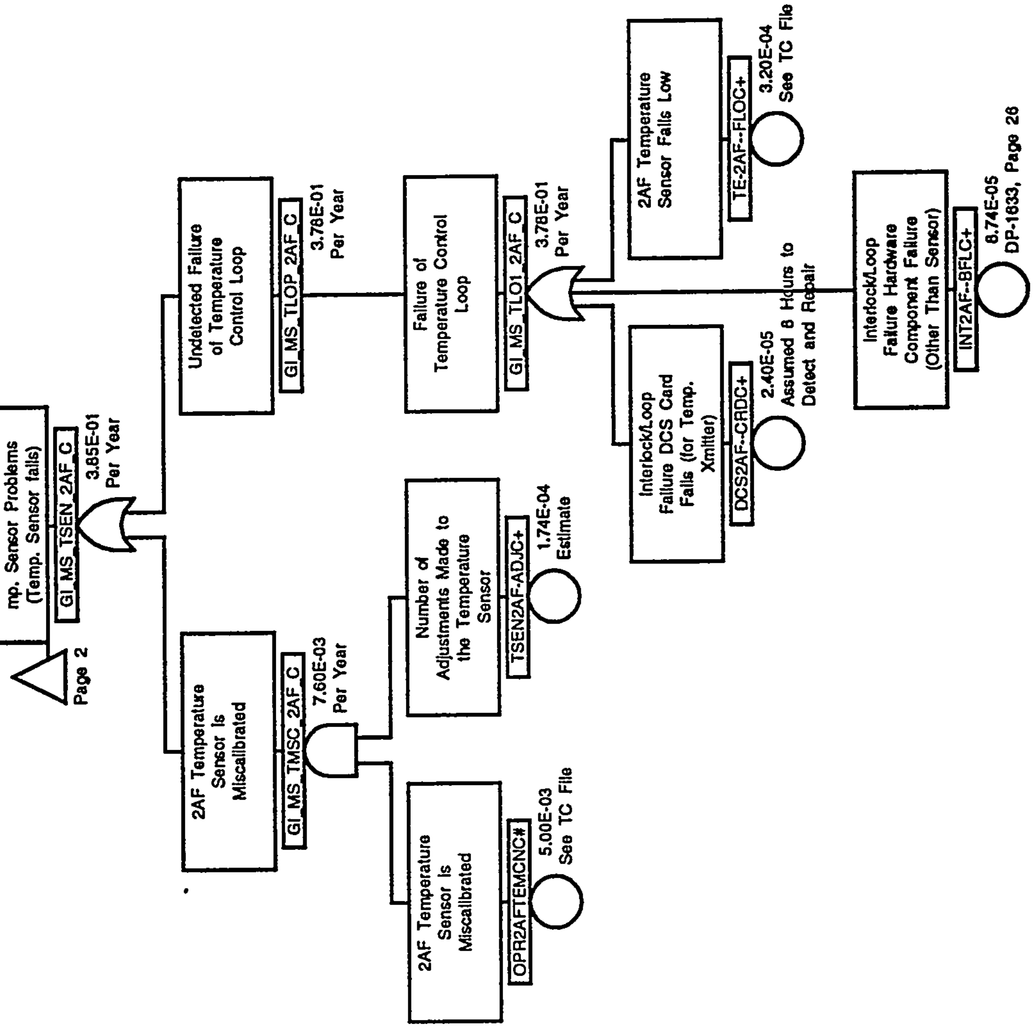

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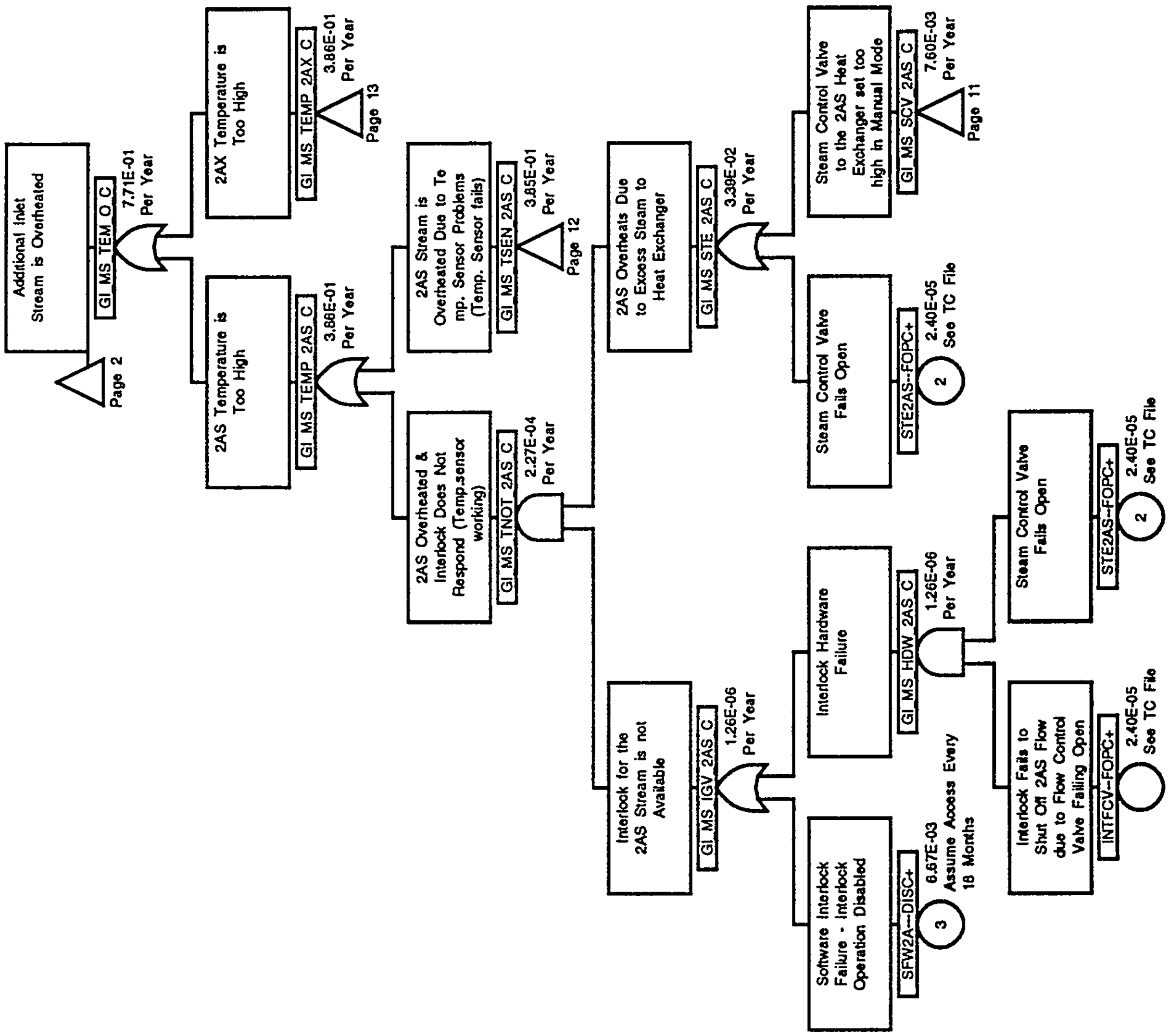

Red Oil in 2nd Pu Mixer Settler | F:2PU.CAF | 6-20-94 | Page 10

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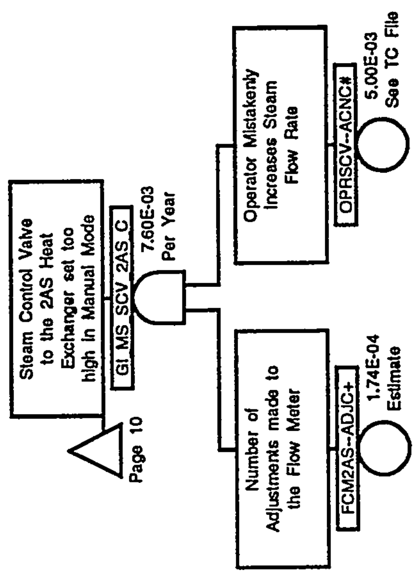

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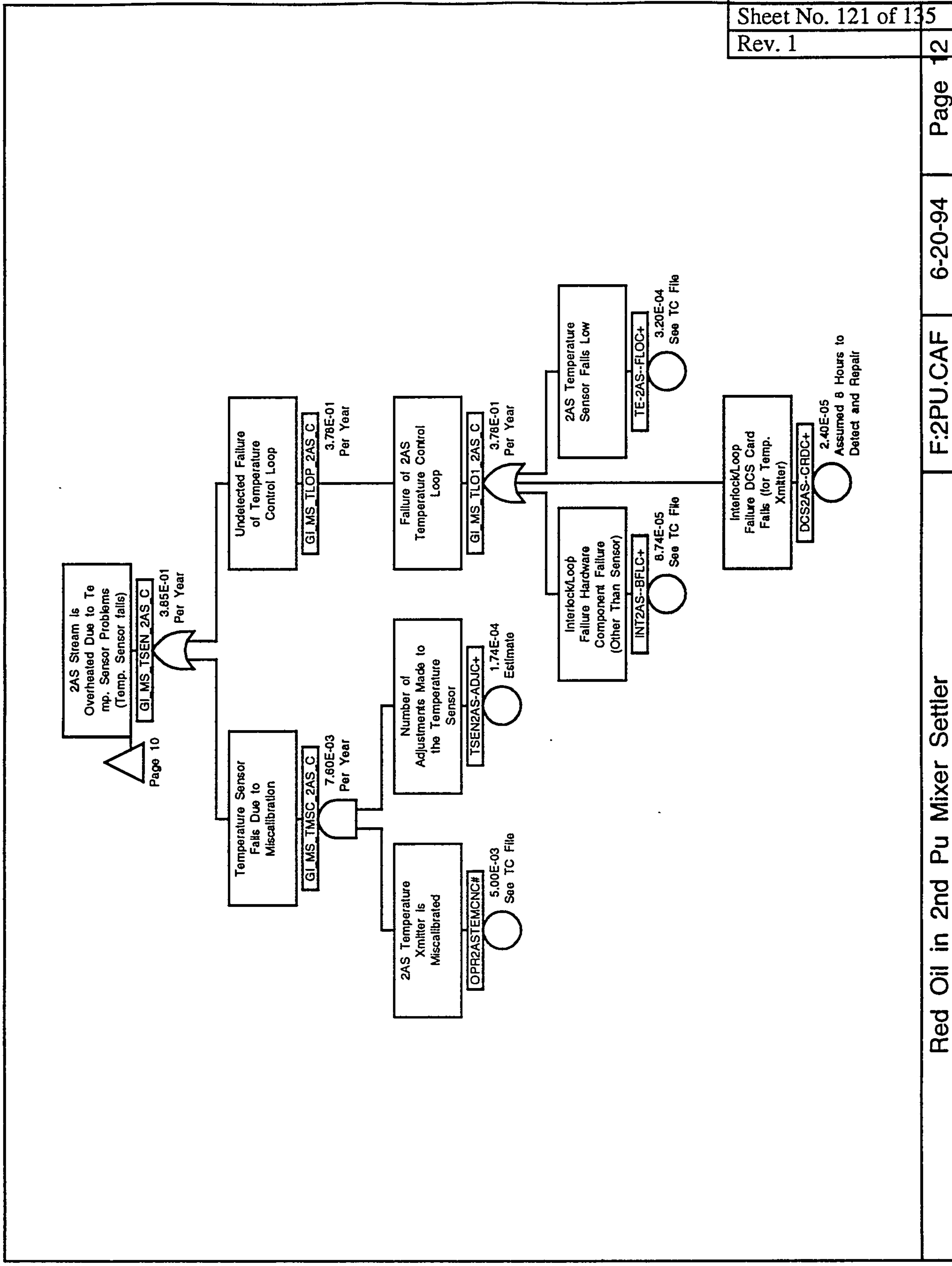

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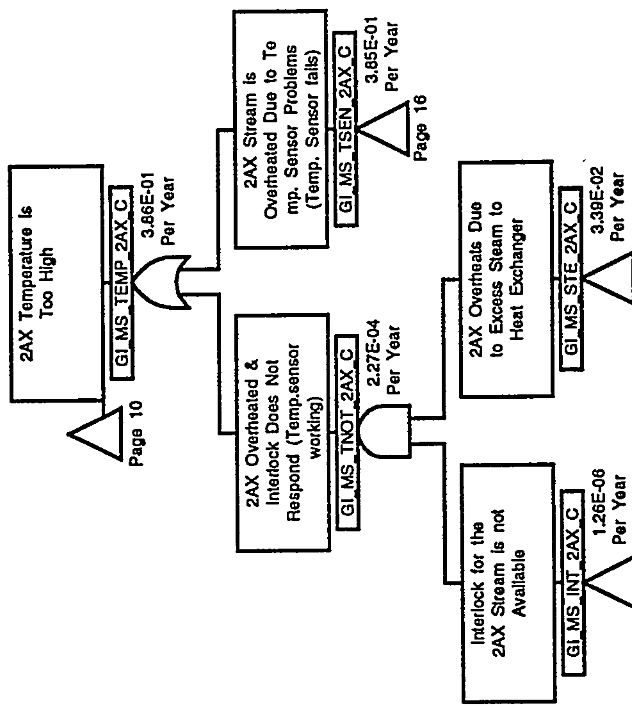

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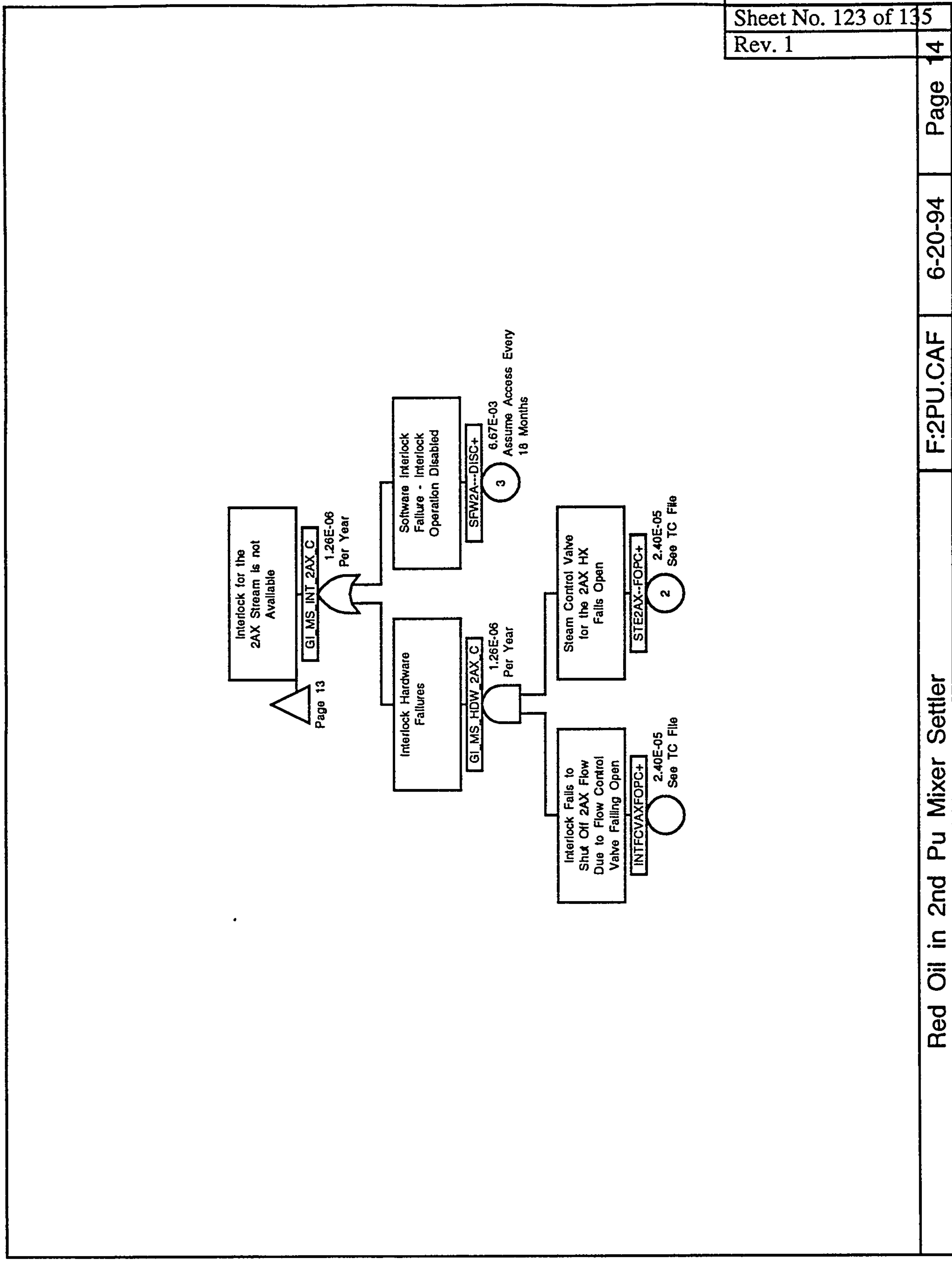

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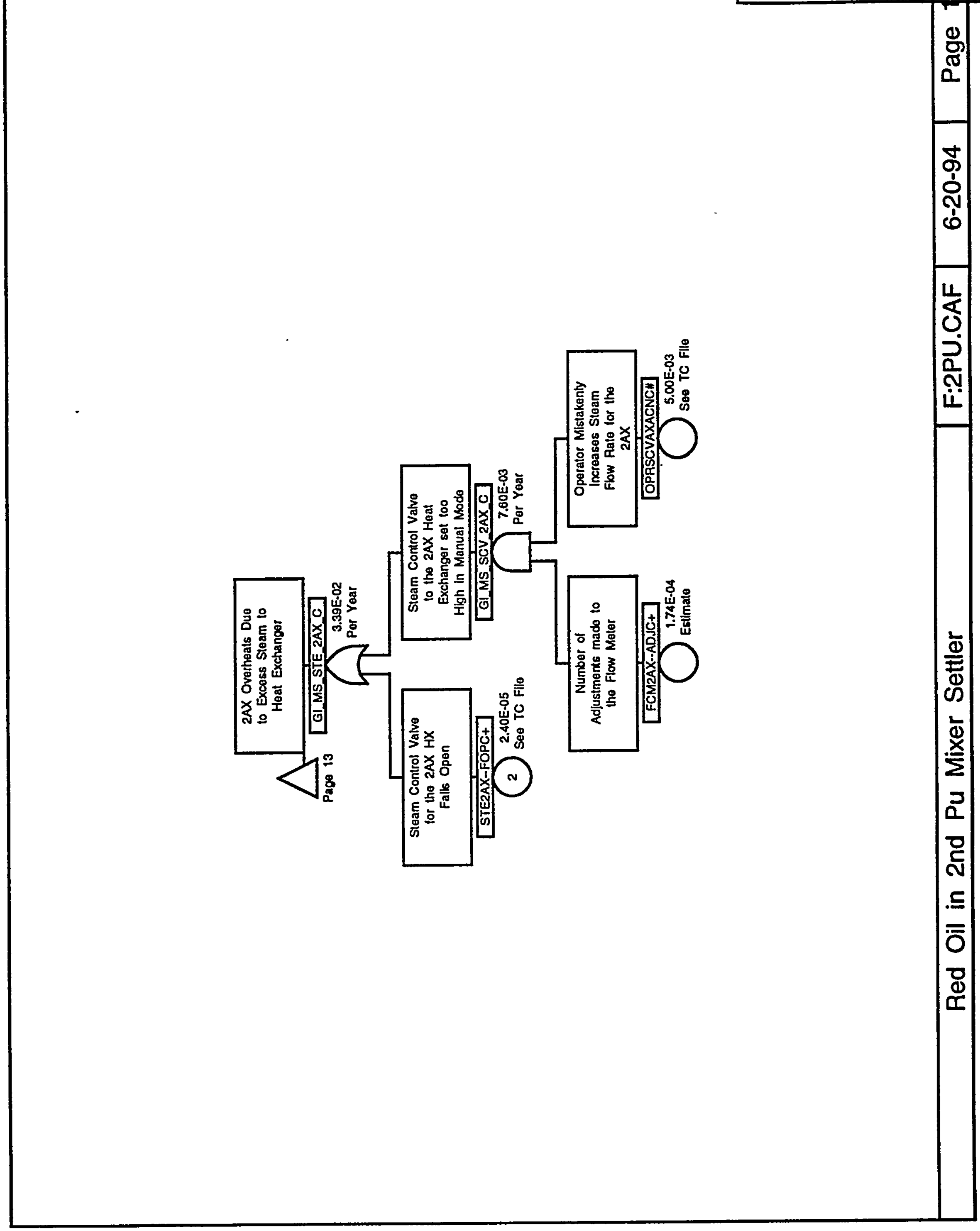

Calculation No. S-CLC-F-00100
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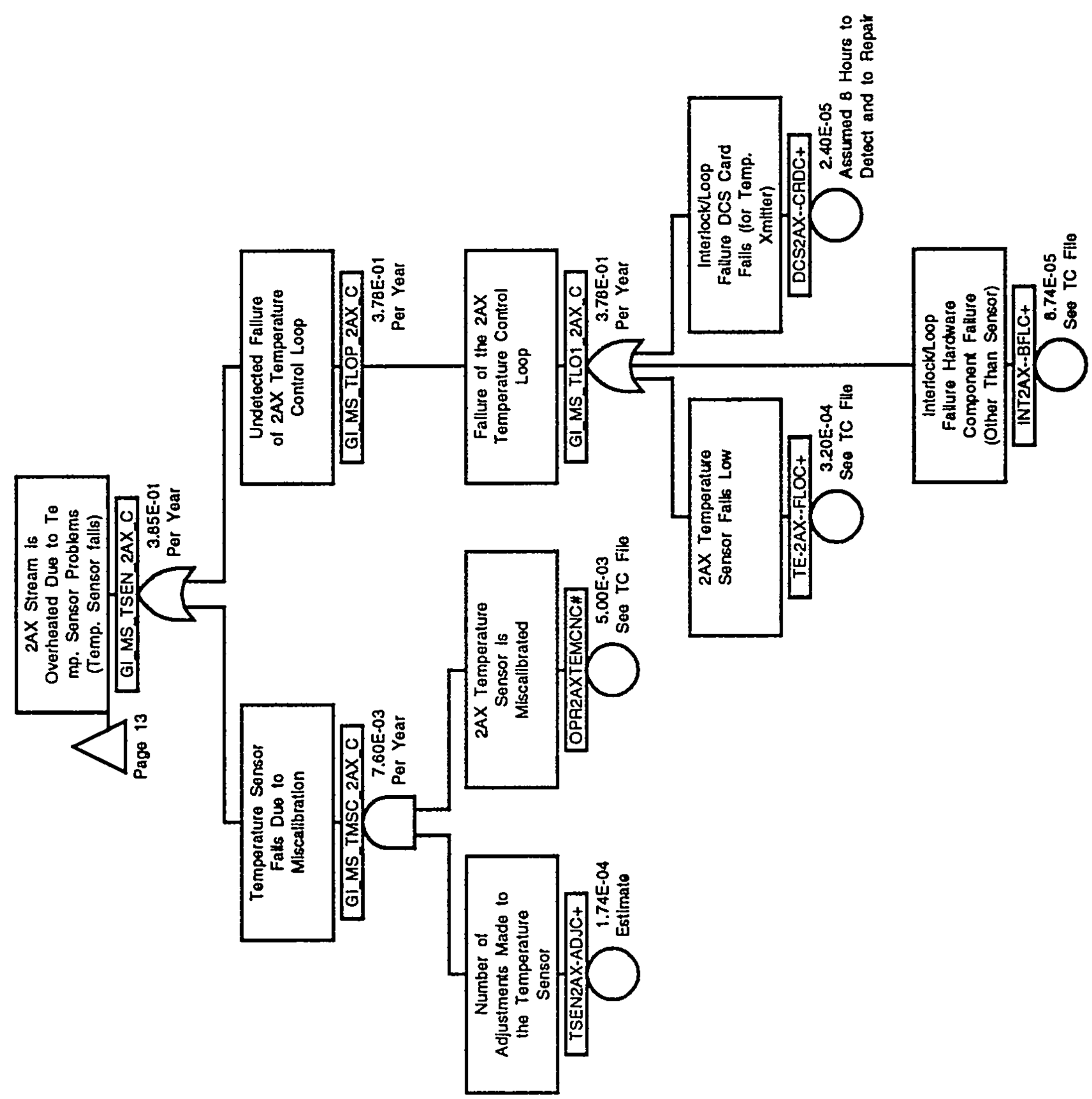

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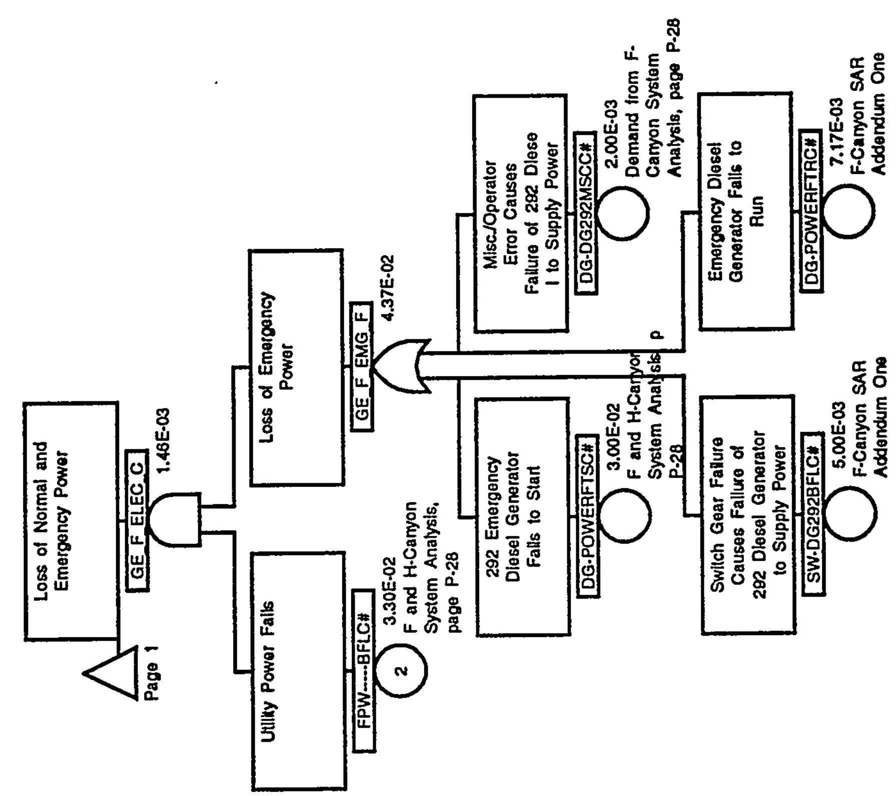

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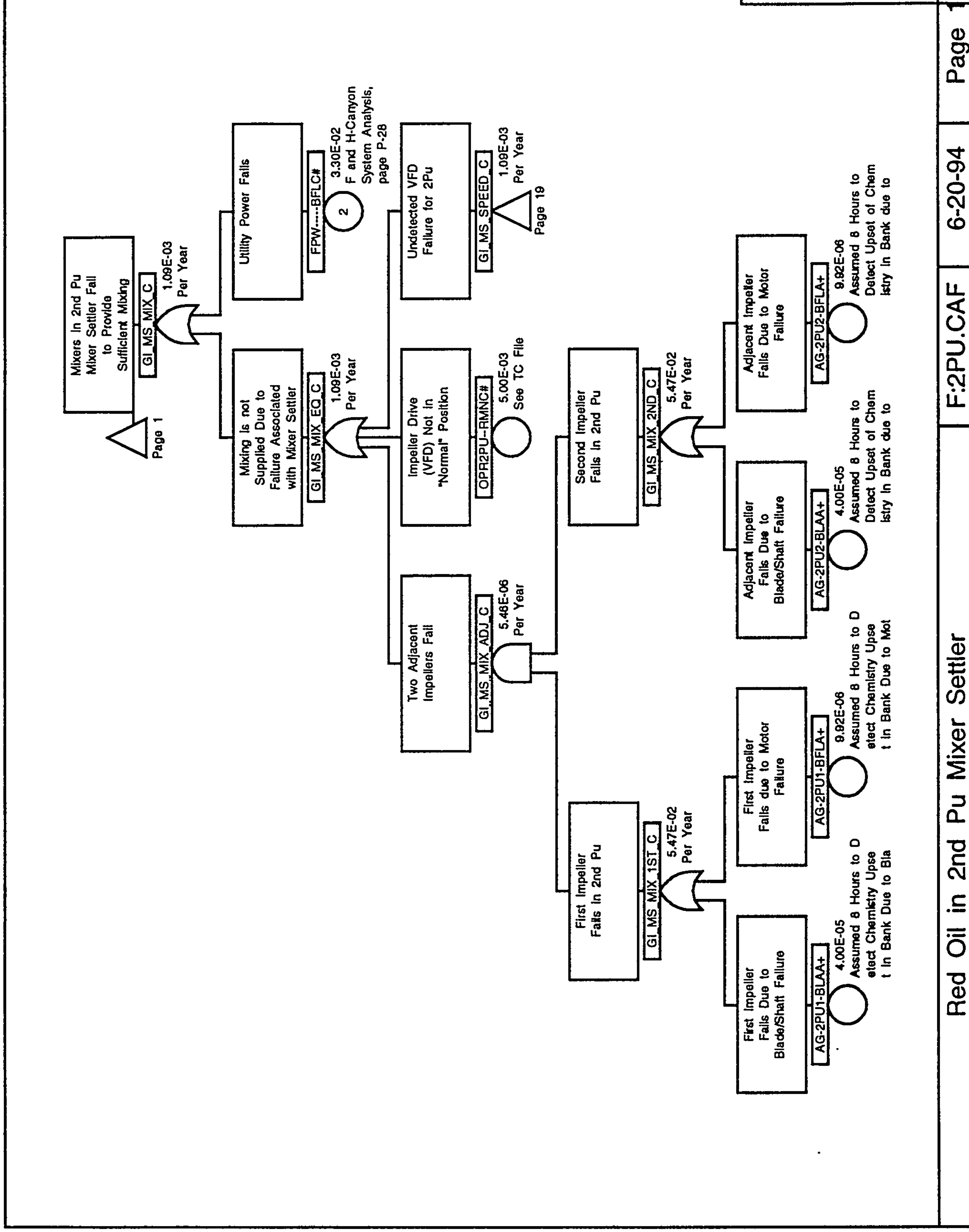

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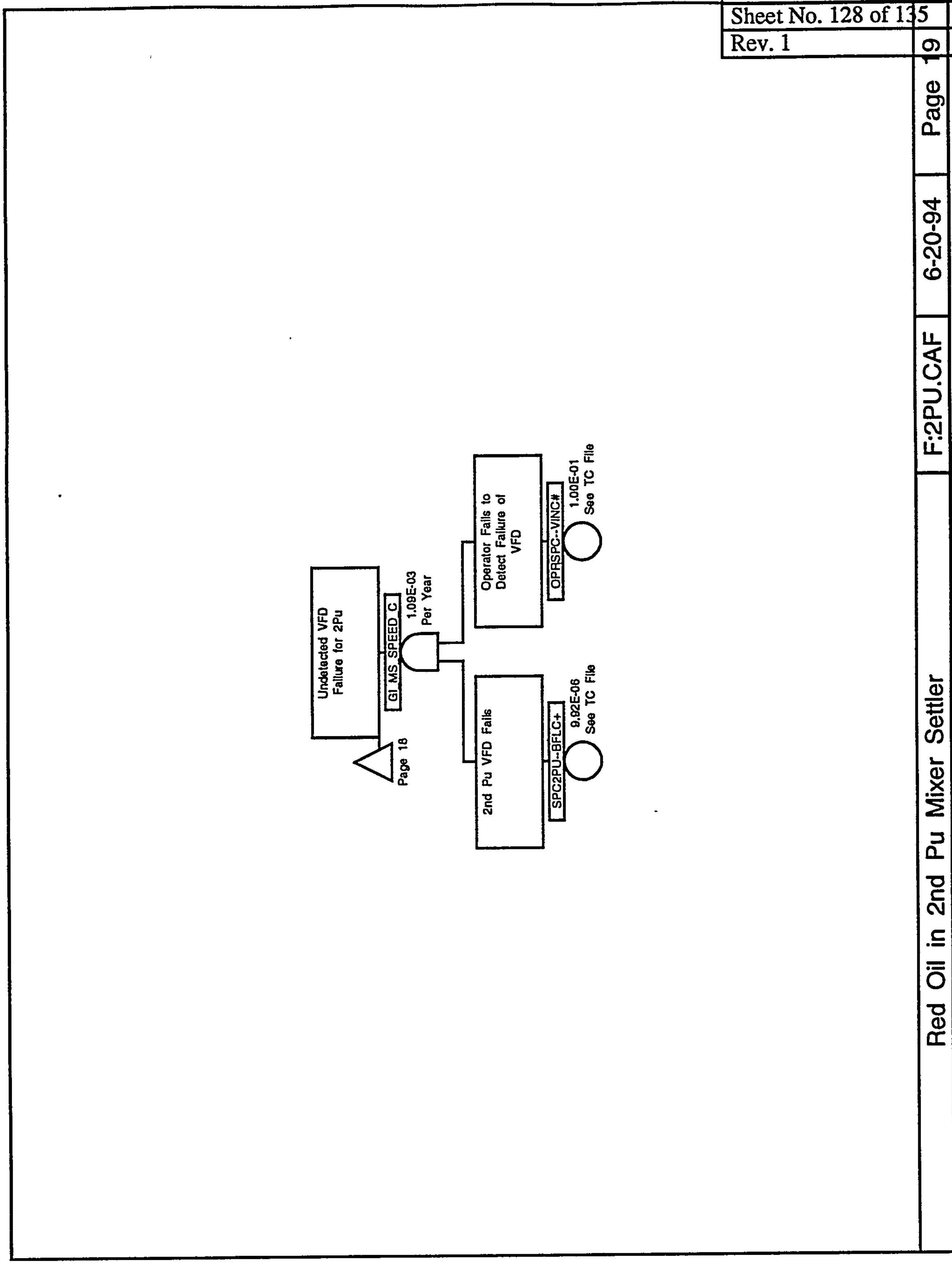

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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AG-2PU1-BFLA+	18		GI_MS_MIX_1ST_C	18		GI_MS_TMSC_2AF_C	9		SW-DG292BFLC#	17	
AG-2PU1-BLAA+	18		GI_MS_MIX_2ND_C	18		GI_MS_TMSC_2AS_C	12		TE-2AF--FLOC+	9	
AG-2PU2-BFLA+	18		GI_MS_MIX_ADJ_C	18		GI_MS_TMSC_2AX_C	16		TE-2AS--FLOC+	12	
AG-2PU2-BLAA+	18		GI_MS_MIX_C	1		GI_MS_TNOT_2AF_C	2		TE-2AX--FLOC+	16	
CHM2PU--OVHC+	1		GI_MS_MIX_C	18		GI_MS_TNOT_2AS_C	10		TNK2AF--FLOC+	8	
CHM2PU--UNRC+	1		GI_MS_MIX_EQ_C	18		GI_MS_TNOT_2AX_C	13		TSEN2AF-ADJC+	9	
DCS2AF--CRDC+	9		GI_MS_NZL_2AF_C	2		GI_MS_TOP_C	1		TSEN2AS-ADJC+	12	
DCS2AS--CRDC+	12		GI_MS_NZL_2AF_C	3		GI_MS_TSEN_2AF_C	2		TSEN2AX-ADJC+	16	
DCS2AX--CRDC+	16		GI_MS_NZL_2AF_C	6		GI_MS_TSEN_2AF_C	9		WAT2AF--FLOC+	4	
DG-DG292MSCC#	17		GI_MS_OVH_2AF_C	2		GI_MS_TSEN_2AS_C	10				
DG-POWERFTRC#	17		GI_MS_SCV_2AS_C	10		GI_MS_TSEN_2AS_C	12				
DG-POWERFTSC#	17		GI_MS_SCV_2AS_C	11		GI_MS_TSEN_2AX_C	13				
EXHCANYNBFLC#	1		GI_MS_SCV_2AX_C	15		GI_MS_TSEN_2AX_C	16				
FCM2AS--ADJC+	11		GI_MS_SJO_2AF_C	2		GV-2AF--BFLC+	7				
FCM2AX--ADJC+	15		GI_MS_SJO_2AF_C	8		GV-2AF--POSC+	7				
FCV2AF--FOPC+	3		GI_MS_SPEED_C	18		INT2AF--BFLC+	9				
FCV2AF--HFLC+	3		GI_MS_SPEED_C	19		INT2AF--STEC+	6				
FPW-----BFLC#	17		GI_MS_STE_2AF_C	2		INT2AS--BFLC+	12				
FPW-----BFLC#	18		GI_MS_STE_2AS_C	10		INT2AX--BFLC+	16				
GE_F_ELEC_C	1		GI_MS_STE_2AX_C	13		INTFCV--FOPC+	10				
GE_F_ELEC_C	17		GI_MS_STE_2AX_C	15		INTFCVAXFOPC+	14				
GE_F_EMG_F	17		GI_MS_STR_2AF_C	2		OPR2AF--ACNC#	8				
GE_MS_CANEXH1_C	1		GI_MS_TEMP_2AF_C	2		OPR2AFTEMCNC#	9				
GI_MS_AV_2AF_C	2		GI_MS_TEMP_2AS_C	10		OPR2ASTEMCNC#	12				
GI_MS_AV_2AF_C	5		GI_MS_TEMP_2AX_C	10		OPR2AXTEMCNC#	16				
GI_MS_FCH_2AF_C	2		GI_MS_TEMP_2AX_C	13		OPR2PU--RMNC#	18				
GI_MS_FCH_2AF_C	4		GI_MS_TEMP_C	1		OPRSCV--ACNC#	11				
GI_MS_HDW_2AF_C	5		GI_MS_TEMP_STR_C	1		OPRSCVAXACNC#	15				
GI_MS_HDW_2AF_C	6		GI_MS_TEMP_STR_C	2		OPRSPC--VINC#	19				
GI_MS_HDW_2AS_C	10		GI_MS_TEM_MIX_C	1		SFW2A---DISC+	5				
GI_MS_HDW_2AX_C	14		GI_MS_TEM_O_C	2		SFW2A---DISC+	10				
GI_MS_IGV_2AS_C	10		GI_MS_TEM_O_C	10		SFW2A---DISC+	14				
GI_MS_INT_2AF_C	2		GI_MS_TLO1_2AF_C	9		SPC2PU--BFLC+	19				
GI_MS_INT_2AF_C	6		GI_MS_TLO1_2AS_C	12		STE2AF--LFLC+	4				
GI_MS_INT_2AF_C	7		GI_MS_TLO1_2AX_C	16		STE2AS--FOPC+	10				
GI_MS_INT_2AX_C	13		GI_MS_TLOP_2AF_C	9		STE2AS--FOPC+	10				
GI_MS_INT_2AX_C	14		GI_MS_TLOP_2AS_C	12		STE2AX--FOPC+	14				
GI_MS_INT_HXV_C	6		GI_MS_TLOP_2AX_C	16		STE2AX--FOPC+	15				

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Cutsets for Red Oil Explosion in the Mixer Settler (2PU.CSR)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	GI_MS_TOP_C					9.74E-07
1.	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	2.22E-07
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
2.	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	2.22E-07
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
3.	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	5.31E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
4.	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	5.31E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
5.	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	3.70E-08
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	

Cutsets for Red Oil Explosion in the Mixer Settler (2PU.CSR) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
6.	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	3.70E-08
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
7.	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	3.07E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AF--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
8.	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	3.07E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AX--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
9.	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	3.07E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AS--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
10.	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	3.07E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AF--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
11.	DCS2AF--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	1.67E-08

Cutsets for Red Oil Explosion in the Mixer Settler (2PU.CSR) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
12.	DCS2AS--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	1.67E-08
	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
13.	DCS2AX--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	1.67E-08
	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
14.	DCS2AF--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	1.67E-08
	DG-POWERFTSC#	292 Emergency Diesel Generator Fails to Start	1	1N 3.0E-2N	3.00E-02N	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
15.	DG-DG292MSCC#	Misc./Operator Error Causes Failure of 292 Diesel to Supply Power	1	1N 2.00E-03N	2.00E-03N	1.48E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
16.	DG-DG292MSCC#	Misc./Operator Error Causes Failure of 292 Diesel to Supply Power	1	1N 2.00E-03N	2.00E-03N	1.48E-08
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	

Cutsets for Red Oil Explosion in the Mixer Settler (2PU.CSR) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
17.	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	7.34E-09
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AF--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
18.	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	7.34E-09
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AX--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
19.	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	7.34E-09
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AS--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
20.	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	7.34E-09
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	INT2AF--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
21.	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	5.12E-09
	INT2AX--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	

Cutsets for Red Oil Explosion in the Mixer Settler (2PU.CSR) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
22.	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	5.12E-09
	INT2AF--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
23.	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	5.12E-09
	INT2AS--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
24.	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	5.12E-09
	INT2AF--BFLC+	Interlock/Loop Failure Hardware Component Failure (Other Than Sensor)	4	672H 1.3E-07H	8.74E-05	
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
25.	DCS2AS--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	3.99E-09
	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
26.	DCS2AF--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	3.99E-09
	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	

Cutsets for Red Oil Explosion in the Mixer Settler (2PU.CSR) (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
27.	DCS2AF--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	3.99E-09
	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AS--FLOC+	2AS Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
28.	DCS2AX--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	3.99E-09
	DG-POWERFTRC#	Emergency Diesel Generator Fails to Run	3	24H 3.0E-04H	7.17E-03	
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
29.	DCS2AF--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	2.78E-09
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AX--FLOC+	2AX Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	
30.	DCS2AS--CRDC+	Interlock/Loop Failure DCS Card Fails (for Temp. Xmitter)	4	8H 3.0E-06H	2.40E-05	2.78E-09
	FPW-----BFLC#	Utility Power Fails	3	24H 1.40E-03H	3.30E-02	
	SW-DG292BFLC#	Switch Gear Failure Causes Failure of 292 Diesel Generator to Supply Power	1	1N 5.00E-3N	5.00E-03N	
	TE-2AF--FLOC+	2AF Temperature Sensor Fails Low	4	8H 4.0E-05H	3.20E-04	

APPENDIX C: EVAPORATOR SAFETY CLASS ITEM ANALYSIS

Calculation Cover Sheet

Project F-Canyon BIO	Calculation No. S-CLC-F-00146	Project Number NA
Title Scoping Study of Red Oil Reactions in the F-Canyon Evaporators(U)	Functional Classification NS Discipline Risk Analysis Group	Sheet 1 of 178

X Preliminary __Committed __Confirmed

Computer Program No. CAFTA+	Version 2.2c

Purpose and Objective

As requested by NMPD Safety Documentation, this Calc-Note determines a scoping evaluation of frequencies of runaway red oil reactions involving more than 3,000 lbs of TBP, in F-Canyon evaporators 8.5E, 7.6E, 7.7E, , and 9.3E. The dominant sequences leading to an explosion and top event frequency for each evaporator are determined by fault tree analyses which include potential system modifications.

Summary of Conclusion

Runaway red oil reactions involving more than 3,000 lbs of TBP in the evaporators (given appropriate modifications) are calculated to be incredible (<10E-6/yr.). Incredibility is achieved by a combination of old and new controls involving: temperature, pressure, solvent inventory, and ensuring that aqueous is present during evaporation. The results of the analysis (i.e. incredibility) are valid only if all changes in the fault tree are incorporated.

Revision

Rev. No.	Revision Description
Rev. A	Initial Issue

Sign Off

Rev. No.	Originator (Print) Sign/Date	Verification / Checking Method	Verifier /Checker (Print) Sign/Date	Manager (Print) Sign/Date
Rev. A	E. V. Browne C. R. Lux L.W. Christiansen			D. A. Sharp

Classification

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OPEN ITEMS

Since this is a scoping study, items which would be considered open in a committed or confirmed calc-note note are listed as assumptions for this study. For this reason, there are no open items.

GENERAL ASSUMPTIONS AND TECHNICAL BASES

1. Very high sp g readings require the operator to shut down the evaporator (high sp g implies that the aqueous layer that prevents runaway red oil reactions is lost).

2. Operator shall verify (via flow measurement) that steam is shut off (closing the steam block valve manually if needed) whenever temperature, steam pressure, or level interlocks demand the steam valve to close.

3. Low solvent hold tank (904, 906, 14.7) level interlock and high level alarm will be installed or modified to ensure that solvent losses do not exceed 10,000 lbs of 30% TBP.

4. The solvent hold tanks (14.7, 904, 906) inventory will be administratively controlled to prevent losses of 30,000 lbs or more.

5. Evaporators will not be operated until levels in solvent hold tanks have stabilized (steady state).

6. Any actuation of the solvent hold tank's (904, 906, 14.7) low level interlock, or discovery of large solvent losses, will require the evaporators to be shut down until accountability of the solvent inventory is performed.

7. Solvent hold tank operator (904, 906, 14.7) will ensure that the solvent feed pump (to banks) is shut off if the low level interlock is demanded.

8. Evaporators will not be operated if the evaporator feed tank agitators are not working.

9. Operator will ensure that agitation is working prior to any transfer into the evaporator feed tanks.

10. Administrative controls will be implemented to limit transfers from 17.5 to 8.7 (and from 7.3 to 8.3) to once per 72 hours to ensure that two full sump receipt tanks are not fed to the continuous evaporator feed tank in an evaporator cycle (ref. 10).

11. Solvent wash waste will not be fed to the batch or continuous evaporators.

12. Verify that sp g in the batch evaporator is greater than 1.1 (matches that of the feed tank at the beginning of the batch) to ensure that an aqueous layer is present.

13. Operator shall trend changes in sp g in the continuous evaporators during roundsheet readings to ensure that feed is not organic (sp g drop).

14. A 1 ft aqueous layer will prevent red oil reaction for up to 9 feet of organic (Ref. 11).

15. Operations will wait for acceptable sample results before continuing processing for those tanks which require sampling (17.5, 7.3, 7.8).

16. Sump receipt tanks (17.5, 7.3) are sampled for O/A prior to any transfers to the evaporators (ref. 10).

17. Operator will stop all transfers to 8.7 if a process upset is detected in 10.8 or 11.7 by the high organic level alarm. If a process upset is detected, the operator will shut down the cycle or ensure that tank contents in 8.7 are not evaporated (ref. 10).

18. Lab must notify F-Canyon if a tank sample has been found to be insufficient (for example the sample is too small) to perform adequate O/A analysis upon it (ref. 10).

19. Every batch must be tested for O/A in tank 7.8.

20. Tanks, cell ventilation, and the F-Canyon structure can withstand runaway red oil reactions involving less than 3,000 lbs of TBP with minimal consequences (ref. 1).

21. Uncontrolled reactions do not generate sufficient heat to raise the evaporator contents over t=120 C and to cause a red oil reaction. Most uncontrolled reactions lead to eructation of evaporator contents, and cause high delta-p's that lead to the steam being shut off. Since it is assumed that uncontrolled reactions cannot lead to red oil reactions, these scenarios are not modeled.

22. Continuous evaporator will not run more than a total of 4 days/month.

23. There exist level, temperature and pressure interlocks, and low feed flow alarms for the continuous evaporators (ref. 10).

24. There exist temperature and pressure interlocks for the batch evaporator (ref. 10).

25. Credit is taken for samples from the 8X11 tanks since 10,000 lbs or greater (of 30% TBP) represents at least 30% of the tank volume. No credit is given to detection of solvent in bi-cell evaporator feed tanks.

26. Calibrations for instrumentation are performed every 6 months.

27. Feed adjustments are performed often enough to ensure that errors leading to failure to supply feed are discovered quickly (prior to evaporation of aqueous).

28. Because small amounts of the TBP will degrade within 72 hours, TBP can not accumulate in the evaporators unless a process upset has occurred (ref. 10).

29. Organic does not accumulate in the evaporator feed tanks as long as the agitator is working.

30. All TBP is assumed to "survive" the continuous evaporator when fed to the batch evaporator.

31. No credit is given to the batch evaporator temperature interlock whenever a very large amount of solvent ($\geq$ 30,000 lbs) is fed because there may not be sufficient aqueous to prevent a runaway reaction even if the steam is shut down.

32. Direct transfer errors to the evaporator feed tanks are not considered because direct solvent paths are assumed blocked off.

33. Operator actions are considered independent when they involve different tanks since the operations usually involve different operators and are not performed simultaneously.

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34. Losses of 10,000 lbs of solvent (3,000 lbs of TBP) can be discovered and corrected prior to feeding an evaporator.

35. Temperature of concentrate in the de-entrainment column will increase and trigger the temperature interlock if there is a failure to supply feed to the evaporator. The temperature will increase due to an increase in the boiling point and sp g of the concentrate (ref. 2).

36. There is sufficient time for the operator to shut off the steam block valve if a high solution temperature or steam pressure is detected (ref. 10).

37. The probability of having 10,000 lbs of solvent in the sump receipt tanks (7.3 & 17.5) is 2.0E-3 (ref. 3).

38. Process upsets occur at a frequency of 1/10 yrs and can be detected and corrected in 12 hours (ref. 10).

39. Agitating prior to sampling is considered an administrative control to ensure that a representative sample is taken (ref. 10).

40. Excess TBP can be received from 1A bank with credit for low level detection in 14.7 to catch a large loss of solvent (≥ 10,000 lbs). For losses involving ≥ 30,000 lbs, credit was given for detection via the low level alarm, since the full capacity of the tank is slightly less than 30,000 lbs and at least one full tank would have to be sent (ref. 12).

41. Can receive excess TBP from 1D bank with credit for low level detection in 904 to catch a large loss of solvent (≥ 10,000 lbs). No credit was given for the low level alarm for losses involving ≥ 30,000 lbs, since the capacity of the tank is large enough that sufficient material could be lost before tripping the alarms.

42. Can receive excess TBP from 7.3 sump receipt tank. Transfers were assumed to be sent from 7.3 5% of the time, per cognizant engineer's estimate.

43. Excess TBP can come from 12.6 during cold streams operations. Cold streams are assumed to be sent to the 9.3E feed tank (via tank 11.4) 25% of the time (ref. 10).

44. No TBP will be received from tank 805 or from 11.3 evaporator overheads.

45. Each batch evaporator processes 100 batches/yr. (ref. 10).

46. In cases where decanting is required, credit has been given to the operators recognizing that they transfer too much organic from feed tank 7.8 to 7.6E during decanting (ref. 10).

47. In cases where decanting is required, credit has been given to the operators recognizing that they transfer too much organic from sump receipt tank 17.5 to 8.7 during decanting (ref. 10).

48. Credit has been given to operators "looking" for a break in sp g indication during all decanting operations (ref. 10).

49. Tanks will be settled by the operator before decanting takes place to prevent the transfer of organic (ref. 10).

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INTRODUCTION

A very small potential exists in the SRS separations operations for an uncontrolled reaction between tri-n-butyl phosphate (TBP) and nitric acid that could result in unacceptable damage to separations facilities and a significant release of radioactive materials.

The recent TBP and nitric acid accident in Tomsk, Russia, resulted in considerable damage and radioactive release. Explosions have also occurred at SRS during the early years of operations. While the SRS separations facilities have operated without incident for many years since the last accident, it is prudent to revisit the SRS defense in depth approach to preventing such an accident and to upgrade preventive procedures and hardware if appropriate.

Originally, due to the lack of knowledge and experimental data , it was assumed in the evaporator's fault trees that a red oil reaction could occur whenever TBP was exposed to temperatures exceeding 120 degrees (C) or at temperatures above 80 degrees but below the evaporation point for the solution. Since evaporation of the solution is a very good mechanism for removing any excess heat from an uncontrolled reaction at temperatures below 120 degrees, the original fault trees modeled runaway reactions occurring during a) cooldown b) heating prior to boiling and c) during excessive heating.

Preliminary experimental results demonstrate that this type of reaction would not occur if an aqueous layer (ref. 1) is present unless the temperature exceeds 120 degrees (C). Since the vessels at SRS are open systems a second set of fault trees were developed to determine the frequency of a red oil reaction due to overheating or due to evaporation of the aqueous layer and several proposed instrumentation and administrative control changes. The presence of aqueous in the evaporator tanks allow credit to be taken for temperature interlocks. The temperature of the solution is limited by the boiling point of the aqueous solution, and the sp g of the solution increases as the aqueous is evaporated (ref. 2).

INPUT

Basic data used to quantify the fault trees came from the following sources: WSRC-TR-93-262, "Savannah River Site Generic Data Base Development", WSRC-TR-83-581, "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities", Low Activity Waste (LAW) Study Guide (221-F Canyon), High Activity Waste (HAW) Study Guide (221-F Canyon), and estimates by F-Canyon and SRTC engineers/scientists (references 2,3,4,5). Complete sources for the basic events in the fault trees are listed in their corresponding "Basic Event and Type Code" reports, which are included in this Calc-Note. The basic event file also includes assumptions involving restoration and mission times used to calculate unavailabilities and unreliabilities of equipment.

ANALYTICAL METHODS AND COMPUTATIONS

Fault tree analysis was used to generate a logic model that generates "minimal" combinations (cutsets) of events that yield a runaway red oil reaction involving in excess of 3,000 lbs of TBP. The fault trees' logic structure was developed based on extensive discussions of a) canyon operations with F-Canyon engineers (D. Chostner, R. Eubanks (ref. 10), S. Marek, and T. G. Campbell), and b) experimental results by SRTC (ref. 1,11).

In order for a runaway red oil reaction of sufficient magnitude to compromise the F-Canyon containment to occur, it must involve at least 3,000 pounds of TBP. In addition, the organic must be heated to 120 C or above in the absence of an aqueous layer of at least one foot.

The fault trees model failures of the three main controls that prevent runaway red oil reaction: solvent inventory control, temperature control, and ensuring the presence of aqueous in the evaporator.

The analysis is conservative because the fault tree calculates the frequency of runaway reaction for 3,000 lbs (in the first two cases below), and for 10,000 lbs (in the last case). Reactions involving more than 3,000 pounds will happen with less frequency than those involving exactly 3,000 lbs because it is less likely to have a large process upset than a small one, so the calculated frequency will conservatively bound the "actual" frequency.

Continuous Evaporators

- Excess TBP (>3,000 lbs) is fed to the continuous evaporator and failure to regulate steam pressure to maintain a safe temperature. Credit is given to automatic shut down of steam by the pressure and temperature interlocks. If the interlocks do not work, but the loss of control is detected by the temperature, steam, and sp g sensors or alarms, then credit is given to an operator for closing a steam block valve.

- Excess TBP (3,000 lbs) is fed to the continuous evaporator and failure to maintain an aqueous layer, and failure to shut down steam. Credit is given to automatic shut down of steam by level and temperature interlocks if the heating tubes begin to uncover. If the interlocks do not work, but failure is detected by the temperature, level, flow, and sp g sensors or alarms, then credit is given to an operator for closing a steam block valve. It is postulated that as long as the steam is shut off before all the aqueous is evaporated a runaway reaction is prevented. It should be noted that operators could be misled by the correct instrumentation signals (high level, low sp g) to increase the steam flow and therefore remove the aqueous present.

- Excess TBP (10,000 lbs) is fed to the continuous evaporator and normal operation. Credit is given to automatic shut down of steam by the temperature interlock. It should be noted that, due to the large amount of TBP and small amount of aqueous in this scenario, a rapid response is necessary.

Batch Evaporators

- Excess TBP (3,000 lbs) is fed to the batch evaporator and failure to regulate steam pressure to maintain a safe temperature. Credit is given to automatic shut down of steam by the pressure and temperature interlocks. If the interlocks do not work, but the loss of control is detected (by the temperature, steam, and sp g sensors or alarms), then credit is given to an operator for closing a steam block valve.

- Excess TBP (3,000 lbs) is fed to the batch evaporator and failure to maintain an aqueous layer by overcooking the feed. Credit is given to sp g instrumentation and to automatic shut down of steam by the temperature interlock (due to an increase in boiling point).

- Excess TBP (7,000) is fed to the batch evaporator from the continuous evaporator bottoms tank during normal operation. Credit is given to verification that the sp g in the batch evaporator matches that of the evaporator feed tank at the beginning of the batch.

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The following table shows the sources of TBP for each evaporator and mechanisms for detecting its presence.

Evaporator	Source of TBP	Detection
Continuous		
8.5E	Solvent Extraction Bank 2A Solvent Extraction Bank 2B (cold streams operations) Sump Receipt Tank 17.5 B-Line (via tank 9.7), this event was judged incredible because: a) no further processing of B-Line material planned b) would have to transfer organic up to B-Line unnoticed then back down to canyon again	Organic high level alarm in tank 906 Organic low level alarm in tank 906 Organic level alarm in decanter 11.7 Organic level alarm in decanter 10.8 Sampling 17.5 Trending sp g in 8.5E (roundsheet)
9.3E	Solvent Extraction Bank 1D Solvent Extraction Bank 1A Sump Receipt Tank 7.3 Tank 12.6 (cold streams operations)	Organic high level alarm in tank 904 Organic low level alarm in tank 904 Organic high level alarm in tank 14.7 Organic low level alarm in tank 14.7 Sampling 7.3 Trending sp g in 9.3E (roundsheet)

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Evaporator	Source of TBP	Detection
Batch		
7.6E	8.5 Bottoms Tank (see above 8.5E)	Sampling in tank 7.8 Verification of matching sp g between 7.6E and 7.8 prior to evaporation
7.7E	8.5 Bottoms Tank (see above 8.5E)	Sampling tank 7.8 Verification of matching sp g between 7.7E and 7.8 prior to evaporation
	.	

The development of the fault trees underwent extensive revisions and the assumptions list the requirements needed to prevent unacceptable runaway red oil reactions. The list below shows some of the additional controls that were considered, but that were not feasible.

- Providing cooling water or drown tanks to the evaporators
- High and low sp g interlocks for the evaporator
- Trending sp g in the evaporator (no interlocks or alarms)
- Improved sampling

RESULTS

The frequency of evaporator explosion due to red oil reaction is listed in the following table for each of the evaporators analyzed. The final sets of fault trees and resulting cutsets are included in Appendices C, D and E.

Evaporator	Operation	Frequency (/yr.)
Continuous		
8.5E	Continuous Mode	9E-11
9.3E	Continuous Mode	2E-9
Batch		
7.6E	Batch (8.5E Bottoms Only)	3E-10
7.7E	Batch (8.5E Bottoms Only)	3E-10

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CONCLUSION

The frequency of red oil explosion in F-Canyon is determined to be incredible by fault tree analysis. These results are contingent upon the facility implementation of all assumptions Runaway red oil reactions are unlikely to occur in the evaporators because very large amounts of TBP are needed to cause significant uncontrolled reactions in a well vented system. Experimental analysis and consequence studies demonstrate that only reactions involving more than 3,000 lbs of TBP could result in unacceptable releases to the environment and public. These red oil reactions are prevented by maintaining administrative controls of solvent inventory, ensuring that the evaporator's temperature remains below 120 C, and ensuring that one foot of aqueous is maintained in the evaporator to provide adequate heat removal.

REFERENCES

1. M. L. Cowen, "Uncontrolled TBP-Nitric Acid BIO Risk Analysis (F-Canyon BIO Reference Paper, Uncontrolled TBP-Nitric Acid Reactions)", EPD-SSS-940010. Westinghouse Savannah River Co. June 20, 1994.

2. Inter-Office Memorandum from T. G. Campbell, "Boiling Points of Various Evaporator Solutions", Westinghouse Savannah River Co. August 26, 1994.

3. Inter-Office Memorandum from T. G. Campbell, "Probability for Accumulation of TBP in Canyon Sumps", Westinghouse Savannah River Co. June 3, 1994.

4. Inter-Office Memorandum from S. H.Marek, "8.5 Evaporator Information", Westinghouse Savannah River Co. August 4, 1994.

5. Inter-Office Memorandum from Tracy Rudisill (with attachments), "RE: Mixing Studies" , Westinghouse Savannah River Co. August 30, 1994.

6. C. H. Blanton and S. A. Eide. "Savannah River Site Generic Data Base Development" ,,WSRC-TR-93-262. Westinghouse Savannah River Co. June 30, 1993

7. H.C. Benhardt et al. "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities", WSRC-TR-93-581. Westinghouse Savannah River Co. February 28, 1994.

8. Low Activity Waste (LAW) Study Guide (221-F Canyon). Training Course NSATSYWE. Westinghouse Savannah River Co.

9. R. E. Vail, "Human Factors Review of the 'Red Oil' Explosion Fault Trees for the F Canyon Evaporators", EPD-SIM-940098. Westinghouse Savannah River Co. October 5, 1994.

10. D. F. Chostner and R. A. L. Eubanks, "Existing Parameters to Mitigate TBP Reaction in 221-F (U)", NMP-EFA-94-0289. Westinghouse Savannah River Company. October 14, 1994.

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14. R. A. L. Eubanks, "906 Operator Independence (U)", NMP-EFA-94-0309. Westinghouse Savannah River Co. November 21, 1994.

15. H. A. Ford, "Common Cause Parameters Using the Multiple Greek Letter Method-Work Performed by Los Alamos National Laboratory for WSRC (U)", WSRC-TR-92-470. Westinghouse Savannah River Co. June 21, 1993.

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ATTACHMENTS AND APPENDICES

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APPENDIX A - MEMORANDA

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INTER-OFFICE MEMORANDUM
Savannah River Site

26-Aug-1994 02:53pm EST

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASRS2)
Dept: NMPD Safety Documentation
Tel : 2-3319

Boiling Points of Various Evaporator Solutions

I have found some good information on vapor-liquid equilibrium and boiling points in DPSOP 250, "200 Areas Process Guidebook". Using this information, I have made some calculations to prove our assumption that the temperature interlock will be reached before all of the aqueous in an evaporator could be boiled away. In these calculations I assumed the temperature interlock was set at 118 C, although I'm sure we could set the interlock lower without adversely impacting operations.

Under normal operating conditions, a continuous evaporator runs with a boiling sp g of 1.25, and makes overheads with about 6% nitric acid. For this condition, the vapor-liquid equilibrium chart in DPSOP 250 gives a sodium nitrate concentration of 25% (about 3.7M) and 20% nitric acid (about 4.0M), with a boiling point of 112 C, which is consistent with our experience. Concentrating this solution to a boiling point of 118 C gives a final sodium nitrate concentration of 33% and nitric acid concentration of 23%. The sp g would be about 1.33 (boiling). The volume reduction to reach this point is only about 30%.

If you assume that the evaporator bottoms have no solids (very unusual), only nitric acid, then to make 6% nitric acid overheads would require the bottoms to be about 32% nitric acid, with a boiling point of about 106 C. To reach a boiling point of 118 C, the evaporator bottoms must be concentrated to about 56% nitric acid. My calculations indicate a volume reduction in this case of about 75%, which is probably somewhat larger than actual because of the conservative assumptions I made about the amount of nitric acid lost to the overheads.

In my opinion, expected operating conditions are closer to the first example, with the second example being more of a worse case. In both of the examples, however, the temperature interlock of 118 C would be reached and the evaporator shut down well before all of the aqueous is gone. As I mentioned earlier, the interlock probably can be lowered to at least 115 C, thus providing even more margin.

Although the above calculations were primarily done with the continous waste evaporators (9.3E and 8.5E) in mind, the same conclusions can be expected with the batch evaporators, especially when they are being used for acid stripping concentrated bottoms. As for 17.7E, you can concentrate uranyl nitrate to a boiling point of 118 C also, but the U concentration (wt%) would have to be increased from about 30% (1.5 sp g) to about 75% (sp g of over 2.2). I find it hard to believe that the evaporator would continue to operate under these conditions. The temperature interlock on 17.7E could be lowered substantially, however, probably to about 110 C.

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INTER-OFFICE MEMORANDUM
Savannah River Site

03-Jun-1994 04:30pm EDT

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASRS2)
Dept: NPSR
Tel: 2-3319

Probability for Accumulation of TBP in Canyon Sumps

Process solvent is expected to be received in canyon sump receipt tanks from time to time due to overflows and leaks from canyon tanks and piping. Procedures require that accumulated solvent be removed from receipt tanks before amounts (about 3000 pounds of TBP) are reached that could be a concern from a "red oil" reaction standpoint. The only way an amount can be received that is large enough to be of concern is from a single sump transfer. Experience indicates that the frequency of receiving such a large mass of organic material unexpectedly into a canyon vessel is very low. Myself, Ronnye Eubanks, and Dave Chostner conservatively estimate that a receipt of solvent, containing more than 3000 pounds of TBP, can be expected in the sump receipt tanks less than once every five years. This value is considered conservative because loss of such a large volume would be detected during operations. Actions other than transfer to sump receipt would be expected in these situations. Also, in our collective experience in the canyons (more than 40 years) we can recall of no occasion when such a large volume of organic material was received into a sump receipt tank from a leak, spill, or transfer error. Please incorporate this value (once in 5 years for receipt of large volumes of solvent in sump receipt) into the sump receipt tank fault trees for "red oil".

Distribution:

To: Lance W. Christiansen
(CHRISTIANSEN-LW-L0489 @A1@SLSRP1)

CC: ONELIO M. EBRA-LIMA (EBRALIMA-OM-T5452 @A1@SLSRP1)
CC: Ray Lux (LUX-CR-T7244 @A1@SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 AT A1 AT SASRS2)
CC: David F. Chostner
(CHOSTNER-DF-03090 AT A1 AT SASRS2)
CC: Ronnye A. L. Eubanks
(EUBANKS-RA-06258 AT A1 AT SASRS2)
CC: Sandra H. Marek (MAREK-SH-07923 AT A1 AT SASRS2)

INTER-OFFICE MEMORANDUM
Savannah River Site

30-Aug-1994 02:25pm EST

To: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)

CC: Thomas G. Campbell (CAMPBELL-TG-05094 @A1@SASR52)

From: Tracy 5. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLSRP1
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : 52539

RE: Mixing Studies

Neguib estimates the experimental work will be complete by the end of September. He anticipates data analysis and documentation will require approximately 2 months. Therefore, we should have correlation(s) for the canyon tanks by the end of November.

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INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 08:15am EST

To: See Below

From: Neguib M. Hassan (HASSAN-NM-L2267 AT A1 AT SASR52)
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : x5-5765

RE: Good News About Mixing Tests

This may be a worse case, but in the next few runs we will reduce the liquid level in small increments and establish a mixing pattern. We know thus far that just below the second impeller (approximately 12 inches of liquid in our tank or about 5.3 feet scaled canyon tank-8' x 11') no organic is detectable in the current sampling procedure.

Distribution:

To: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52)

CC: DON F. PADDLEFORD
(PADDLEFORD-DF-H0010 AT A1 AT SLSRP1)
CC: Tracy 5. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLSRP1)
CC: Lee Hyder (HYDER-ML-T3258 AT A1 AT SLSRP1)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT A1 AT SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 @A1QSASRS2)
CC: Ray Lux (LUX-CR-T7244 AT A1 AT SLSRP1)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)
CC: Thomas G. Campbell (CAMPBELL-TG-05094 @A1@SASRS2)
CC: David F. Chostner (CHOSTNER-DF-03090 @A1@SASRS2)
CC: Charlene B. Cochran (COCHRAN-CB-06921 @A1@SASRS2)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT A1 AT SLSRP1)
CC: Jim Knight (KNIGHT-JR-T3559 AT A1 AT SLSRP1)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT A1 AT SLSRP1)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @A1@SASRS2)
CC: Major C. Thompson (THOMPSON-MC-T3324 @A1@SASRS2)

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INTER-OFFICE MEMORANDU~
Savannah River Site

22-Jul-1994 08:23am EST

To:**See Below**

From: Tracy 5. Rudisill
(RUDISILL-TS-T6876 AT Al AT SLSRPl
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : 52539

RE: Good News About Mixing Tests

When the tank is full, two agitator blades are used to mix the tank. This doubles the mixing power and is apparently enough to form a dispersion which reaches the dip tube at the bottom of the tank. In Neguib's previous work, the liquid level was just below the bottom of the top agitator.

There will also be a very low liquid level where the mixing quality would permit the detection of large amounts of organic. At this point, a single agitator would provide enough power to disperse the organic phase. Intermediate levels seem to be the problem.

Distribution:

To: Charlene B. Cochran
(COCHRAN-CB-06921 AT Al AT SASRS2)
To: Thomas G. Campbell (CAMPBELL-TG-05094 @Al@SASR52)

CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl)
CC: Lee Hyder (HYDER-ML-T3258 AT Al AT SLSRPl)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT Al AT SLSRPl)
CC: William E. Harris (HARRIS-WE-05596 @Al@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT Al AT SLSRPl)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT Al AT SLSRPl)
CC: David F. Chostner (CHOSTNER-DF-03090 @AlQSASR52)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT Al AT SLSRPl)
CC: Jim Knight (KNIGHT-JR-T3559 AT Al AT SLSRPl)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT Al AT SLSRPl)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @AlQSASR52)
CC: Major C. Thompson (THOMPSON-MC-T3324 @Al@SASRS2)

INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 11:02am EST

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52
Dept: NMPD Safety Documentation
Tel : 2-3319

RE: Good News About Mixing Tests

I've got to make one more comment on this subject.

If covering the top set of agitator blades is what is important for sampling organic, then a tank certainly does not have to be "full". In canyon tanks, both sets of agitator blades are covered by the time the tank is about half full. In 8x11 and 10x11 tanks, there is four feet between the bottom of the lower set of blades and the bottom of the upper set of blades. The bottom set of blades is within about six inches of the bottom of the tank. Therefore both sets of blades should be covered before the tank contains five feet of solution. In bicell tanks, which are 15 feet high, there is six feet from bottom to bottom of the agitator blades. Again, the upper set of blades are covered by the time the tank is about half full.

From what Neguib said in his message, I'm not sure your test equipment is scaled correctly. He said the upper impeller is uncovered at 5'3" of liquid level. In an actual canyon 8x11 tank, the upper set of agitator blades would be covered by at least 3 inches of solution at that level.

Distribution:

To: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLSRP1)

CC: Charlene B. Cochran
(COCHRAN-CB-06921 AT A1 AT SASRS2)
CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT A1 AT SLSRP1)
CC: Lee Hyder (HYDER-ML-T3258 AT A1 AT SLSRP1)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT A1 AT SLSRP1)
CC: William E Harris (HARRIS-WE-05596 QA1@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT A1 AT SLSRP1)
CC: ONELIO M EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)
CC: David F Chostner (CHOSTNER-DF-03090 @A1@SASRS2)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT A1 AT SLSRP1)
CC: Jim Knight (KNIGHT-JR-T3559 AT A1 AT SLSRP1)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT A1 AT SLSRP1)
CC: Neguib M Hassan (HASSAN-NM-L2267 QA1@SASRS2)
CC: Major C Thomp~on (THOMPSON-MC-T3324 @A1@SASR52)

INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 11:40am EST

To: See Below

From: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl Dept: WESTINGHOUSE STAFF
Tel :45420

RE: Good News About Mixing Tests

I guess I meant---filled above upper stirrer blades--- instead of full. Apparently this would only be half full according to T. Campbell's response. You may well be right that full could represent a bad situation too?? I don't know whether the scale tests covered this "full" depth or not.

Don

Distribution:

To: Charlene B. Cochran
(COCHRAN-CB-06921 AT Al AT SASRS2)

CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT Al AT SLSRPl)
CC: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT Al AT SLSRPl)
CC: Lee Hyder (HYDER-ML-T3258 AT Al AT SLSRPl)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT Al AT SLSRPl)
CC: William E. Harris (HARRIS-WE-05596 @Al@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT Al AT SLSRPl)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT Al AT SLSRPl)
CC: Thomas G. Campbell (CAMPBELL-TG-05094 @Al@SASRS2)
CC: David F. Chostner (CHOSTNER-DF-03090 @Al@SASRS2)
CC: Charlene B. Cochran (COCHRAN-CB-06921 @Al@SASRS2)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT Al AT SLSRPl)
CC: Jim Knight (~NIGHT-JR-T3559 AT Al AT SLSRPl)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT Al AT SLSRPl)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @Al@SASR52)
CC: Major C. Thompson (THOMPSON-MC-T3324 @Al@SASRS2)

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INTER-OFFICE MEMORANDUM
Savannah River Site

22-Jul-1994 12:30pm EST

To: See Below

From: Neguib M. Hassan (HASSAN-NM-L2267 AT A1 AT SASR52
Dept: CPT/CHEMICAL & HYDROGEN TECH
Tel : x5-5765

RE: Good News About Mixing Tests

The second impeller in our small tank is currently located 14 inches from the bottom of the tank and it can be moved up/down. In the prelimenary test runs, we collected data at 6, 8 and 12 inches with one set of impeller and found that no organic is detectable at the 12 inch level even when the initial concentration of organic was 8% volume. In the current runs, we raised the liquid level above the second impeller to see the effect. As I mentioned we can locate the second impeller at any point in the shaft and repeat an experiment. Thanks for the information

Distribution:

To: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52)

CC: Tracy S. Rudisill
(RUDISILL-TS-T6876 AT A1 AT SLSRP1)
CC: Charlene B. Cochran
(COCHRAN-CB-06921 AT A1 AT SASRS2)
CC: DON F. PADDLEFORD
(PADDLEFORD-DF-HOO10 AT A1 AT SLSRP1)
CC: Lee Hyder (HYDER-ML-T3258 AT A1 AT SLSRP1)
CC: James R. Schornhorst
(SCHORNHORST-JR-Y4538 AT A1 AT SLSRP1)
CC: William E. Harris (HARRIS-WE-05596 @A1@SASRS2)
CC: Ray Lux (LUX-CR-T7244 AT A1 AT SLSRP1)
CC: ONELIO M. EBRA-LIMA
(EBRALIMA-OM-T5452 AT A1 AT SLSRP1)
CC: David F Chostner (CHOSTNER-DF-03090 @A1@SASR52)
CC: CLINT R. WOLFE (WOLFE-CR-H0021 AT A1 AT SLSRP1)
CC: Jim Knight (KNIGHT-JR-T3559 AT A1 AT SLSRP1)
CC: Frank R. Graham (GRAHAM-FR-T6413 AT A1 AT SLSRP1)
CC: Neguib M. Hassan (HASSAN-NM-L2267 @A1@SASRS2)
CC: Major C. Thompson (THOMPSON-MC-T3324 @A1@SASR52)

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INTER-OFFICE MEMORANDUM
Savannah River Site

30-Aug-1994 03:35pm EST

To: See Below

From: Thomas G. Campbell
(CAMPBELL-TG-05094 AT A1 AT SASR52)
Dept: NMPD Safety Documentation
Tel : 2-3319

See Attached

It looks like it will be a long time before we have anything conclusive on O/A sampling reliability from SRTC. As Dave has suggested, an in-canyon test is still probably our best bet to get useful information anytime soon.

Diatribution:

To: Andrew P. Mock (MOCK-AP-L0498 AT A1 AT SASR52)
To: Charlene B. Cochran
(COCHRAN-CB-06921 AT A1 AT SASRS2)
To: Renee H. Spires (SPIRES-RH-06630 AT A1 AT SASRS2)
To: David F. Chostner
(CHOSTNER-DF-03090 AT A1 AT SASR52)
To: Ray Lux (LUX-CR-T7244 QA1QSLSRP1)
To: Eric V. Browne (BROWNE-EV-Y8089 QA1QSLSRP1)
To: J. Stuart Evans (EVANS-JS-07266 AT A1 AT SASRS2)

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INTER-OFFICE MEMORANDUM
Savannah River Site

04-Aug-199408:26am FDT

To: Eric V. Browne (BROWNE-EV-Y8089 eA1QSLSRP1)

CC: Charlene B. Cochran
(COCHRAN-CB-06921 AT A1 AT SASRS2)
CC: Ronnye A. L. Eubanks
(EUBANKS-RA-06258 AT A1 AT SASRS2)
CC: David F. Chostner
(CHOSTNER-DF-03090 AT A1 AT SASRS2)

From: Sandra H. Marek (MAREK-SH-07923 AT A1 AT SASRS2)
Dept: NMPD/SEP TECH.
Tel : 9524199

8.5 Evaporator Information

Attached is the information you reque~ted for 8.5E. Bryan, one of our STE's, reviewed some blueprints to perform the calculations and verified/corrected the numbers I gave you off the top of my head on Tuesday. I'll call you later today to discuss these numbers and some of your other assumptions.

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INTER-OFFICE MEMORANDUM
Savannah River Site

03-Aug-1994 05:28am EDT

To: Sandra H. Marek (MAREK-SH-07923 AT A1 AT SASRS2)

From: Bryan K. Altringer
(ALTRINGER-BK-Y5558 AT A1 AT SASRS2
Dept: SEP TECH
Tel : 952-2153

__Info you requested (U)__

OK...
By now you should have found the four prints I left you. Hope they are helpful. Sorry about the poor quality of the one showing the trays.

1. The overflow wier is at 96.7", or 15,360 lb water

2. Typical steam rates for 8.5E are 13,500 lb/hr to 16,500 lb/hr (or 15,000+/-1500 lb/hr). It's unusual to see it run outside this range. I normally assume 15,000 lb/hr as the normal rate.

3. Time to lose 1 ft level....this is a fun one.

Assumptions: 15,000 lb/hr steam 90% efficiency (0.9 lb evap per lb steam) initial liquid level at wier height, 96.7" sp gr at 1.0 (this made it easier for me)

Calculations:
Feed rate = (15,000 lb/hr)(0.9) = 13,500 lb/hr
Final liquid level = 96.7" - 12" = 84.7"
Final pounds = ~11,634 lb (per calib chart)

Pounds depletion = 15,360 lb - 11,634 lb
= 3726 lb

Time = (3726 lb)/(13,500 lb/hr) = 0.26 hr
= 16.56 minutes (How 'bout those sig figs!)

NOTE: You know as well as I do how the lb/in varies so much in a continuous evaporator. Ultimately, this calculation is only one of many possibilities for the evaporator...

4. The typical length of a run:

Assumptions:
Full 8.7 at 146,797 lb water
Heel of 36,000 lb water
Typical run rate = 13,500 lb/hr feed

Time = (146,797 lb - 36,000 lb)/(13,500 lb/hr)
8.2 hr

If you count startup and shutdown heating and cooling times (while the evaporator above 80 degrees C), Ronnve mav have been able to stretch it to 16 hours. I do not believe we could have gotten 16 hours on feed.

5. How far down 'till we uncover the tube bundle? A quickie roundabout calculation based on the prints lead~ me to believe that we could go down as far as 1.5 ft below wier level before uncovering tubes. Unfortunately, this number sounds funny to me. Check it out.

6. Distance between the bottom of the de-entrainment column and the bottoms of the reboiler looks to be about 4.5 feet based on the prints. You can check it out yourself.

I didn't have time to look into any of the instrumentation stuff. I saw the alarm light you saw for the "low hat flow," but that's all I saw.

Have fun...

APPENDIX B - DIAGRAMS

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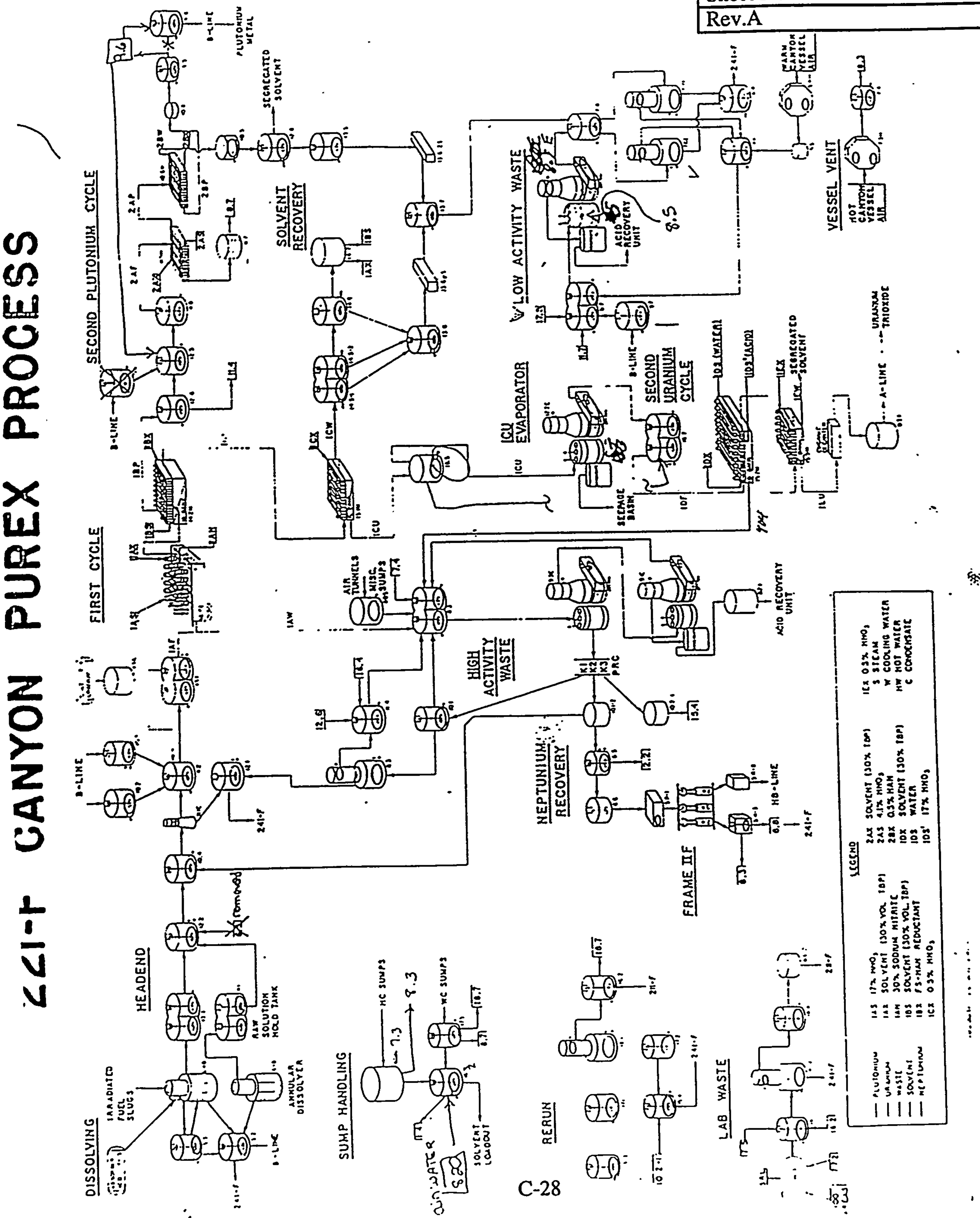

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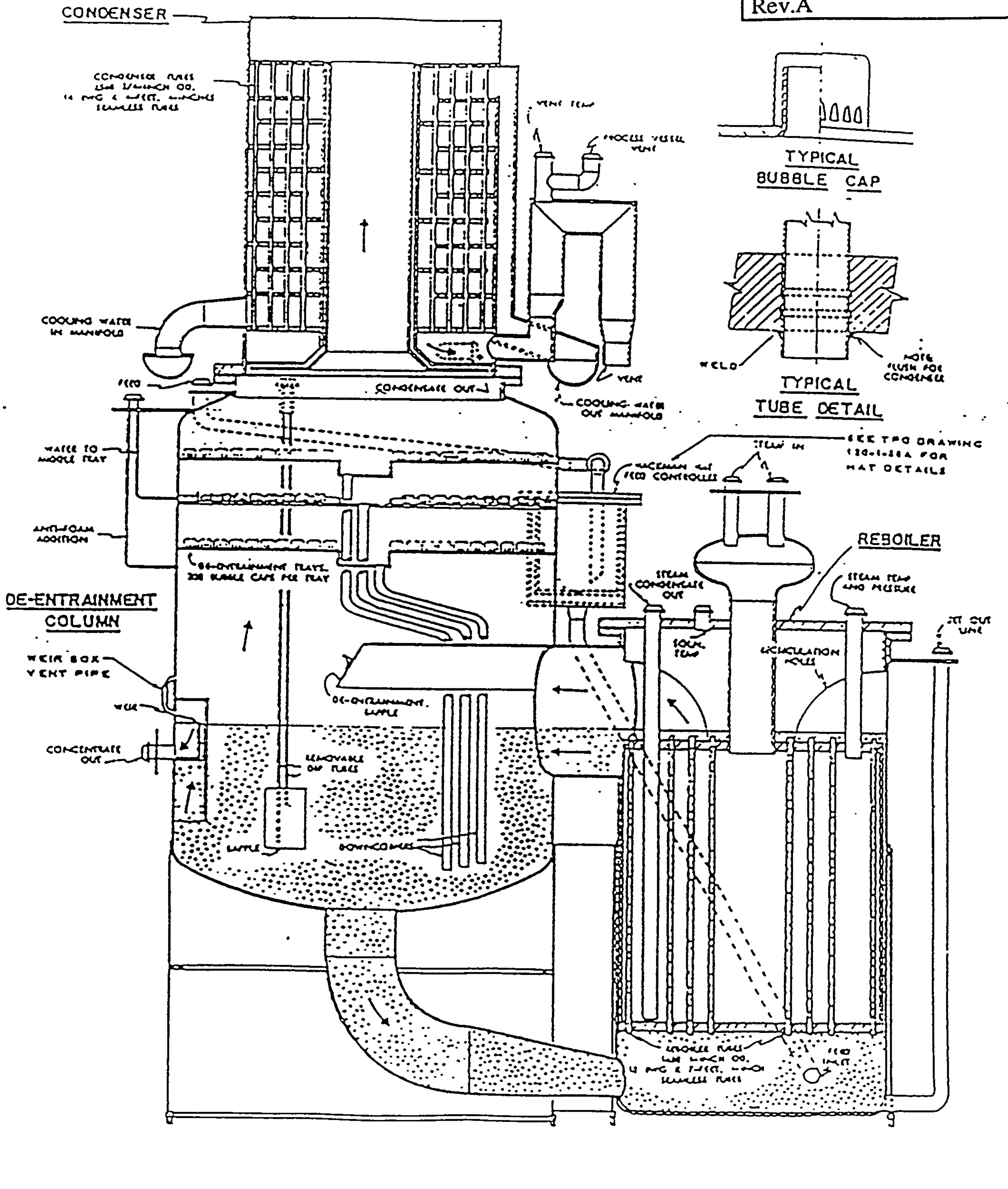

Schematic of Continuous Evaporator

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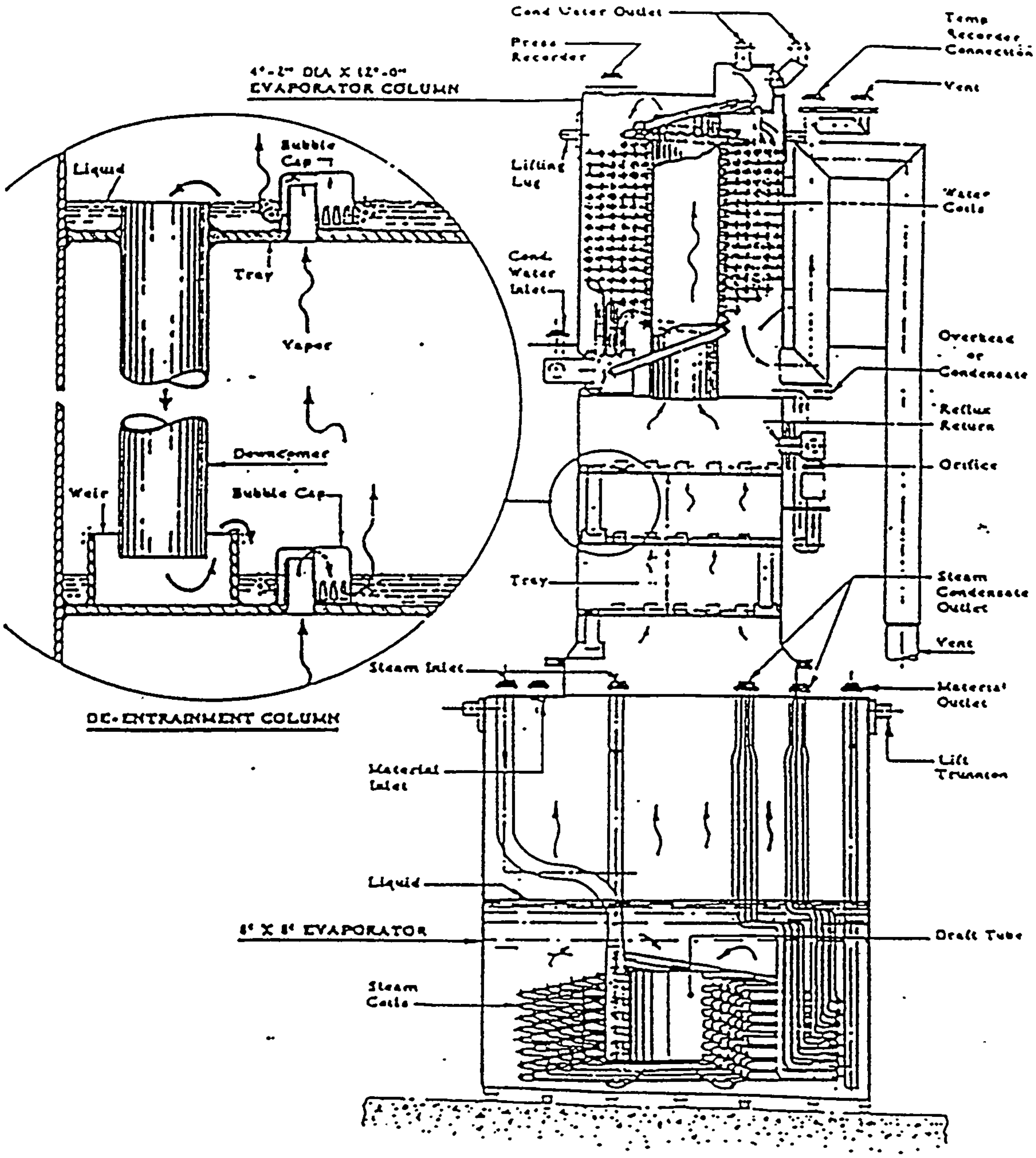

Standard Coil Batch Evaporator and Column

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APPENDIX C - 8.5E EVAPORATOR FAULT TREE AND DATA

The following abbreviations appear on the fault tree print out and in the basic event file for the fault tree:

FR=Failure Rate

a:= assumption

COG= cognizant engineer estimate/information

TRUNC= Truncation limit of cutset evaluator

The Beta Factor method used to estimate common cause alarm failure is explained in Reference 15.

NOTE: Events in this tree with a probability of "1E-32" are incredible. They do not contribute to the top event frequency and were included only to show that they had been considered. The number "1E-32" was used because it is the smallest number CAFTA is capable of handling.

Fault Tree (Page 29)

Gate/Event Cross Reference (Page 57)

Cutset Report (Page 59)

Basic Event Data (Page 69)

Type Code Data (Page 73)

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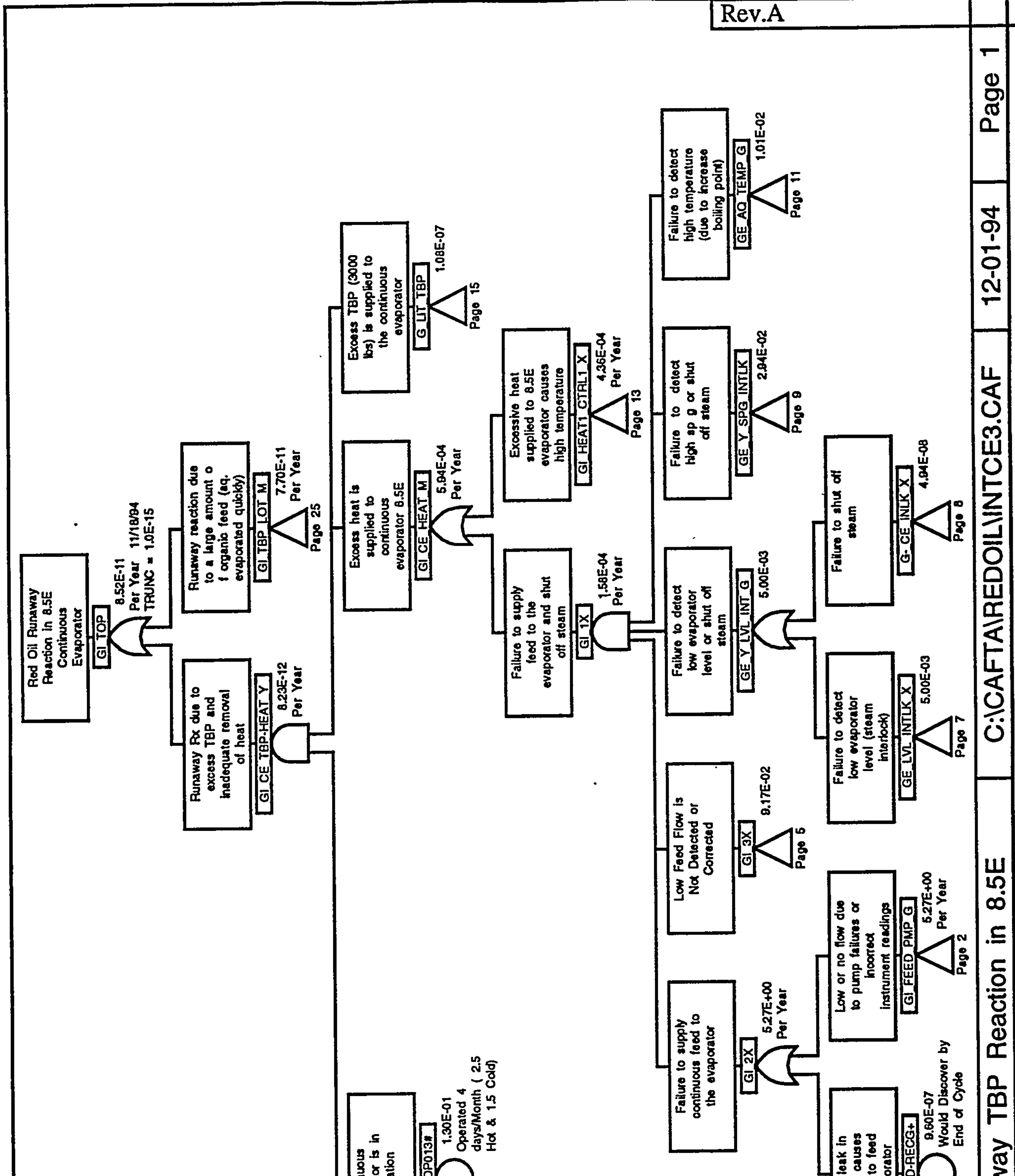

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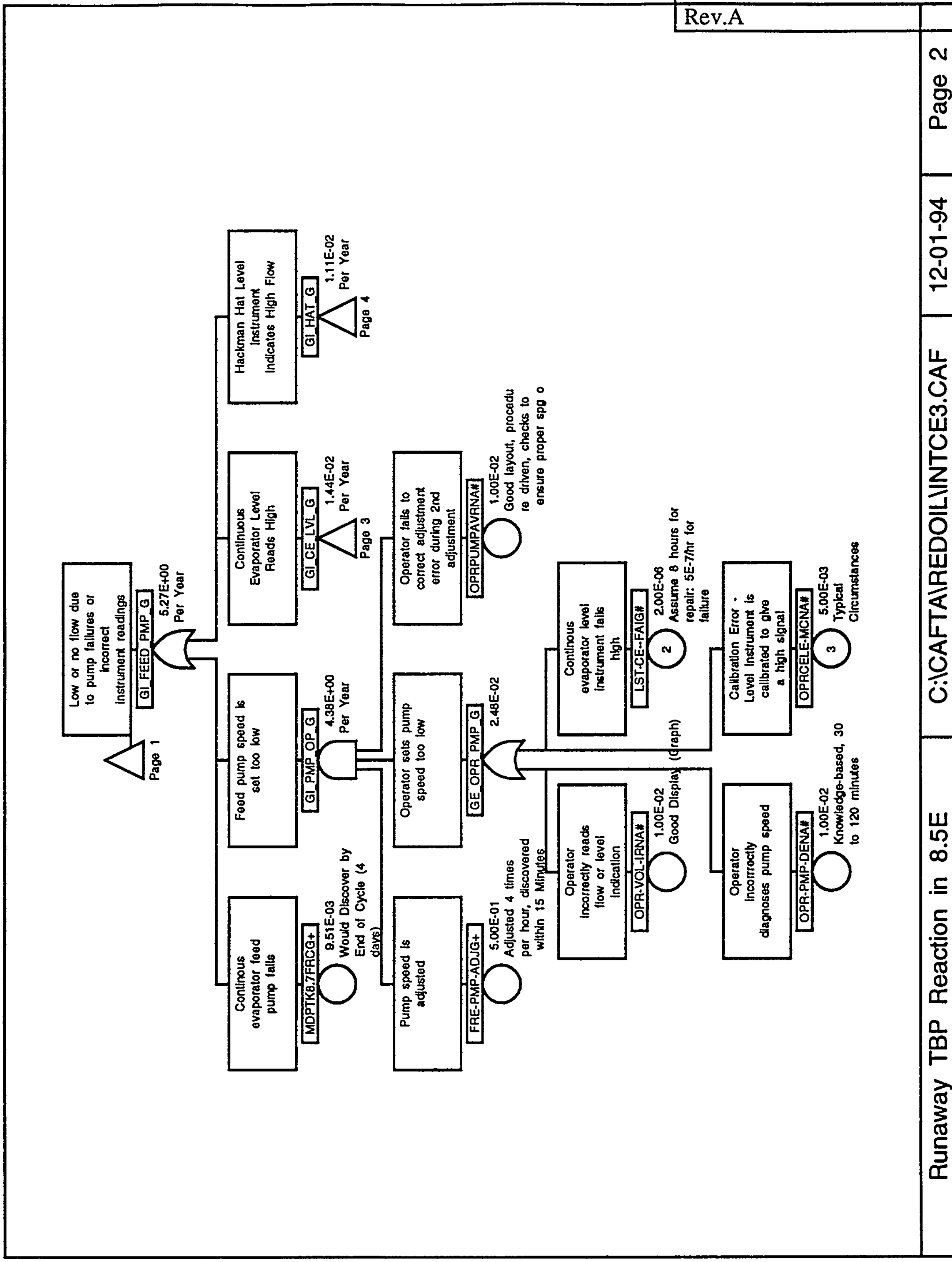

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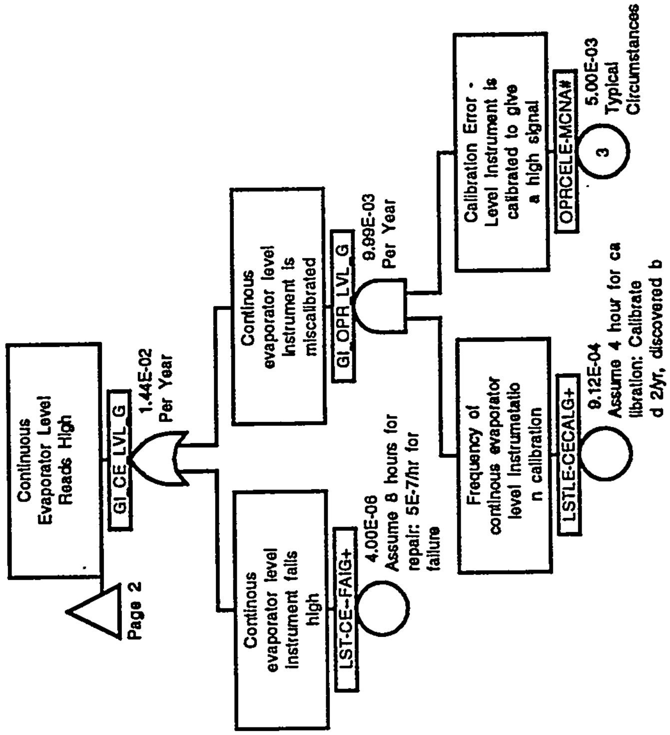

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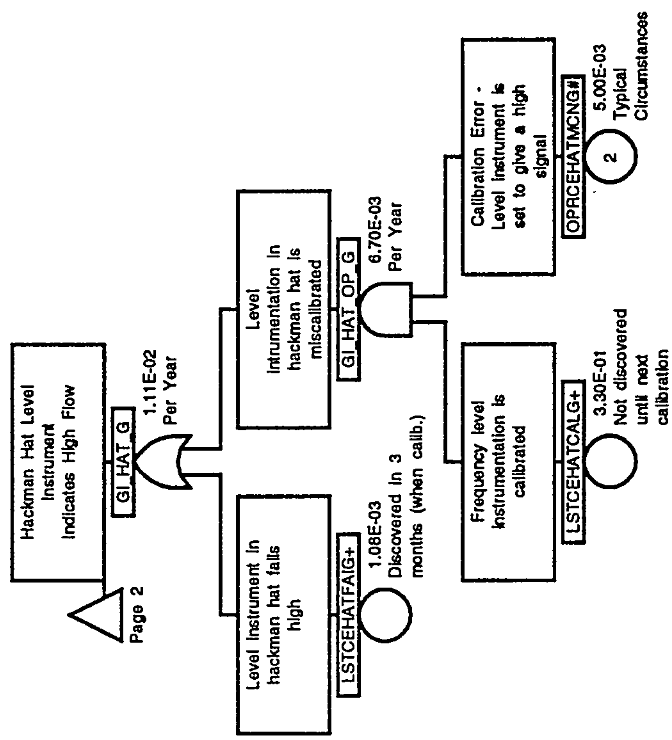

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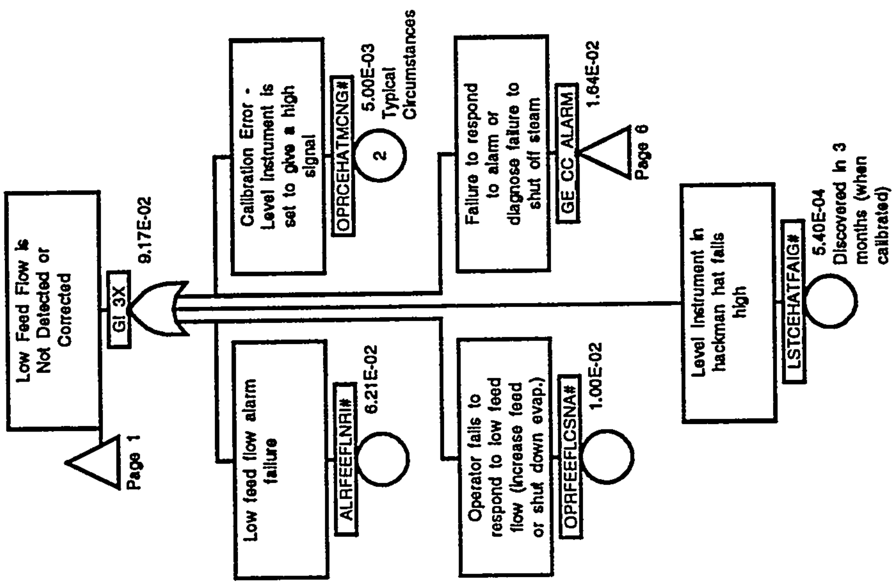

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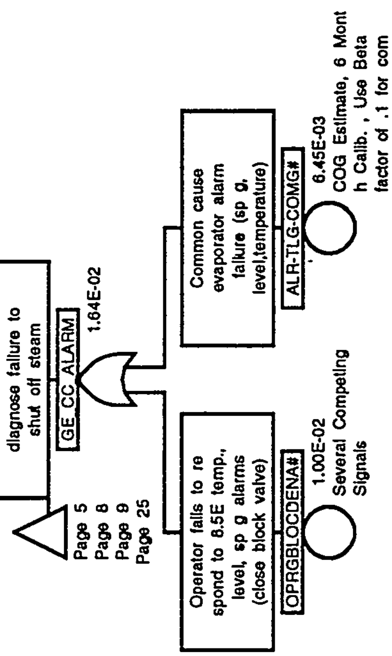

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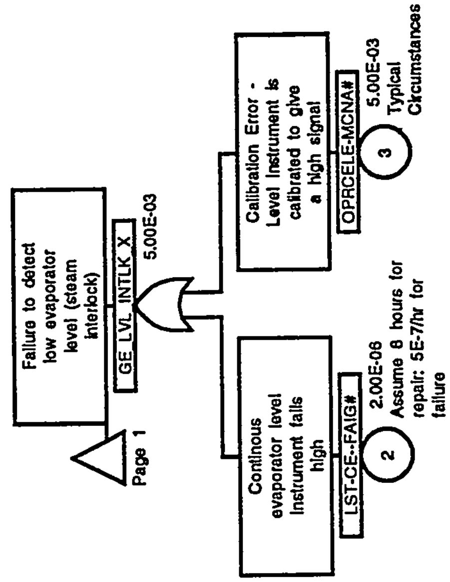

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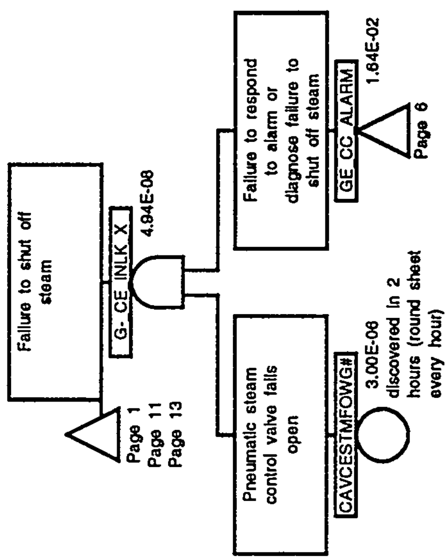

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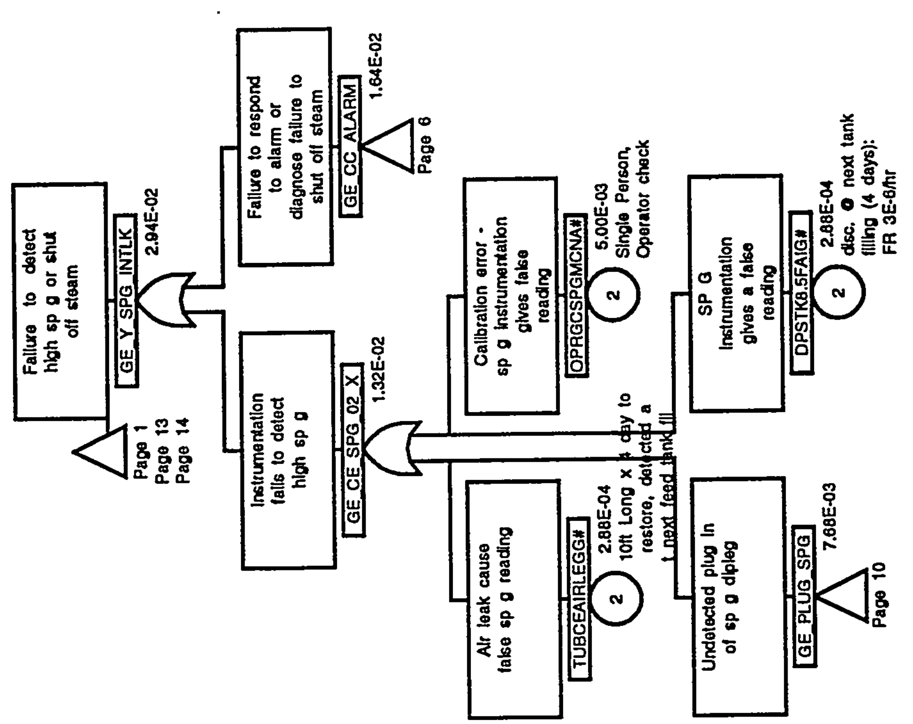

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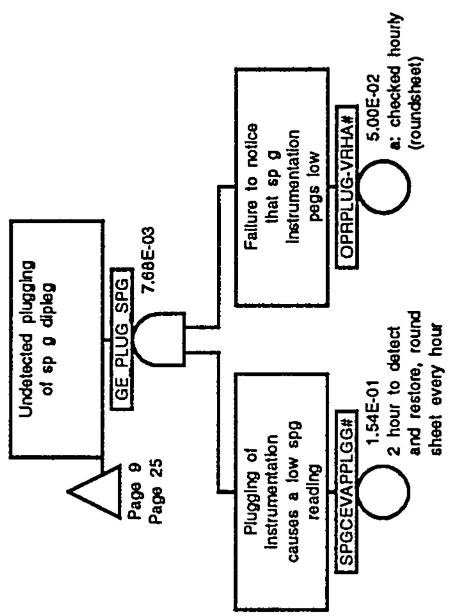
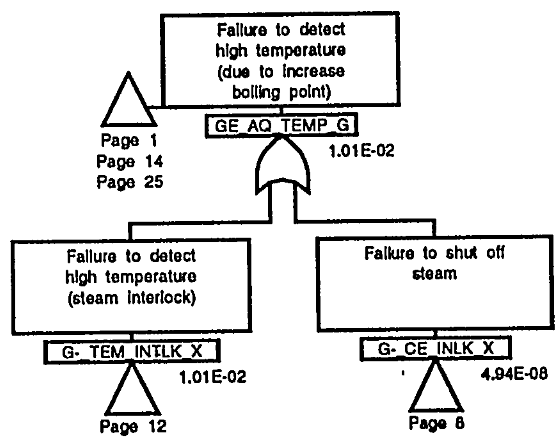
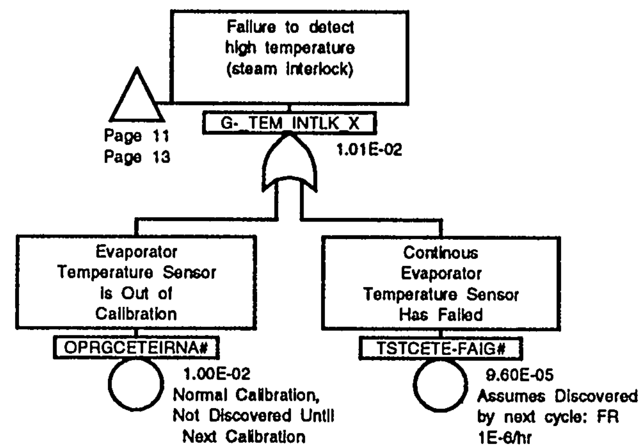


Runaway TBP Reaction in 8.5E | C:\CAFTA\REDOIL\INTCE3.CAF | 12-01-94 | Page 10



Runaway TBP Reaction in 8.5E	C:\CAFTA\REDOIL\INTCE3.CAF	12-01-94	Page 11



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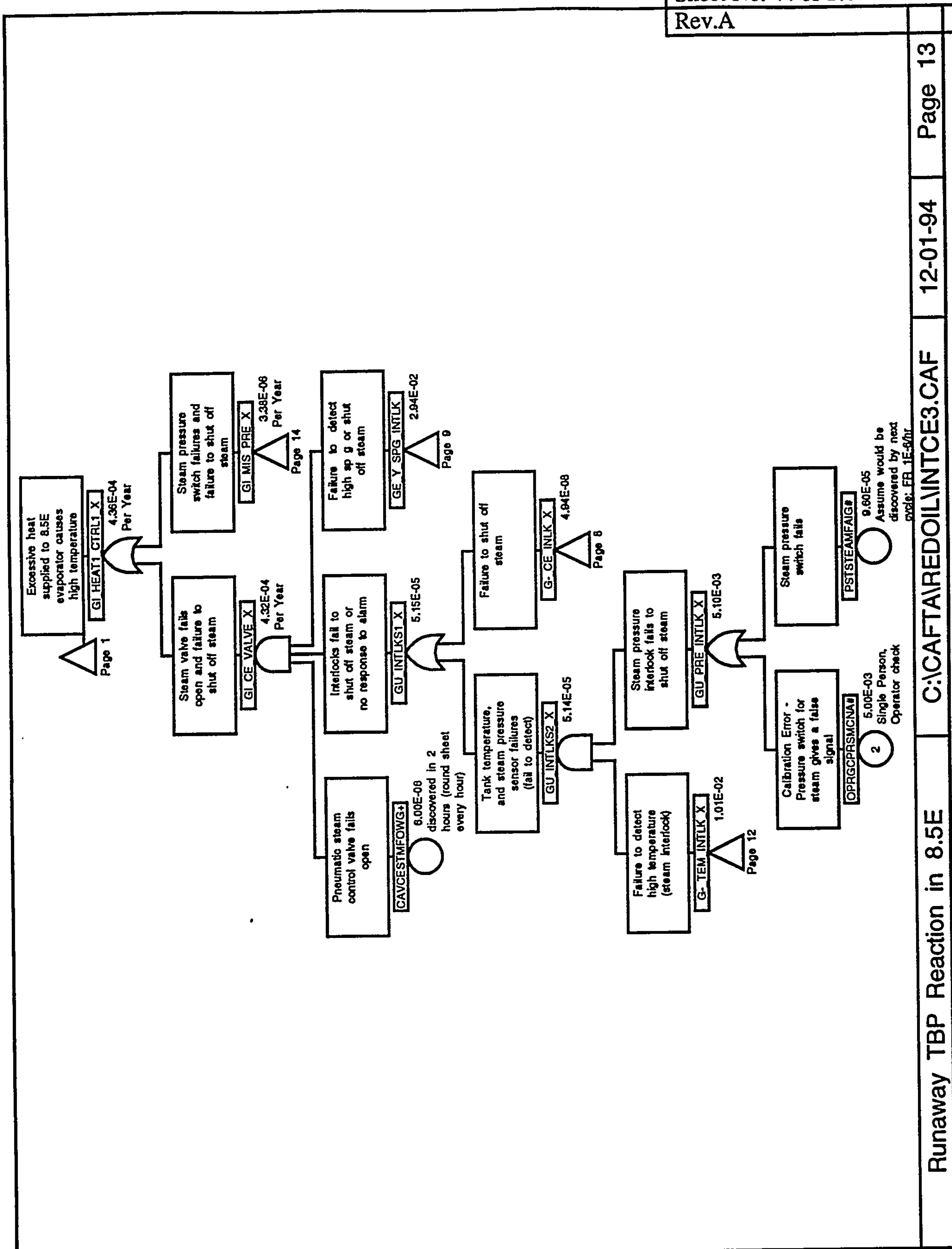

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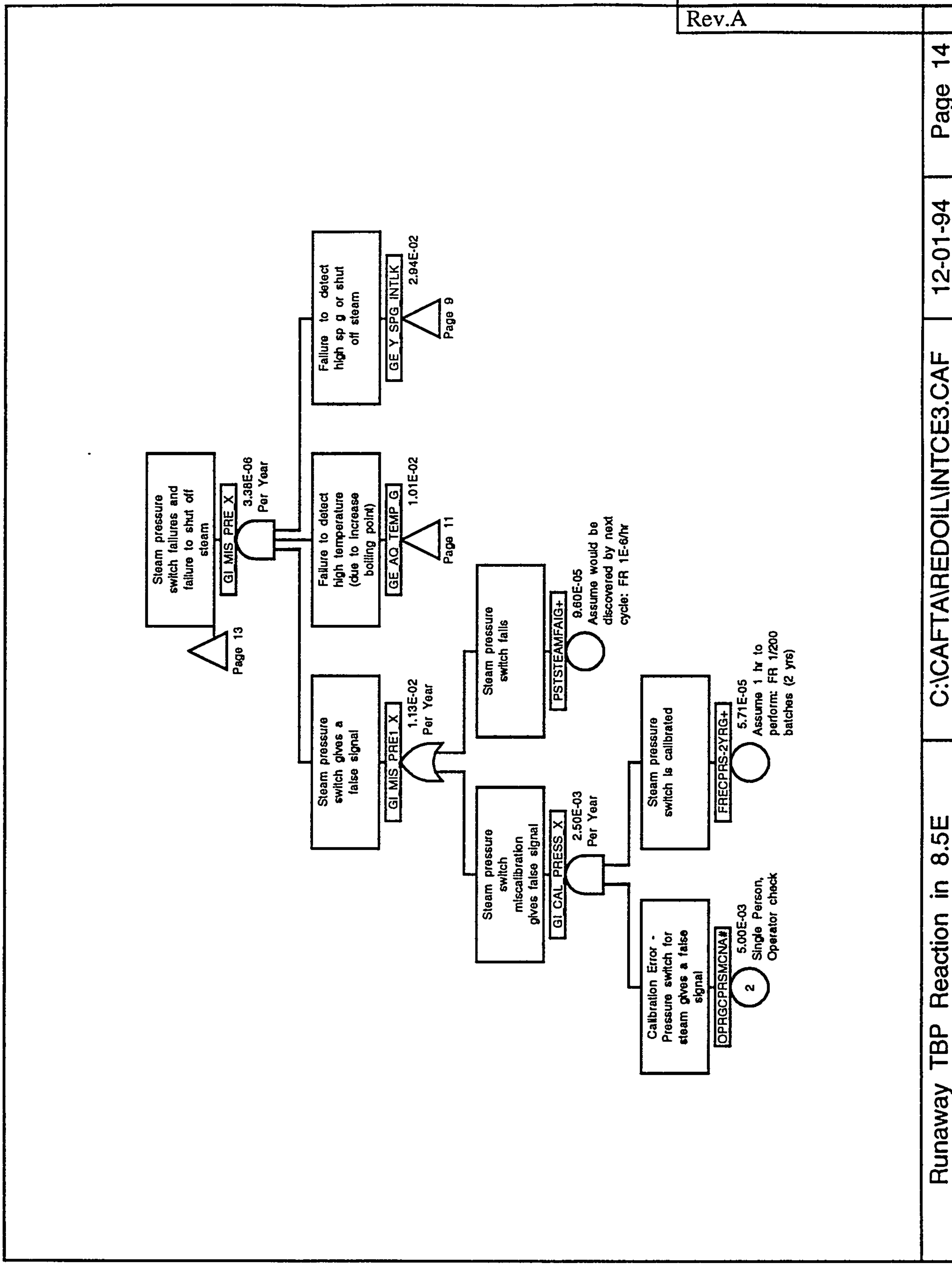

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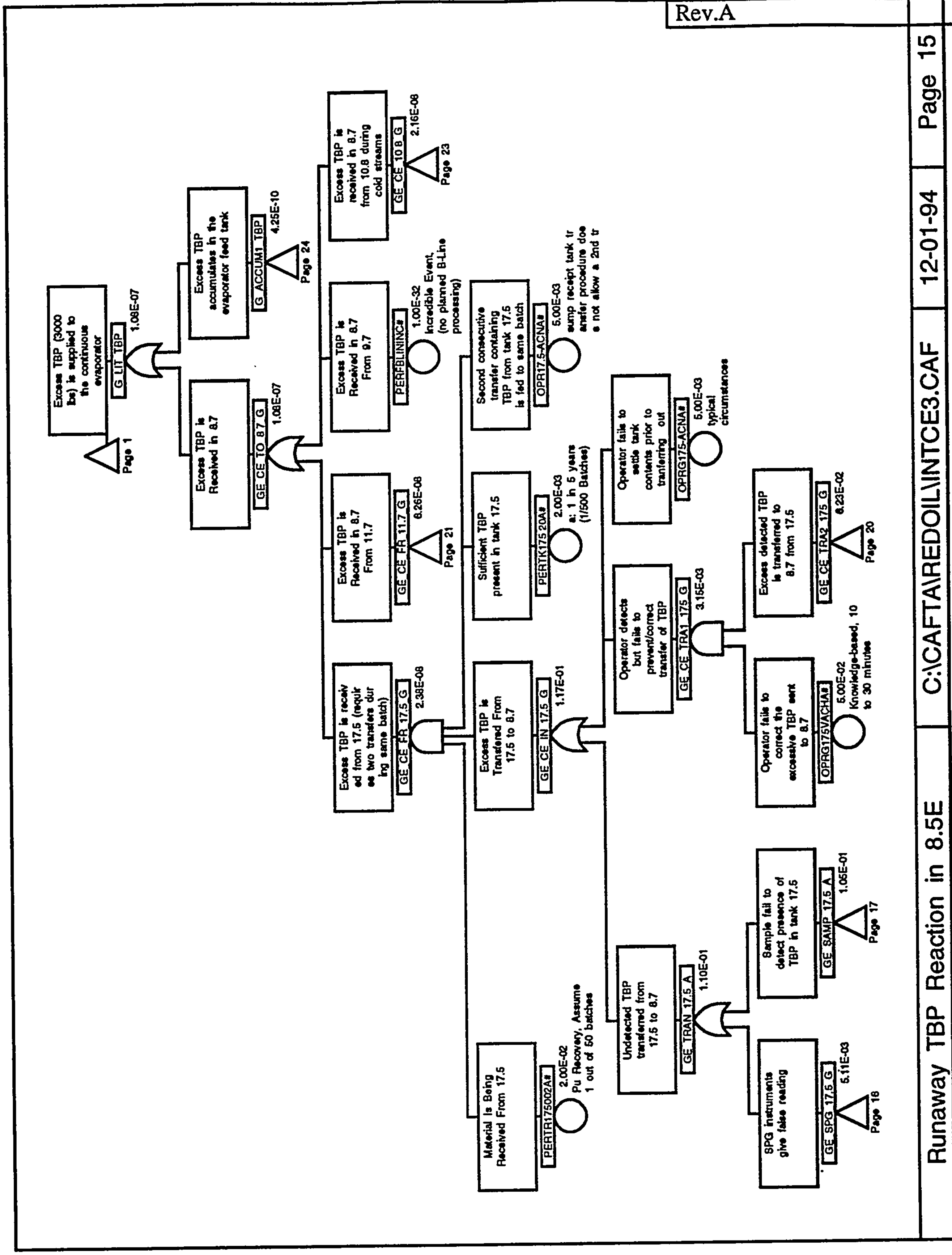

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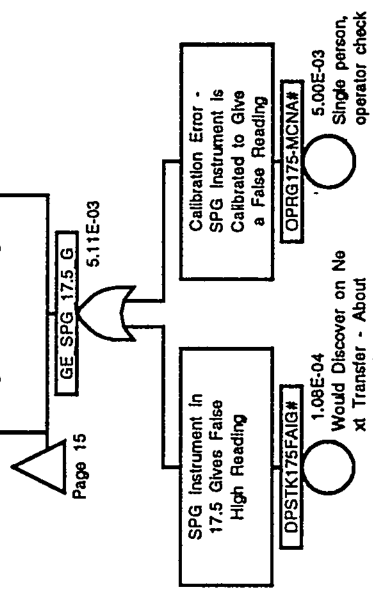

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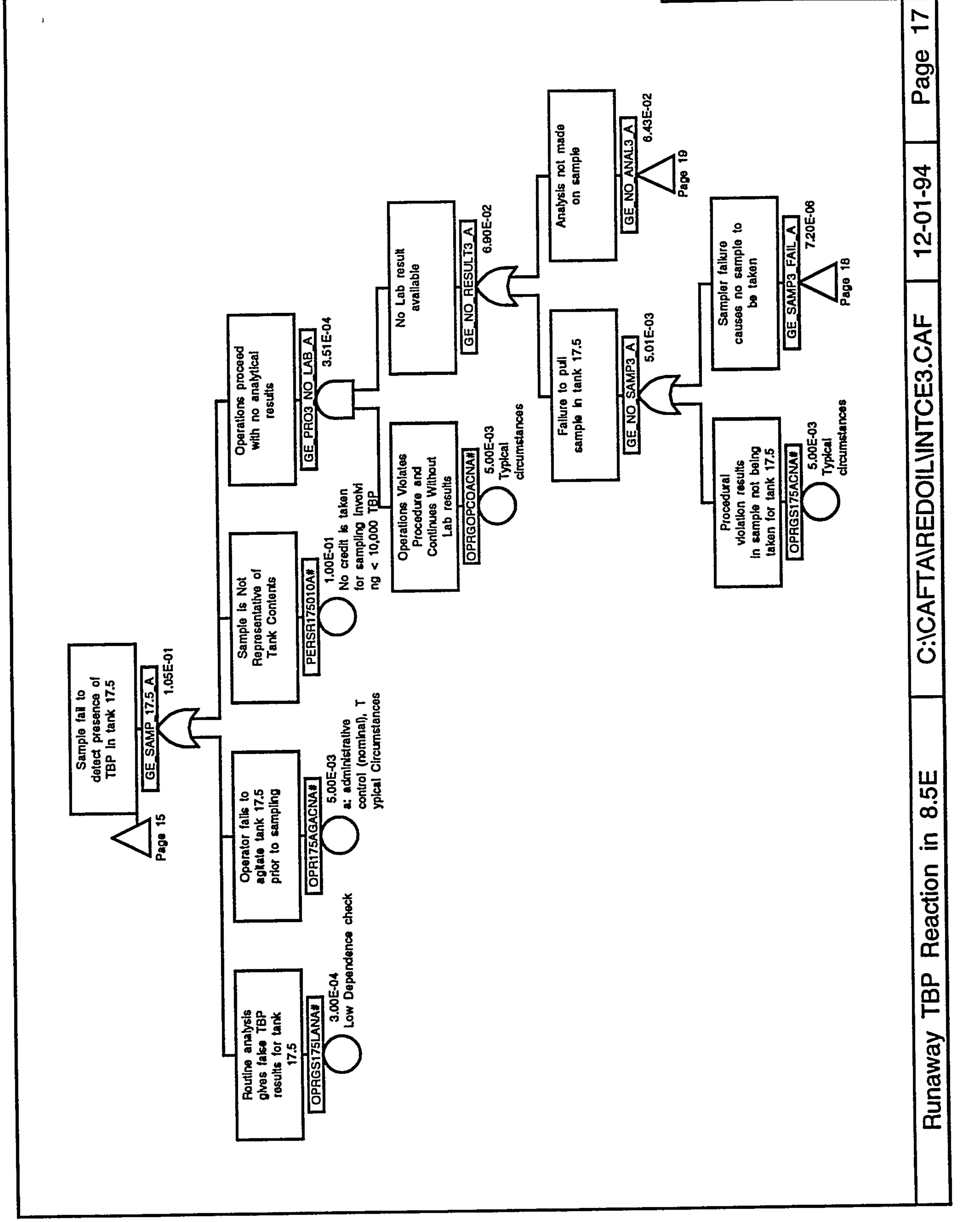

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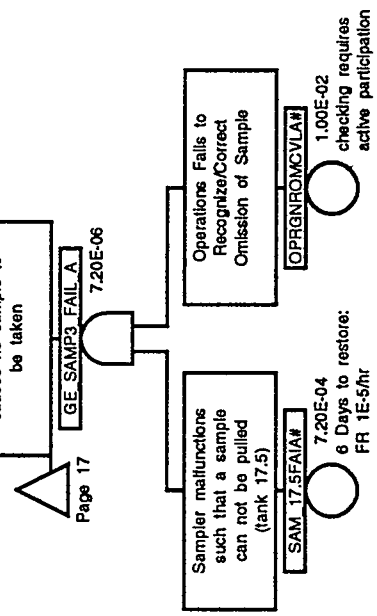

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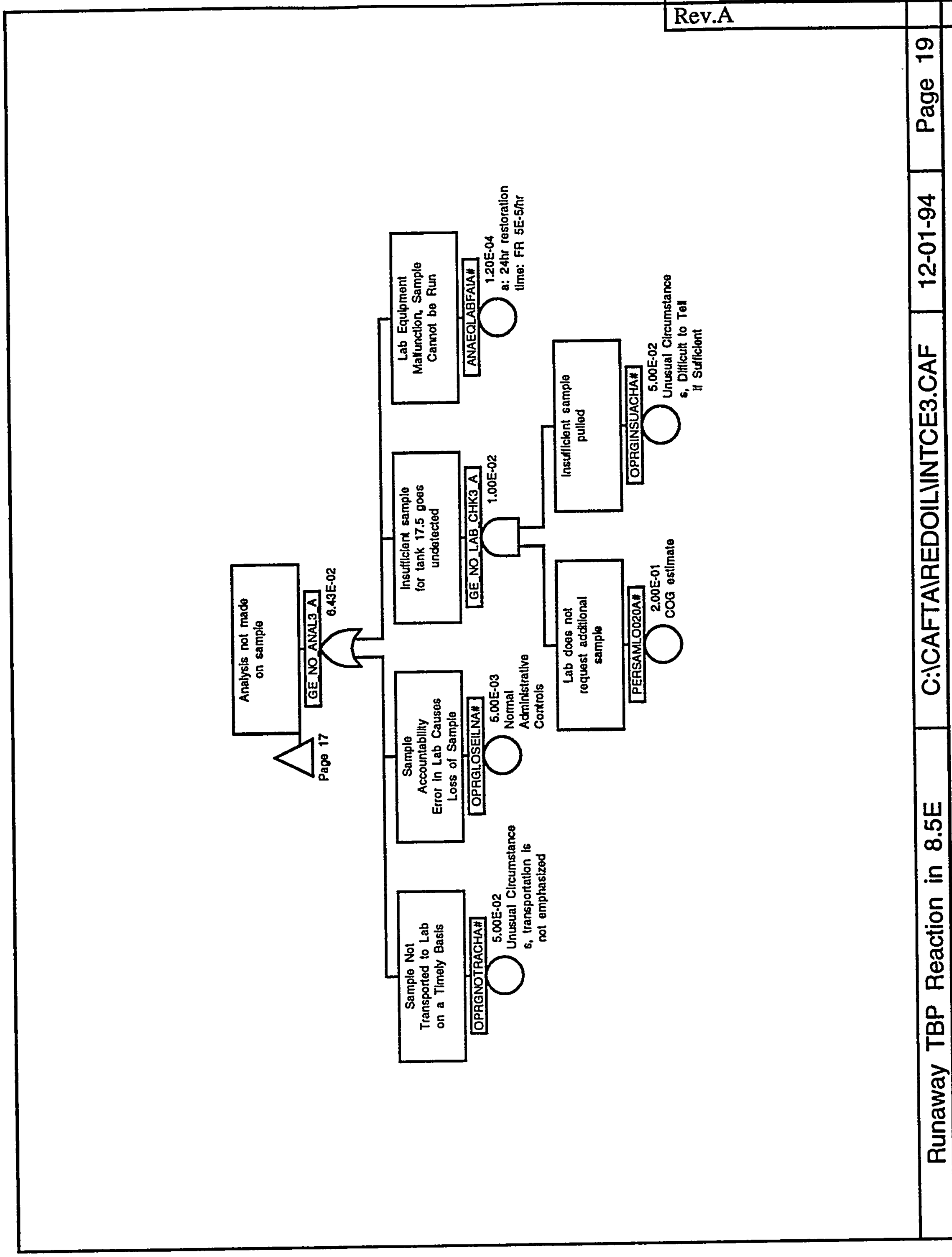

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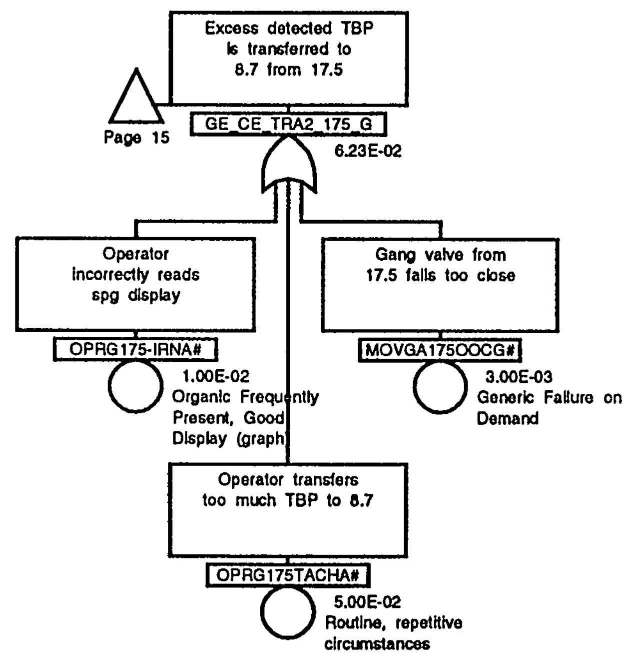
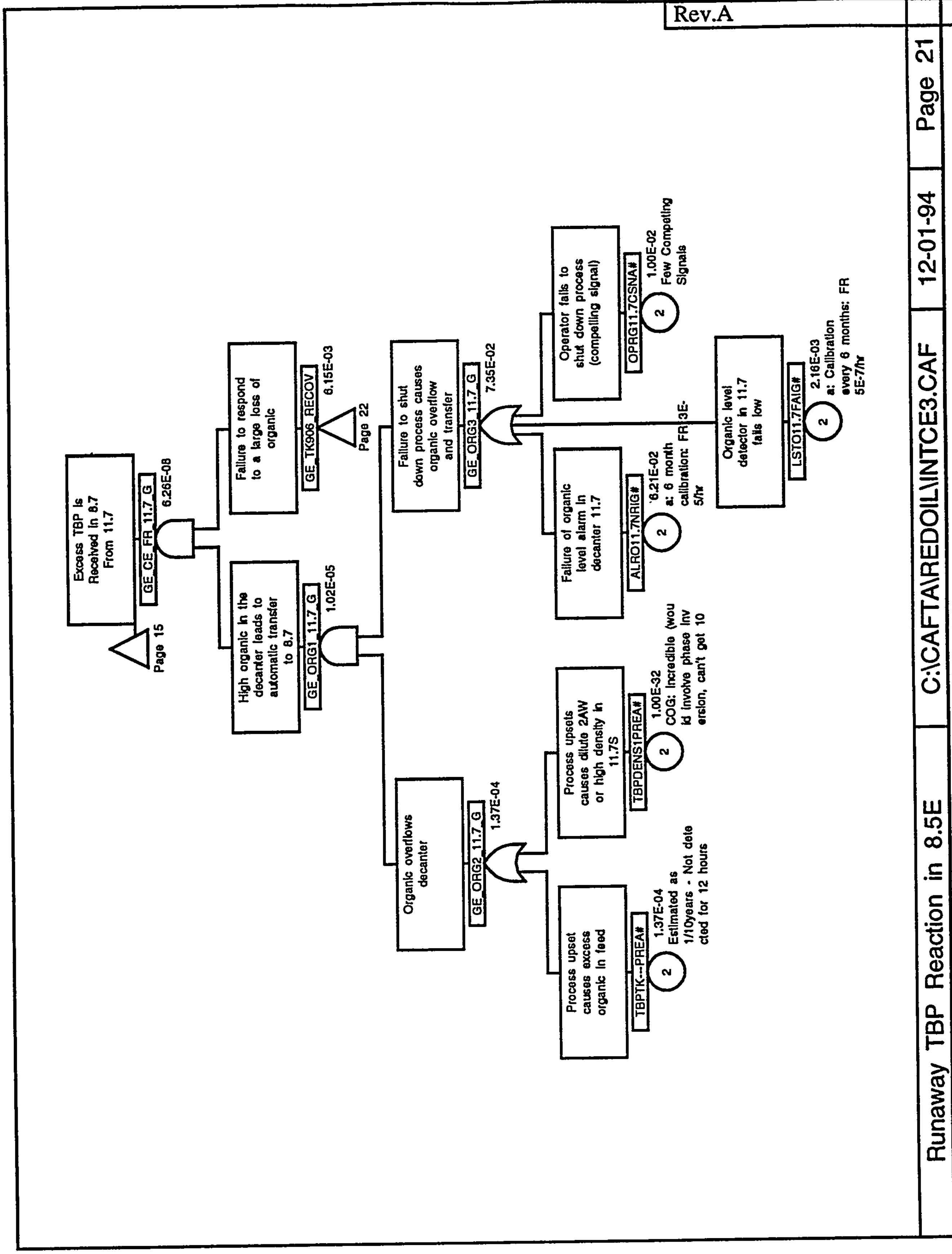


Runaway TBP Reaction in 8.5E	C:\CAFTA\REDOIL\INTCE3.CAF	12-01-94	Page 20


Excess TBP is Received in 8.7 From 11.7
GE_CE_FR_11.7_G
6.26E-08
Page 15
High organic in the decanter leads to automatic transfer to 8.7
GE_ORG1_11.7_G
1.02E-05
Failure to respond to a large loss of organic
GE_TK906_RECOV
6.15E-03
Page 22
Failure to shut down process causes organic overflow and transfer
GE_ORG3_11.7_G
7.35E-02
Organic overflows decanter
GE_ORG2_11.7_G
1.37E-04
Process upset causes excess organic in feed
TBPTK--PREA#
2
1.37E-04
Estimated as 1/10years - Not dete cted for 12 hours
Process upsets causes dilute 2AW or high density in 11.7S
TBPDENS1PREA#
2
1.00E-32
COG: Incredible (wou ld involve phase inv ersion, can't get 10
Failure of organic level alarm in decanter 11.7
ALRO11.7NRIG#
2
6.21E-02
a: 6 month calibration: FR 3E- 5/hr
Organic level detector in 11.7 fails low
LSTO11.7FAIG#
2
2.16E-03
a: Calibration every 6 months: FR 5E-7/hr
Operator fails to shut down process (compelling signal)
OPRG11.7CSNA#
2
1.00E-02
Few Competing Signals
Runaway TBP Reaction in 8.5E
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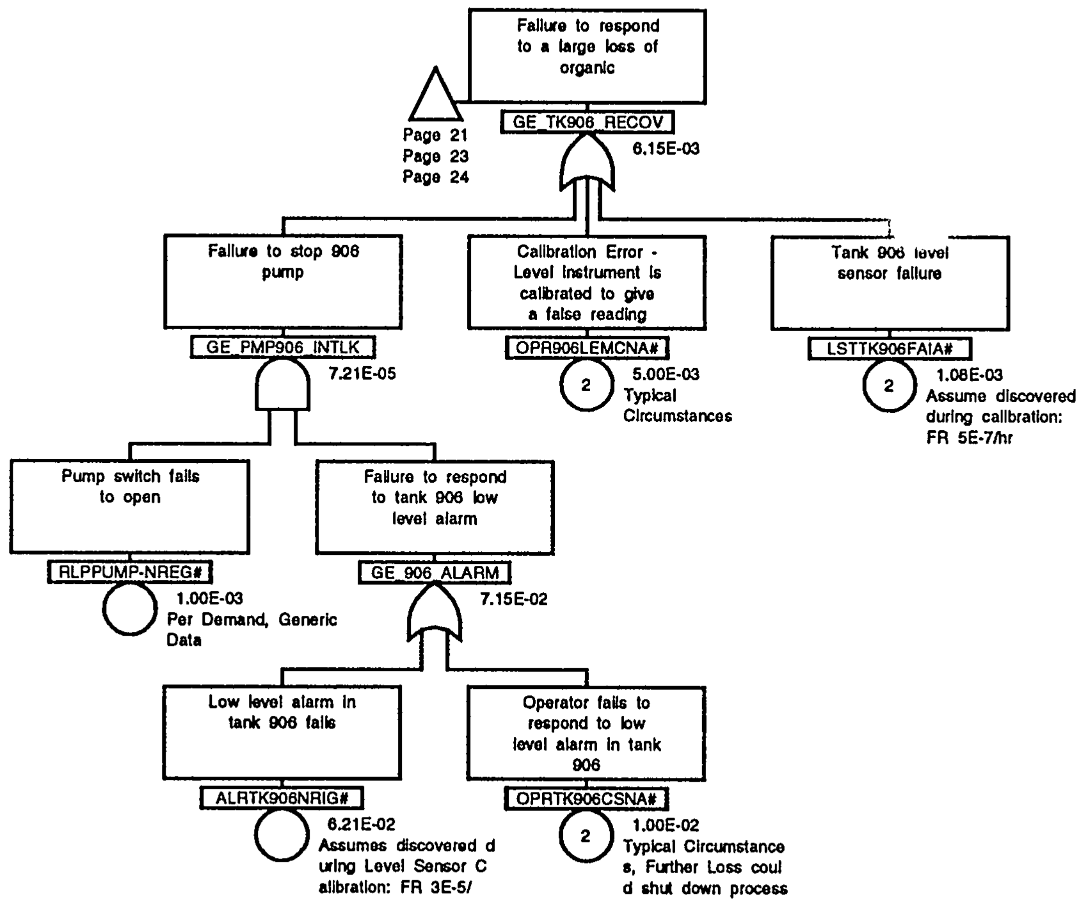

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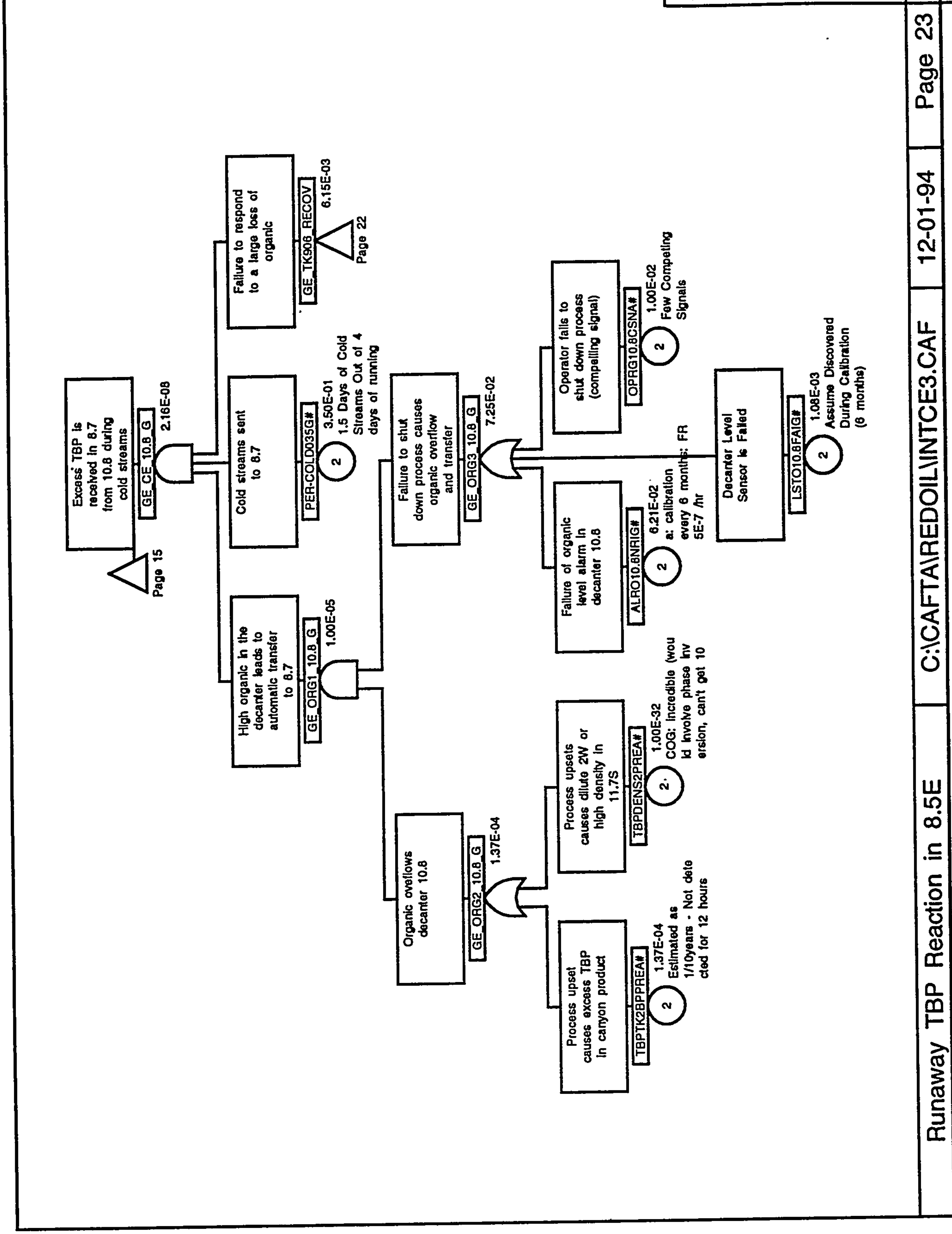

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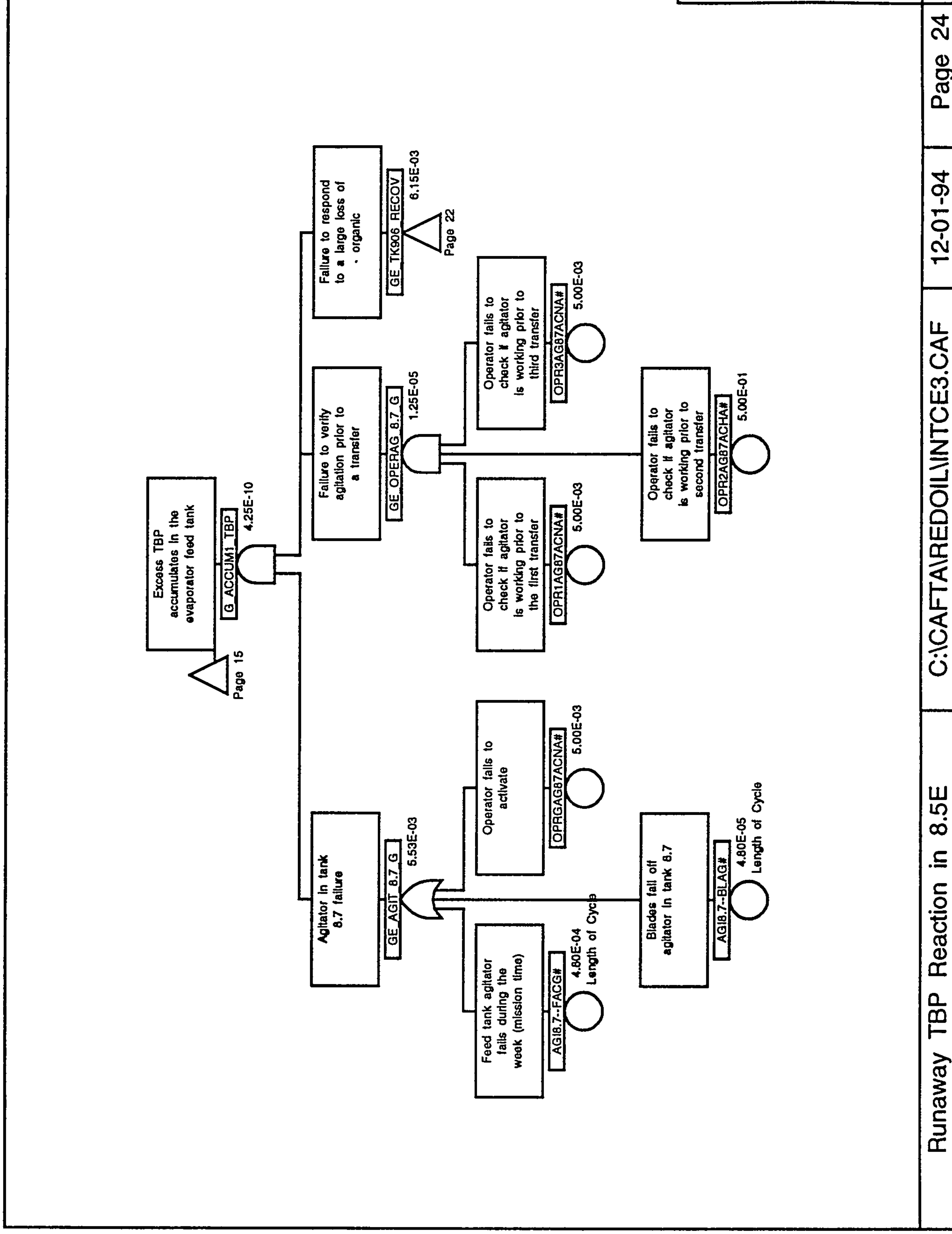

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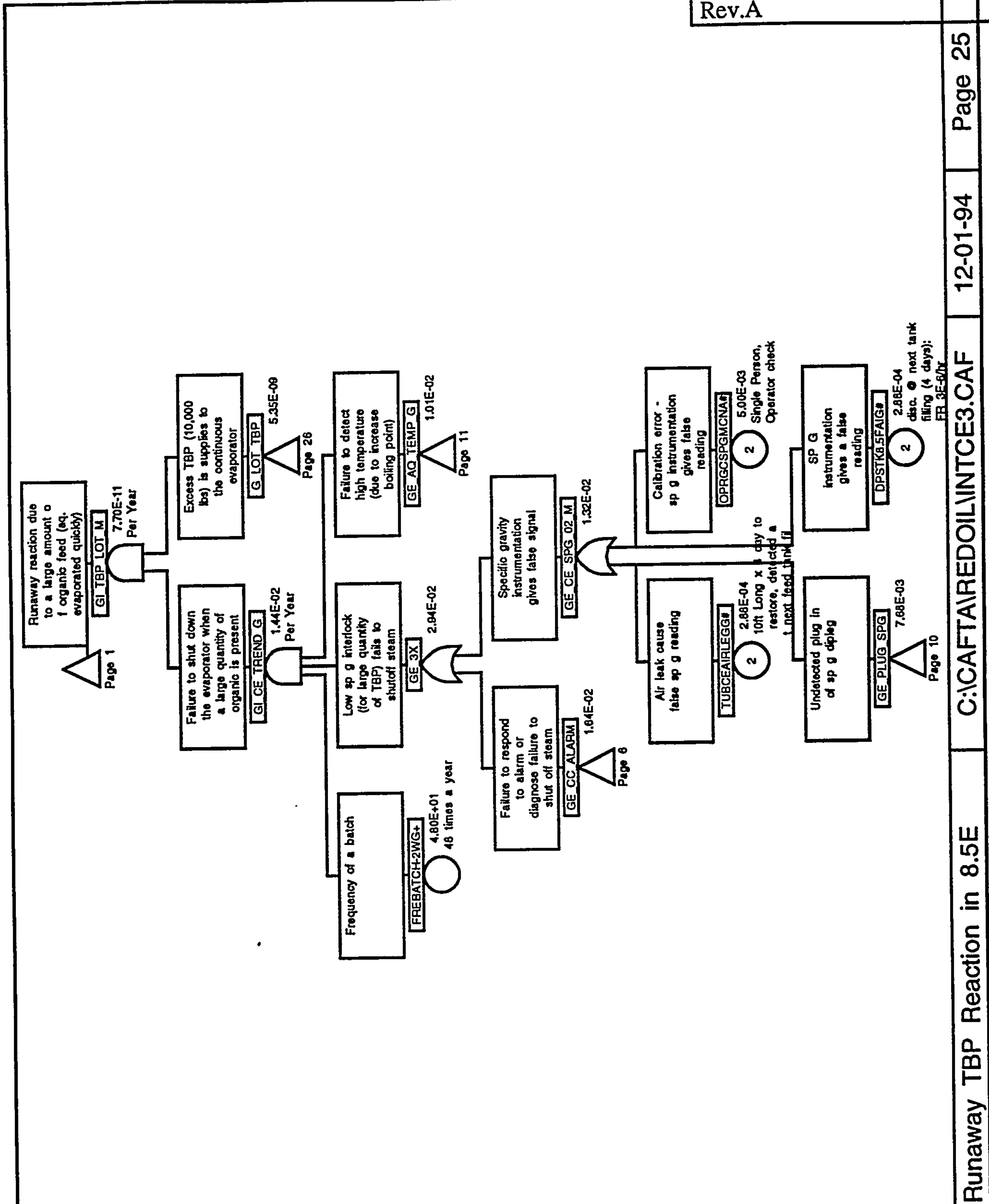

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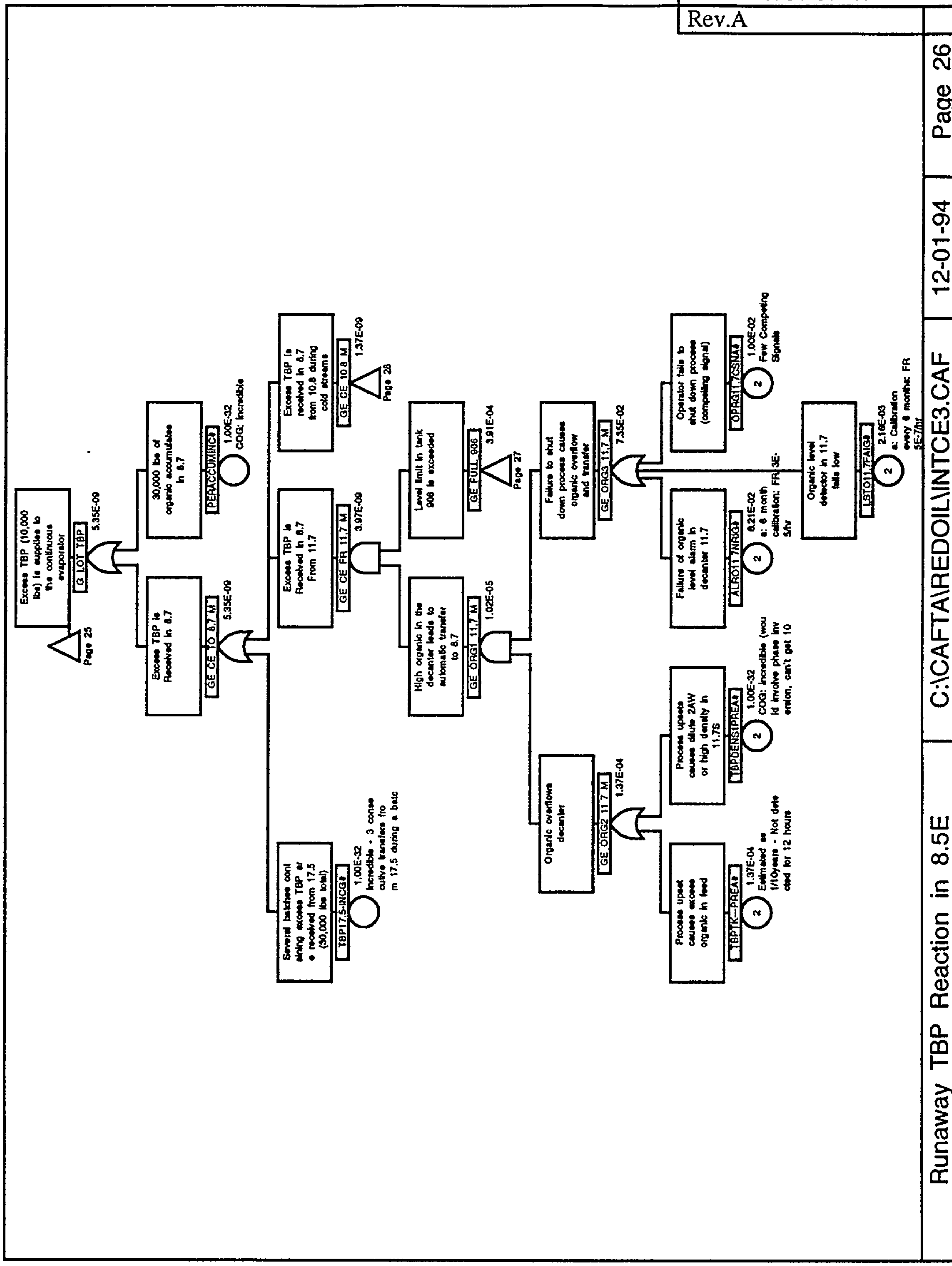

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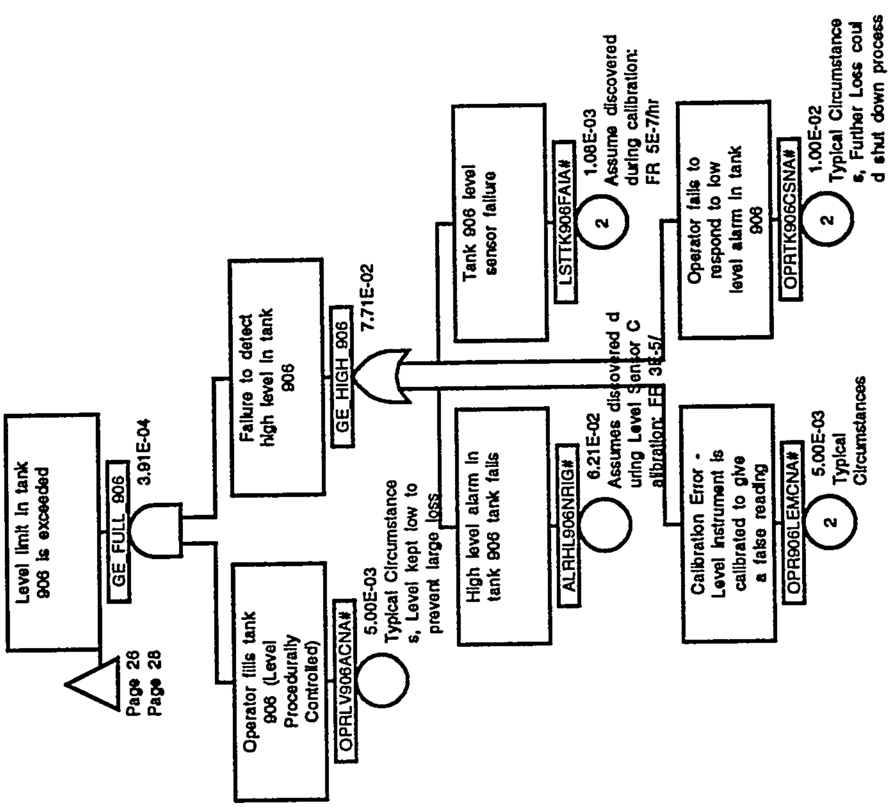

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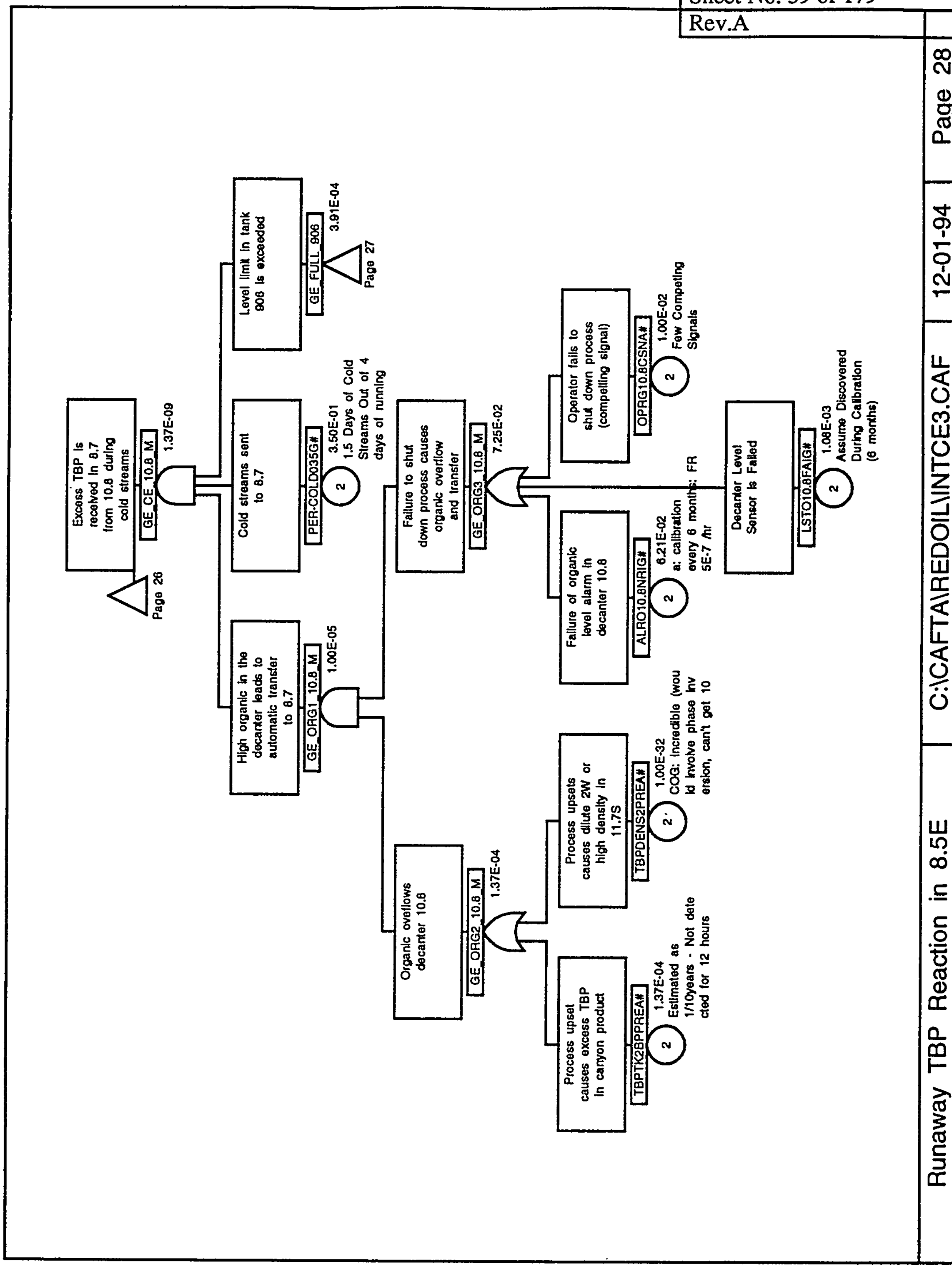

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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AGI8.7--BLAG#	24		GE_CE_10.8_G	15		GE_ORG3_10.8_M	28		GI_HAT_G	4	
AGI8.7--FACG#	24		GE_CE_10.8_G	23		GE_ORG3_11.7_G	21		GI_HAT_OP_G	4	
ALR-TLG-COMG#	6		GE_CE_10.8_M	26		GE_ORG3_11.7_M	26		GI_HEAT1_CTRL1_X	1	
ALRFEEFLNRI#	5		GE_CE_10.8_M	28		GE_PLUG_SPG	9		GI_HEAT1_CTRL1_X	13	
ALRHL906NRIG#	27		GE_CE_FR_11.7_G	15		GE_PLUG_SPG	10		GI_MIS_PRE1_X	14	
ALRO10.8NRIG#	23		GE_CE_FR_11.7_G	21		GE_PLUG_SPG	25		GI_MIS_PRE_X	13	
ALRO10.8NRIG#	28		GE_CE_FR_11.7_M	26		GE_PMP906_INTLK	22		GI_MIS_PRE_X	14	
ALRO11.7NRIG#	21		GE_CE_FR_17.5_G	15		GE_PRO3_NO_LAB_A	17		GI_OPR_LVL_G	3	
ALRO11.7NRIG#	26		GE_CE_IN_17.5_G	15		GE_SAMP3_FAIL_A	17		GI_PMP_OP_G	2	
ALRTK906NRIG#	22		GE_CE_SPG_02_M	25		GE_SAMP3_FAIL_A	18		GI_TBP_LOT_M	1	
ANAEQLABFAIA#	19		GE_CE_SPG_02_X	9		GE_SAMP_17.5_A	15		GI_TBP_LOT_M	25	
CAVCESTMFOWG#	8		GE_CE_TO_8.7_G	15		GE_SAMP_17.5_A	17		GI_TOP	1	
CAVCESTMFOWG+	13		GE_CE_TO_8.7_M	26		GE_SPG_17.5_G	15		GU_INTLKS1_X	13	
DPSTK175FAIG#	16		GE_CE_TRA1_175_G	15		GE_SPG_17.5_G	16		GU_INTLKS2_X	13	
DPSTK8.5FAIG#	9		GE_CE_TRA2_175_G	15		GE_TK906_RECOV	21		GU_PRE_INTLK_X	13	
DPSTK8.5FAIG#	25		GE_CE_TRA2_175_G	20		GE_TK906_RECOV	22		G_ACCUM1_TBP	15	
FRE-PMP-ADJG+	2		GE_FULL_906	26		GE_TK906_RECOV	23		G_ACCUM1_TBP	24	
FREBATCH-2WG+	25		GE_FULL_906	27		GE_TK906_RECOV	24		G_LIT_TBP	1	
FRECPRS-2YRG+	14		GE_FULL_906	28		GE_TRAN_17.5_A	15		G_LIT_TBP	15	
G-_CE_INLK_X	1		GE_HIGH_906	27		GE_Y_LVL_INT_G	1		G_LOT_TBP	25	
G-_CE_INLK_X	8		GE_LVL_INTLK_X	1		GE_Y_SPG_INTLK	1		G_LOT_TBP	26	
G-_CE_INLK_X	11		GE_LVL_INTLK_X	7		GE_Y_SPG_INTLK	9		JPRFEED-RECG+	1	
G-_CE_INLK_X	13		GE_NO_ANAL3_A	17		GE_Y_SPG_INTLK	13		LST-CE--FAIG#	2	
G-_TEM_INTLK_X	11		GE_NO_ANAL3_A	19		GE_Y_SPG_INTLK	14		LST-CE--FAIG#	7	
G-_TEM_INTLK_X	12		GE_NO_LAB_CHK3_A	19		GI_1X	1		LST-CE--FAIG+	3	
G-_TEM_INTLK_X	13		GE_NO_RESULT3_A	17		GI_2X	1		LSTCEHATCALG+	4	
GE_3X	25		GE_NO_SAMP3_A	17		GI_3X	1		LSTCEHATFAIG#	5	
GE_906_ALARM	22		GE_OPERAG_8.7_G	24		GI_3X	5		LSTCEHATFAIG+	4	
GE_AGIT_8.7_G	24		GE_OPR_PMP_G	2		GI_CAL_PRESS_X	14		LSTLE-CECALG+	3	
GE_AQ_TEMP_G	1		GE_ORG1_10.8_G	23		GI_CE_HEAT_M	1		LSTO10.8FAIG#	23	
GE_AQ_TEMP_G	11		GE_ORG1_10.8_M	28		GI_CE_LVL_G	2		LSTO10.8FAIG#	28	
GE_AQ_TEMP_G	14		GE_ORG1_11.7_G	21		GI_CE_LVL_G	3		LSTO11.7FAIG#	21	
GE_AQ_TEMP_G	25		GE_ORG1_11.7_M	26		GI_CE_TBP-HEAT_Y	1		LSTO11.7FAIG#	26	
GE_CC_ALARM	5		GE_ORG2_10.8_G	23		GI_CE_TREND_G	25		LSTTK906FAIA#	22	
GE_CC_ALARM	6		GE_ORG2_10.8_M	28		GI_CE_VALVE_X	13		LSTTK906FAIA#	27	
GE_CC_ALARM	8		GE_ORG2_11.7_G	21		GI_FEED_PMP_G	1		MDPTK8.7FRCG+	2	
GE_CC_ALARM	9		GE_ORG2_11.7_M	26		GI_FEED_PMP_G	2		MOVGA1750OCG#	20	
GE_CC_ALARM	25		GE_ORG3_10.8_G	23		GI_HAT_G	2		OPR-PMP-DENA#	2	

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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
OPR-VOL-IRNA#	2		OPRPLUG-VRHA#	10							
OPR17.5-ACNA#	15		OPRPUMPAVRNA#	2							
OPR175AGACNA#	17		OPRTK906CSNA#	22							
OPR1AG87ACNA#	24		OPRTK906CSNA#	27							
OPR2AG87ACHA#	24		PER-COLD035G#	23							
OPR3AG87ACNA#	24		PER-COLD035G#	28							
OPR906LEMCNA#	22		PER8.5OP013#	1							
OPR906LEMCNA#	27		PERACCUMINC#	26							
OPRCEHATMCNG#	4		PERFBLININC#	15							
OPRCEHATMCNG#	5		PERSAMLO020A#	19							
OPRCELE-MCNA#	2		PERSR175010A#	17							
OPRCELE-MCNA#	3		PERTK175.20A#	15							
OPRCELE-MCNA#	7		PERTR175002A#	15							
OPRFEEFLCSNA#	5		PSTSTEAMFAIG#	13							
OPRG10.8CSNA#	23		PSTSTEAMFAIG+	14							
OPRG10.8CSNA#	28		RLPPUMP-NREG#	22							
OPRG11.7CSNA#	21		SAM_17.5FAIA#	18							
OPRG11.7CSNA#	26		SPGCEVAPPLGG#	10							
OPRG175-ACNA#	15		TBP17.5-INCG#	26							
OPRG175-IRNA#	20		TBPDENS1PREA#	21							
OPRG175-MCNA#	16		TBPDENS1PREA#	26							
OPRG175TACHA#	20		TBPDENS2PREA#	23							
OPRG175VACHA#	15		TBPDENS2PREA#	28							
OPRGAG87ACNA#	24		TBPTK---PREA#	21							
OPRGBLOCDENA#	6		TBPTK---PREA#	26							
OPRGCETEIRNA#	12		TBPTK2BPPREA#	23							
OPRGCPRSMCNA#	13		TBPTK2BPPREA#	28							
OPRGCPRSMCNA#	14		TSTCETE-FAIG#	12							
OPRGCSPGMCNA#	9		TUBCEAIRLEGG#	9							
OPRGCSPGMCNA#	25		TUBCEAIRLEGG#	25							
OPRGINSUACHA#	19										
OPRGLOSEILNA#	19										
OPRGNOTRACHA#	19										
OPRGNROMCVLA#	18										
OPRGOPCOACNA#	17										
OPRGS175ACNA#	17										
OPRGS175LANA#	17										
OPRLV906ACNA#	27										

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Cutsets for 8.5E Evaporator

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	GI_TOP					8.52E-11
1.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	1.27E-11
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
2.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	9.73E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
3.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	8.18E-12
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
4.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	6.34E-12

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCSPGMCNA#	Calibration error - sp g instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
5.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	4.44E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
6.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	3.40E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
7.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	2.86E-12

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Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+ OPRGCETEIRNA#	Frequency of a batch Evaporator Temperature Sensor is Out of Calibration	1	48Y 1N 1.0E-2 N	4.80E+01Y 1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
8.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.22E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+ OPRGCETEIRNA#	Frequency of a batch Evaporator Temperature Sensor is Out of Calibration	1	48Y 1N 1.0E-2 N	4.80E+01Y 1.00E-02N	
	OPRGCSPGMCNA#	Calibration error - sp g instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
9.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	2.04E-12
	FREBATCH-2WG+ OPRGBLOCDENA#	Frequency of a batch Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	48Y 1N 1.0E-2 N	4.80E+01Y 1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
10.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.04E-12
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
11.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	1.57E-12
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
12.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	1.57E-12
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
13.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	1.45E-12
	CAVCESTMFOWG+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
14.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.32E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+ OPRGCETEIRNA#	Frequency of a batch Evaporator Temperature Sensor is Out of Calibration	 1	48Y 1N 1.0E-2 N	4.80E+01Y 1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
15.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.32E-12
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+ OPRG11.7CSNA#	Frequency of a batch Operator fails to shut down process (compelling signal)	 1	48Y 1N 1.0E-2 N	4.80E+01Y 1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
16.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	1.02E-12
	FREBATCH-2WG+ OPRGCETEIRNA#	Frequency of a batch Evaporator Temperature Sensor is Out of Calibration	 1	48Y 1N 1.0E-2 N	4.80E+01Y 1.00E-02N	
	OPRGCSPGMCNA#	Calibration error - sp g instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
17.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	1.02E-12
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
18.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	1.02E-12
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCSPGMCNA#	Calibration error - sp g instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
19.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	9.37E-13
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	CAVCESTMFOWG+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
20.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	7.83E-13
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
21.	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	7.14E-13
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
22.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	7.14E-13
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRG10.8CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
23.	CAVCESTMFOWG+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	6.83E-13

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPR17.5-ACNA#	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	1	1N 5.0E-3 N	5.00E-03N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N	
	PERSR175010A#	Sample is Not Representative of Tank Contents	1	1N 1.00E-01N	1.00E-01N	
	PERTK175.20A#	Sufficient TBP present in tank 17.5	1	1N 2.00E-03N	2.00E-03N	
	PERTR175002A#	Material Is Being Received From 17.5	1	1N 2.00E-02N	2.00E-02N	
24.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	6.58E-13
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
25.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	5.48E-13
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRG10.8CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
26.	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	5.48E-13
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that sp g instrumentation pegs low	1	1N .05N	5.00E-02N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	SPGCEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	2H 2.0D	1.54E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
27.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	5.10E-13
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCSPGMCNA#	Calibration error - sp g instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
28.	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	5.08E-13
	CAVCESTMFOWG+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
29.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	4.84E-13
	FRE-PMP-ADJG+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	

Cutsets for 8.5E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRCELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N	
	OPRGBLOCDENA#	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRPUMPAVRNA#	Operator fails to correct adjustment error during 2nd adjustment	1	1N 1.0E-2 N	1.00E-02N	
	PER8.5OP013#	Continuous Evaporator is in Operation	1	1N 1.30E-01N	1.30E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
30.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	4.61E-13
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	
	FREBATCH-2WG+	Frequency of a batch		48Y	4.80E+01Y	
	OPRG10.8CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRGCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	

Basic Event Data for 8.5E Evaporator

Event	C	Input	Calc.	Description	Source
AGI8.7--BLAG#	3	4D 5.0E-7H	4.80E-05	Blades fall off agitator in tank 8.7	Length of Cycle
AGI8.7--FACG#	3	4D 5.0E-6H	4.80E-04	Feed tank agitator fails during the week (mission time)	Length of Cycle
ALR-TLG-COMG#	5	6M 3.00E-06H	6.45E-03	Common cause evaporator alarm failure (sp g, level,temperature)	COG Estimate, 6 Month Calib. , Use Beta factor of .1 for common cause
ALRFEEFLNRI#	5	6M 3.00E-05H	6.21E-02	Low feed flow alarm failure	
ALRHL906NRIG#	5	6M 3.00E-05H	6.21E-02	High level alarm in tank 906 tank fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
ALRO10.8NRIG#	5	6M 3.00E-05H	6.21E-02	Failure of organic level alarm in decanter 10.8	a: calibration every 6 months: FR 5E-7 /hr
ALRO11.7NRIG#	5	6M 3.00E-05H	6.21E-02	Failure of organic level alarm in decanter 11.7	a: 6 month calibration: FR 3E-5/hr
ALRTK906NRIG#	5	6M 3.00E-05H	6.21E-02	Low level alarm in tank 906 fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
ANAEQLABFAIA#	3	24H 5.00E-06 H	1.20E-04	Lab Equipment Malfunction, Sample Cannot be Run	a: 24hr restoration time: FR 5E-5/hr
CAVCESTMFOWG#	5	2H 3.00E-06 H	3.00E-06	Pneumatic steam control valve fails open	discovered in 2 hours (round sheet every hour)
CAVCESTMFOWG+	4	2H 3.00E-06 H	6.00E-06	Pneumatic steam control valve fails open	discovered in 2 hours (round sheet every hour)
DPSTK175FAIG#	5	3D 3.00E-06 H	1.08E-04	SPG Instrument in 17.5 Gives False High Reading	Would Discover on Next Transfer - About 3 days: FR 3E-06/hr
DPSTK8.5FAIG#	3	4D 3.00E-06 H	2.88E-04	SP G instrumentation gives a false reading	disc. @ next tank filling (4 days): FR 3E-6/hr
FRE-PMP-ADJG+	4	0.25H 4H	5.00E-01	Pump speed is adjusted	Adjusted 4 times per hour, discovered within 15 Minutes
FREBATCH-2WG+		48Y	4.80E+01Y	Frequency of a batch	48 times a year
FRECPRS-2YRG+	4	1H 0.5Y	5.71E-05	Steam pressure switch is calibrated	Assume 1 hr to perform: FR 1/200 batches (2 yrs)
JPRFEED-RECG+	4	96H 1.00E-08 H	9.60E-07	Large leak in jumper causes failure to feed evaporator	Would Discover by End of Cycle
LST-CE--FAIG#	5	8H 5.00E-07 H	2.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: 5E-7/hr for failure
LST-CE--FAIG+	4	8H 5.00E-07 H	4.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: 5E-7/hr for failure
LSTCEHATCALG+	4	3M 2.0Y	3.30E-01	Frequency level instrumentation is calibrated	Not discovered until next calibration
LSTCEHATFAIG#	5	3M 5.00E-07 H	5.40E-04	Level instrument in hackman hat fails high	Discovered in 3 months (when calibrated)
LSTCEHATFAIG+	4	3M 5.00E-07 H	1.08E-03	Level instrument in hackman hat fails high	Discovered in 3 months (when calib.
LSTLE-CECALG+	4	4H 2.0Y	9.12E-04	Frequency of continous evaporator level instrumetation calibration	Assume 4 hour for calibration: Calibrated 2/yr, discovered before next cycle
LSTO10.8FAIG#	5	6M 5.00E-07 H	1.08E-03	Decanter Level Sensor is Failed	Assume Discovered During Calibration (6 months)

Basic Event Data for 8.5E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
LSTO11.7FAIG#	3	6M 5.00E-07 H	2.16E-03	Organic level detector in 11.7 fails low	a: Calibration every 6 months: FR 5E-7/hr
LSTTK906FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 906 level sensor failure	Assume discovered during calibration: FR 5E-7/hr
MDPTK8.7FRCG+	4	96H 1.00E-04 H	9.51E-03	Continous evaporator feed pump fails	Would Discover by End of Cycle (4 days)
MOVGA175OOCG#	1	1N 3.00E-03 N	3.00E-03N	Gang valve from 17.5 fails too close	Generic Failure on Demand
OPR-PMP-DENA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrrectly diagnoses pump speed	Knowledge-based, 30 to 120 minutes
OPR-VOL-IRNA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrectly reads flow or level indication	Good Display (Graph)
OPR17.5-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	sump receipt tank transfer procedure does not allow a 2nd transfer
OPR175AGACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to agitate tank 17.5 prior to sampling	a: administrative control (nominal), Typical Circumstances
OPR1AG87ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to check if agitator is working prior to the first transfer	
OPR2AG87ACHA#		0.5N	5.00E-01	Operator fails to check if agitator is working prior to second transfer	
OPR3AG87ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to check if agitator is working prior to third transfer	
OPR906LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is calibrated to give a false reading	Typical Circumstances
OPRCEHATMCNG#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is set to give a high signal	Typical Circumstances
OPRCELE-MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level Instrument is calibrated to give a high signal	Typical Circumstances
OPRFEEFLCSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to low feed flow (increase feed or shut down evap.)	
OPRG10.8CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to shut down process (compelling signal)	Few Competing Signals
OPRG11.7CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to shut down process (compelling signal)	Few Competing Signals
OPRG175-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to settle tank contents prior to tranferring out	typical circumstances
OPRG175-IRNA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrectly reads spg display	Organic Frequently Present, Good Display (graph)
OPRG175-MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - SPG Instrument is Calibrated to Give a False Reading	Single person, operator check
OPRG175TACHA#	1	1N 5.0E-2 N	5.00E-02N	Operator transfers too much TBP to 8.7	Routine, repetitive circumstances
OPRG175VACHA#	1	1N 5.0E-2 N	5.00E-02N	Operator fails to correct the excessive TBP sent to 8.7	Knowledge-based, 10 to 30 minutes
OPRGAG87ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to activate	

Basic Event Data for 8.5E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
OPRGBLOCDENA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to 8.5E temp., level, sp g alarms (close block valve)	Several Competing Signals
OPRGCETEIRNA#	1	1N 1.0E-2 N	1.00E-02N	Evaporator Temperature Sensor is Out of Calibration	Normal Calibration, Not Discovered Until Next Calibration
OPRGCPRSMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Pressure switch for steam gives a false signal	Single Person, Operator check
OPRGCSPGMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration error - sp g instrumentation gives false reading	Single Person, Operator check
OPRGINSUACHA#	1	1N 5.0E-2 N	5.00E-02N	Insufficient sample pulled	Unusual Circumstances, Difficult to Tell if Sufficient
OPRGLOSEILNA#	1	1N 5.0E-3 N	5.00E-03N	Sample Accountability Error in Lab Causes Loss of Sample	Normal Administrative Controls
OPRGNOTRACHA#	1	1N 5.0E-2 N	5.00E-02N	Sample Not Transported to Lab on a Timely Basis	Unusual Circumstances, transportation is not emphasized
OPRGNROMCVLA#	1	1N 1.0E-2 N	1.00E-02N	Operations Fails to Recognize/Correct Omission of Sample	checking requires active participation
OPRGOPCOACNA#	1	1N 5.0E-3 N	5.00E-03N	Operations Violates Procedure and Continues Without Lab results	Typical circumstances
OPRGS175ACNA#	1	1N 5.0E-3 N	5.00E-03N	Procedural violation results in sample not being taken for tank 17.5	Typical circumstances
OPRGS175LANA#	1	1N 3.0E-4 N	3.00E-04N	Routine analysis gives false TBP results for tank 17.5	Low Dependence check
OPRLV906ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fills tank 906 (Level Procedurally Controlled)	Typical Circumstances, Level kept low to prevent large loss of organic
OPRPLUG-VRHA#	1	1N .05N	5.00E-02N	Failure to notice that sp g instrumentation pegs low	a: checked hourly (roundsheet)
OPRPUMPAVRNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to correct adjustment error during 2nd adjustment	Good layout, procedure driven, checks to ensure proper spg or level
OPRTK906CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to low level alarm in tank 906	Typical Circumstances, Further Loss could shut down process
PER-COLD035G#	1	1N 3.50E-01N	3.50E-01N	Cold streams sent to 8.7	1.5 Days of Cold Streams Out of 4 days of running
PER8.5OP013#	1	1N 1.30E-01N	1.30E-01N	Continuous Evaporator is in Operation	Operated 4 days/Month (2.5 Hot & 1 Cold)
PERACCUMINC#	1	1N 1.00E-32N	1.00E-32N	30,000 lbs of organic accumulates in 8.7	COG: incredible
PERFBLININC#	1	1N 1.00E-32N	1.00E-32N	Excess TBP is Received in 8.7 From 9.7	Incredible Event, (no planned B-Line processing)
PERSAMLO020A#	1	1N 2.00E-01N	2.00E-01N	Lab does not request additional sample	COG estimate
PERSR175010A#	1	1N 1.00E-01N	1.00E-01N	Sample is Not Representative of Tank Contents	No credit is taken for sampling involving < 10,000 TBP
PERTK175.20A#	1	1N 2.00E-03N	2.00E-03N	Sufficient TBP present in tank 17.5	a: 1 in 5 years (1/500 Batches)
PERTR175002A#	1	1N 2.00E-02N	2.00E-02N	Material Is Being Received From 17.5	Pu Recovery, Assume 1 out of 50 batches

Basic Event Data for 8.5E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
PSTSTEAMFAIG#	3	4D 1.00E-06 H	9.60E-05	Steam pressure switch fails	Assume would be discovered by next cycle: FR 1E-6/hr
PSTSTEAMFAIG+	4	4D 1.00E-06 H	9.60E-05	Steam pressure switch fails	Assume would be discovered by next cycle: FR 1E-6/hr
RLPPUMP-NREG#	1	1N 1.0E-3N	1.00E-03N	Pump switch fails to open	Per Demand, Generic Data
SAM_17.5FAIA#	5	6D 1.00E-05 H	7.20E-04	Sampler malfunctions such that a sample can not be pulled (tank 17.5)	6 Days to restore: FR 1E-5/hr
SPGCEVAPPLGG#	3	2H 2.0D	1.54E-01	Plugging of instrumentation causes a low spg reading	2 hour to detect and restore, round sheet every hour
TBP17.5-INCG#		1.0E-32N	1.00E-32	Several batches containing excess TBP are received from 17.5 (30,000 lbs total)	Incredible - 3 consecutive transfers from 17.5 during a batch
TBPDENS1PREA#		1.0E-32N	1.00E-32	Process upsets causes dilute 2AW or high density in 11.7S	COG: incredible (would involve phase inversion, can't get 10,000 lbs organic)
TBPDENS2PREA#		1.0E-32H	8.76E-29Y	Process upsets causes dilute 2W or high density in 11.7S	COG: incredible (would involve phase inversion, can't get 10,000 lbs organic)
TBPTK---PREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess organic in feed	Estimated as 1/10years - Not detected for 12 hours
TBPTK2BPPREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess TBP in canyon product	Estimated as 1/10years - Not detected for 12 hours
TSTCETE-FAIG#	3	4D 1.00E-06 H	9.60E-05	Continous Evaporator Temperature Sensor Has Failed	Assumes Discovered by next cycle: FR 1E-6/hr
TUBCEAIRLEGG#	3	40D 3.00E-07 H	2.88E-04	Air leak cause false sp g reading	10ft Long x 4 day to restore, detected at next feed tank filling

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Data Type Codes for 8.5E Evaporator

Type Code	Rate	Description	Source	EF	D
AGI BLA	5.0E-7H	Agitor blades fall off	a: fails at 1/10 frequency of agitator failure		
AGI FAC	5.0E-6H	Agitator failure	WSRC-TR-93-262		
ALR COM	3.00E-06H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I		
ALR NRI	3.00E-05H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
ANA FAI	5.00E-06 H	Analyzer, Failure (Instr. & Control)	WSRC-TR-93-262, ANA-FA-I	10	L
CAV FOW	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Water)	WSRC-TR-93-262, CAV-FO-W	10	L
DPS FAI	3.00E-06 H	Sensor/Transmit., Transdu./Proc. Sw., Differ. Pres., Failure (Instr. & Control)	WSRC-TR-93-262, DPS-FA-I	10	L
FRE 2YR	0.5Y	Frequency	a: every 2 years (COG)		
FRE ADJ	4H	Speed of Feed Pump Adjusted 4 Times per hourt	Operations personnel		
JPR REC	1.00E-08 H	Jumper, Rupture (external) (Chemical)	WSRC-TR-93-262, JPR-RE-C	30	L
LST CAL	2.0Y	Level Instrument Calibration Frequency	Assumed Value		
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
MDP FRC	1.00E-04 H	Pump, Motor-Driven, Fails to run (Chemical)	WSRC-TR-93-262, MDP-FR-C	10	L
MOV OOC	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, MOV-OO-C	10	L
OPR ACH	5.0E-2 N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High	5	L
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR CSN	1.0E-2 N	Failure to respond to compelling signal (Nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal	5	L
OPR CVL	1.0E-2 N	Checker verification error	WSRC-TR-93-581, Table 4, Item 8, Low	5	L
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR ILN	5.0E-3 N	Incorrect labeling or tagging (Nominal)	WSRC-TR-93-581, Table 4, Item 10, Nominal	10	L
OPR IRN	1.0E-2 N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal	5	L
OPR LAN	3.0E-4 N	Laboratory analysis error (Nominal)	WSRC-TR-93-581, Table 4, Item 19, Nominal	10	
OPR MCN	5.0E-3 N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	
OPR VRH	.05N				
OPR VRN	1.0E-2 N	Failure to verify within control room (Nominal)	WSRC-TR-93-581, Table 4, Item 3, Nominal	5	
PER .20	2.00E-03N	0.2% chance			
PER 002	2.00E-02N	2% chance			
PER 010	1.00E-01N	10% Chance			
PER 013	1.30E-01N	13% Chance			
PER 020	2.00E-01N	20% chance			
PER 035	3.50E-01N	35% chance			
PER INC	1.00E-32N	Incredible Event			
PST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Press., Failure (Instr. & Control)	WSRC-TR-93-262, PST-FA-I	3	L
RLP NRE	1.0E-3N	Relay fails to open	WSRC-TR-93-262m RLP-NRE		

Data Type Codes for 8.5E Evaporator (CONT.)

Type Code	Rate	Description	Source	EF	D
SAM FAI	1.00E-05 H	Sampler, Failure (Instr. & Control)	WSRC-TR-93-262, SAM-FA-I	10	L
SPG PLG	2.0D	TUBE PLUGS	Estimate by facility sep. tech (Chostner) - Plugs frequently		
TBP PRE	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L
TUB LEG	3.00E-07 H	Tube, Leakage (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, TUB-LE-G	10	L

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APPENDIX D - 9.3E EVAPORATOR FAULT TREE AND DATA

The following abbreviations appear on the fault tree print out and in the basic event file for the fault tree:

FR=Failure Rate

a:= assumption

COG= cognizant engineer estimate/information

TRUNC= Truncation limit of cutset evaluator

The Beta Factor method used to estimate common cause alarm failure is explained in Reference 15.

NOTE: Events in this tree with a probability of "1E-32" are incredible. They do not contribute to the top event frequency and were included only to show that they had been considered. The number "1E-32" was used because it is the smallest number CAFTA is capable of handling.

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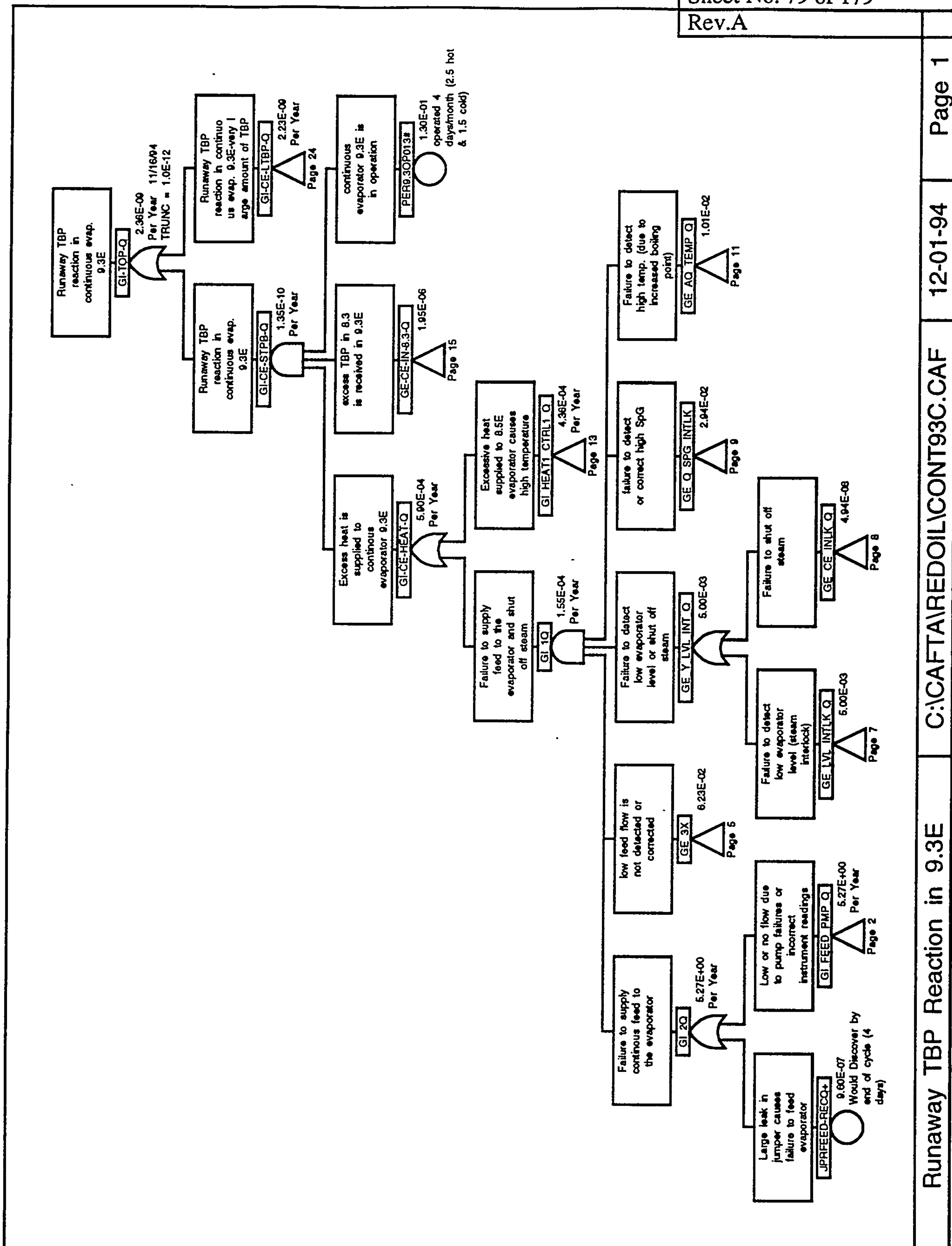

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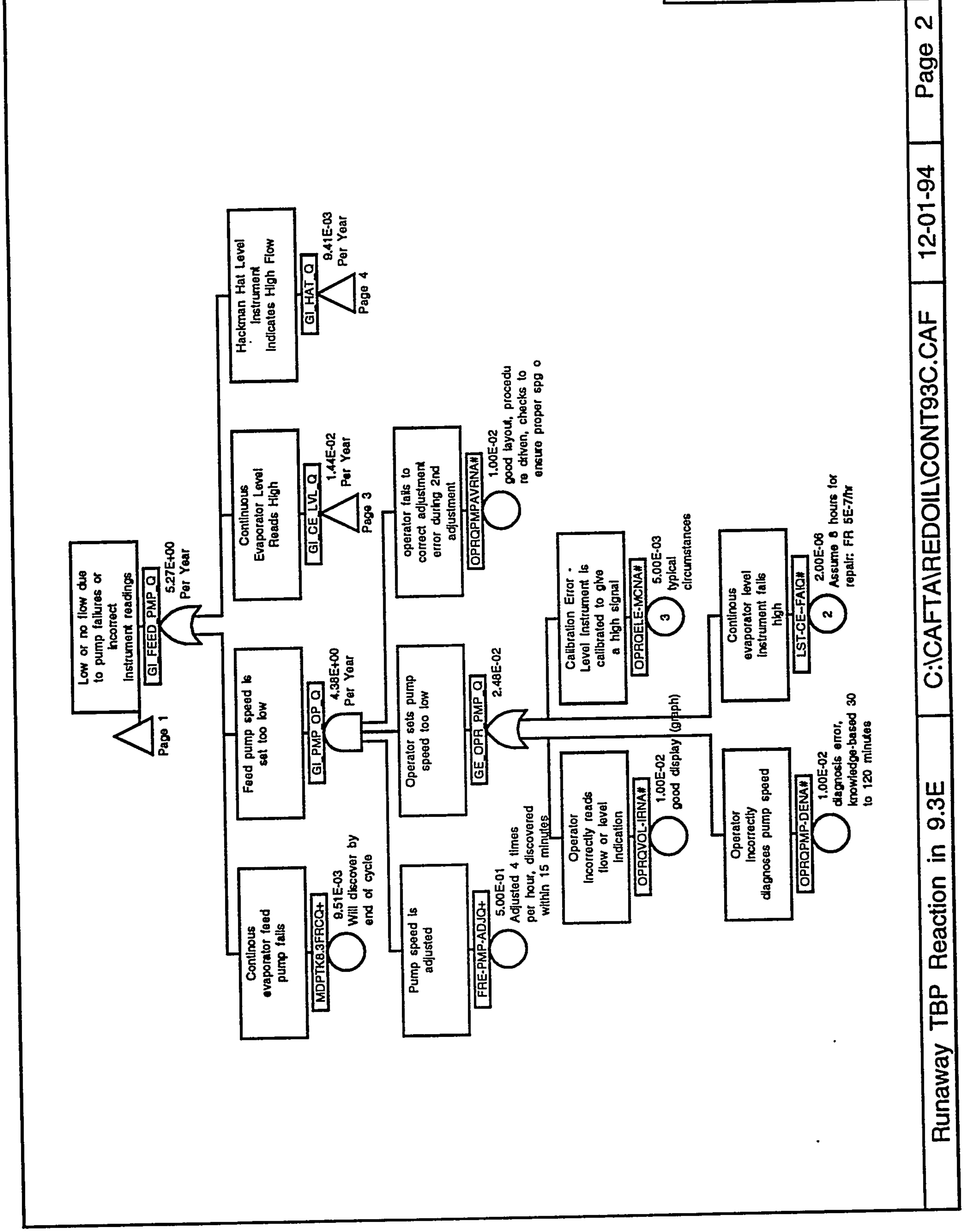

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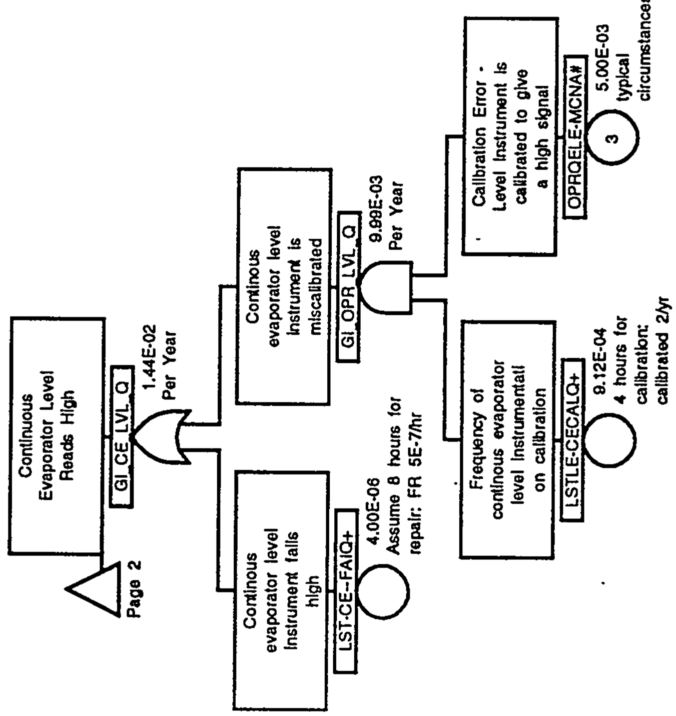

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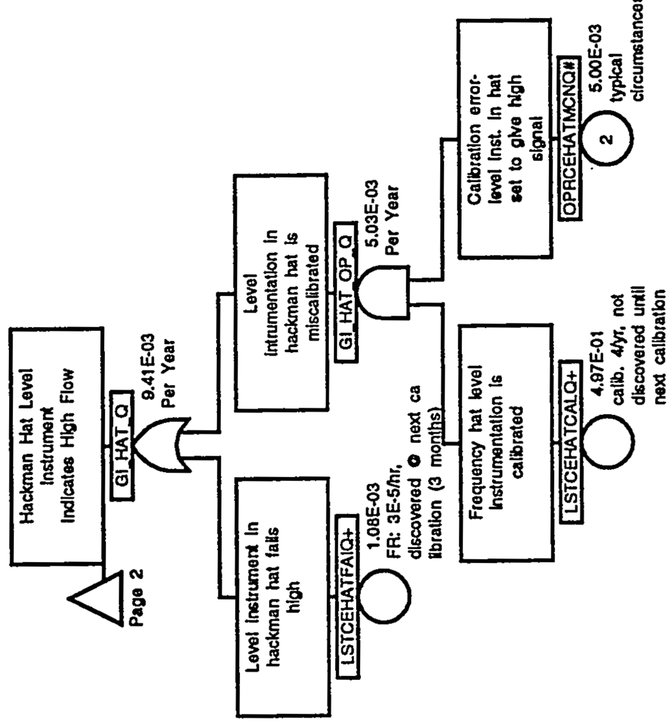

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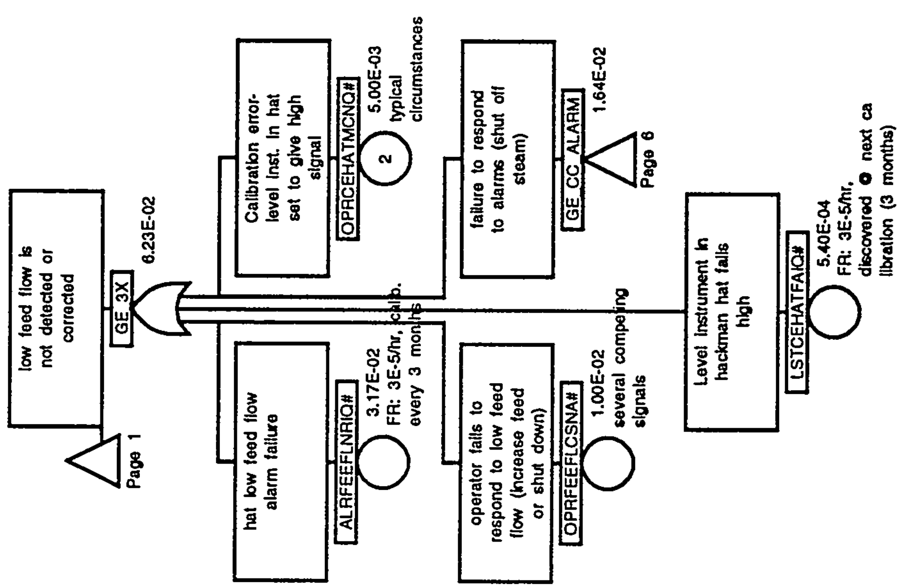

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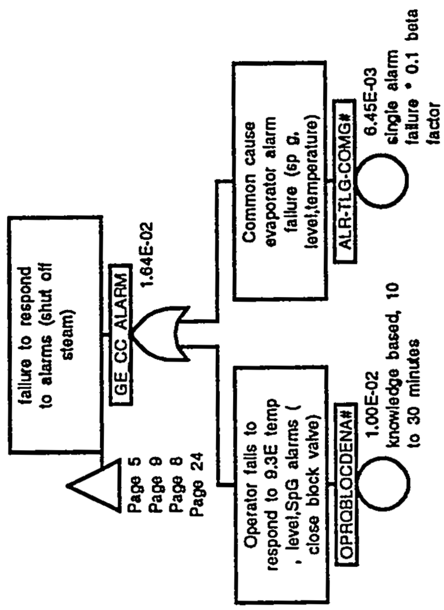

Runaway TBP Reaction in 9.3E | C:\CAFTA\REDOIL\CONT93C.CAF | 12-01-94 | Page 6

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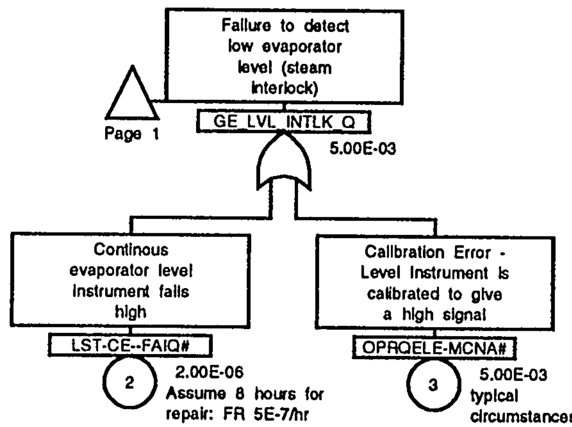

Runaway TBP Reaction in 9.3E	C:\CAFTA\REDOIL\CONT93C.CAF	12-01-94	Page 7

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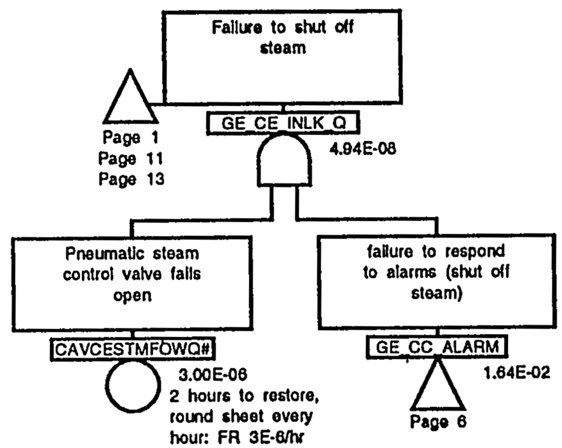

Runaway TBP Reaction in 9.3E	C:\CAFTA\REDOIL\CONT93C.CAF	12-01-94	Page 8

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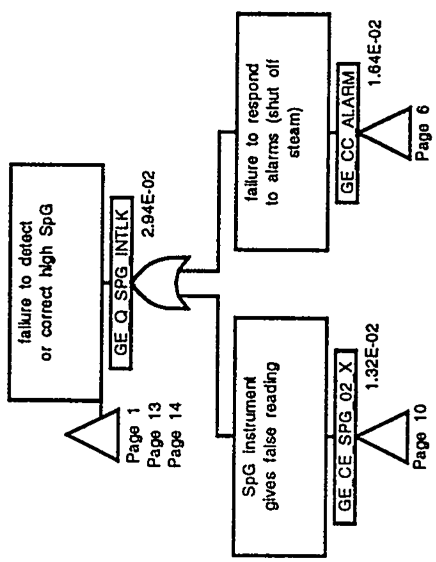
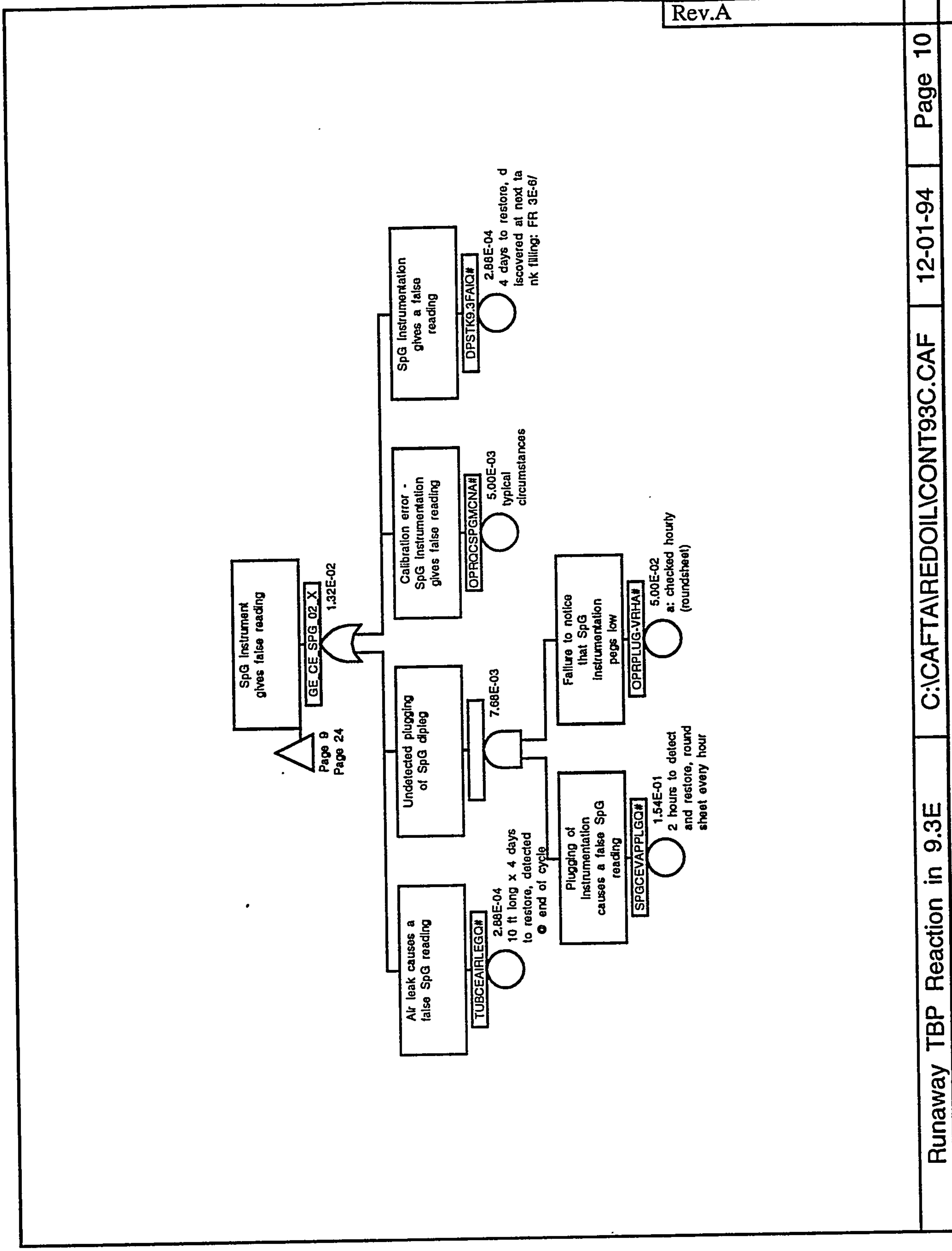


Runaway TBP Reaction in 9.3E | C:\CAFTA\REDOIL\CONT93C.CAF | 12-01-94 | Page 9


SpG Instrument gives false reading
GE_CE_SPG_02_X
1.32E-02
Page 9
Page 24
Air leak causes a false SpG reading
TUBCEAIRLEGQ#
2.88E-04
10 ft long x 4 days to restore, detected @ end of cycle
Undetected plugging of SpG dipleg
7.68E-03
Plugging of Instrumentation causes a false SpG reading
SPGCEVAPPLGQ#
1.54E-01
2 hours to detect and restore, round sheet every hour
Failure to notice that SpG instrumentation pegs low
OPRPLUG-VRHA#
5.00E-02
a: checked hourly (roundsheet)
Calibration error - SpG instrumentation gives false reading
OPRQCSPGMCNA#
5.00E-03
typical circumstances
SpG Instrumentation gives a false reading
DPSTK9.3FAIQ#
2.88E-04
4 days to restore, d iscovered at next ta nk filling: FR 3E-6/
Runaway TBP Reaction in 9.3E
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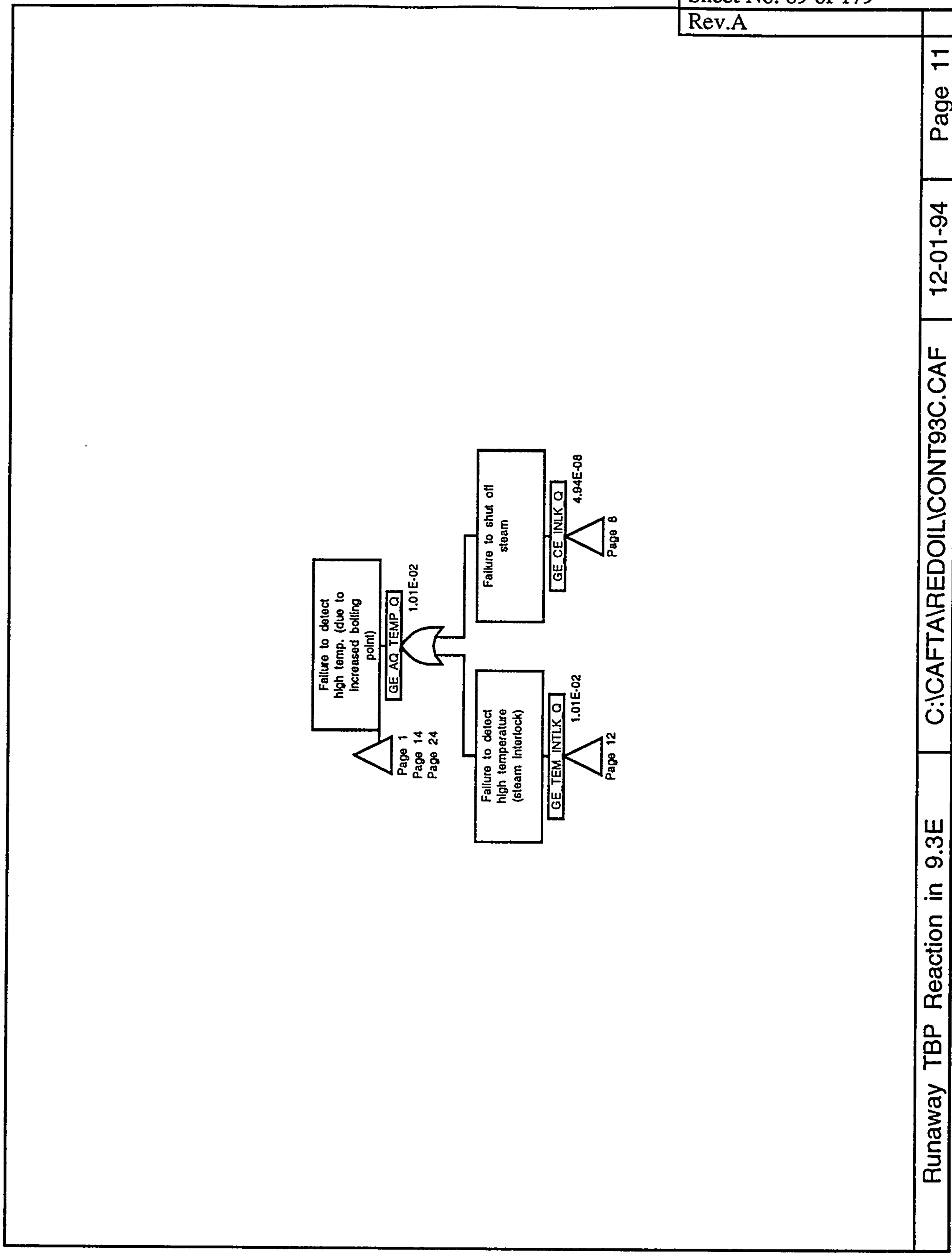

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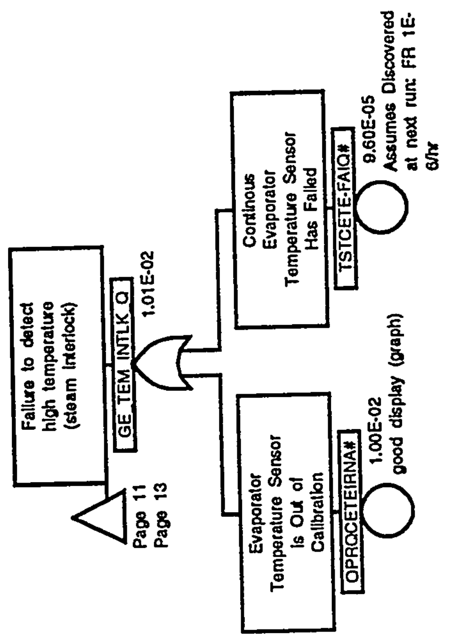
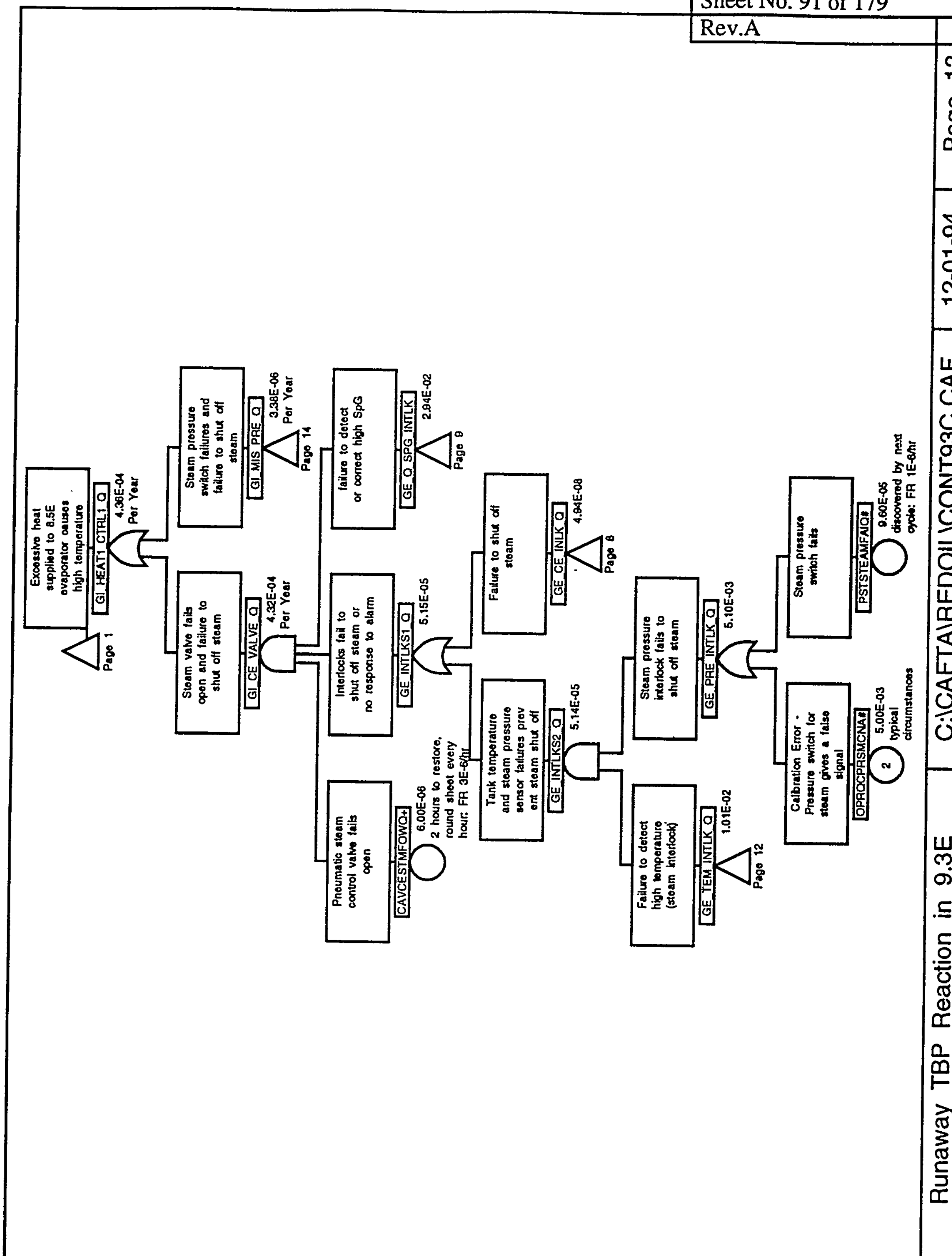


Runaway TBP Reaction in 9.3E | C:\CAFTA\REDOIL\CONT93C.CAF | 12-01-94 | Page 12


Excessive heat supplied to 8.5E evaporator causes high temperature
GI_HEAT1_CTRL1_Q
4.36E-04 Per Year
Page 1
Steam pressure switch failures and failure to shut off steam
GI_MIS_PRE_Q
3.38E-06 Per Year
Page 14
Steam valve fails open and failure to shut off steam
GI_CE_VALVE_Q
4.32E-04 Per Year
failure to detect or correct high SpG
GE_Q_SPG_INTLK
2.94E-02
Page 9
Interlocks fail to shut off steam or no response to alarm
GE_INTLKS1_Q
5.15E-05
Pneumatic steam control valve fails open
CAVCESTMFOWQ+
6.00E-06
2 hours to restore, round sheet every hour: FR 3E-6/hr
Failure to shut off steam
GE_CE_INLK_Q
4.94E-08
Page 8
Tank temperature and steam pressure sensor failures prevent steam shut off
GE_INTLKS2_Q
5.14E-05
Steam pressure interlock fails to shut off steam
GE_PRE_INTLK_Q
5.10E-03
Failure to detect high temperature (steam interlock)
GE_TEM_INTLK_Q
1.01E-02
Page 12
Steam pressure switch fails
PSTSTEAMFAIQ#
9.60E-05
discovered by next cycle: FR 1E-6/hr
Calibration Error - Pressure switch for steam gives a false signal
OPRQCPRSMCNA#
2
5.00E-03
typical circumstances
Runaway TBP Reaction in 9.3E
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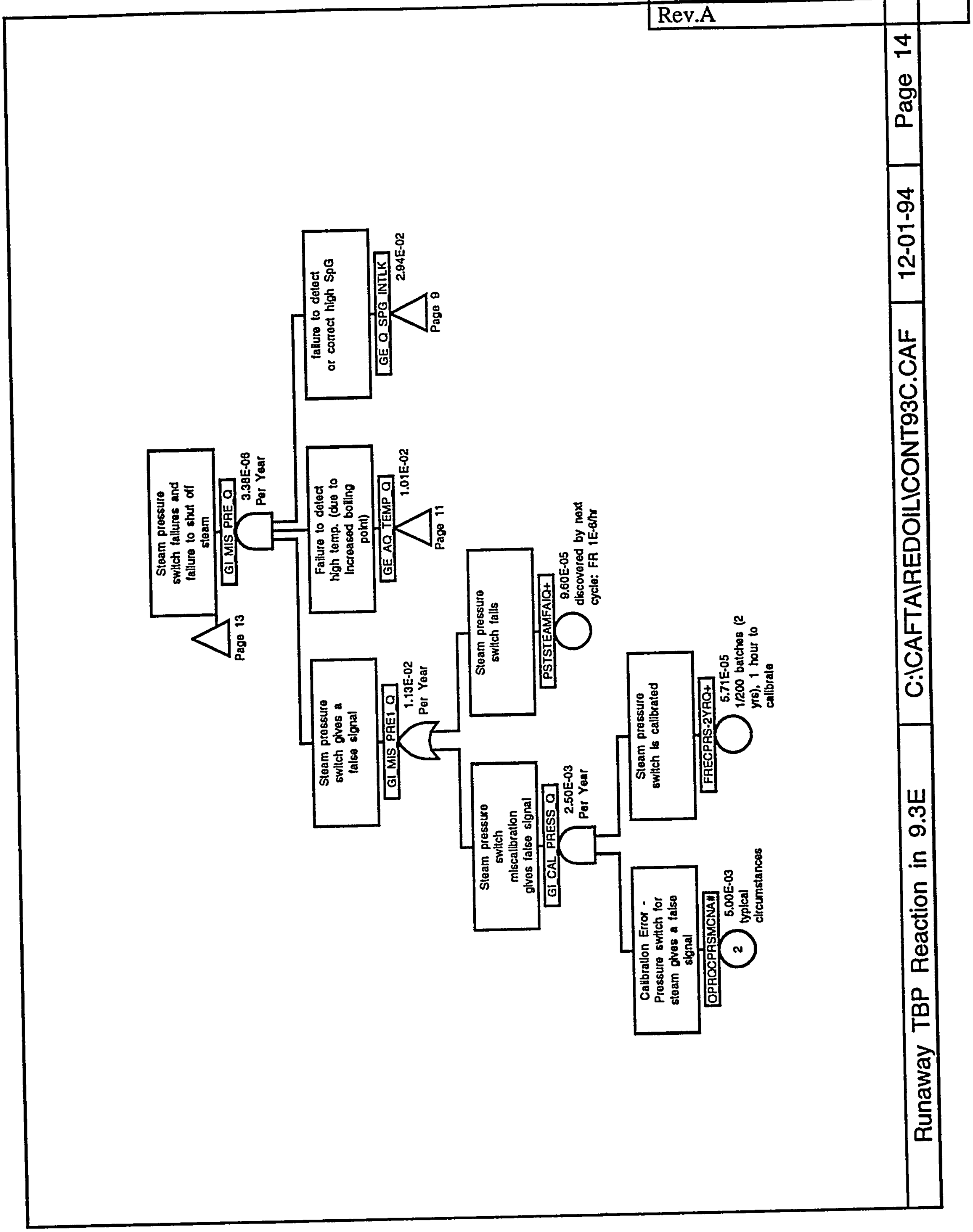

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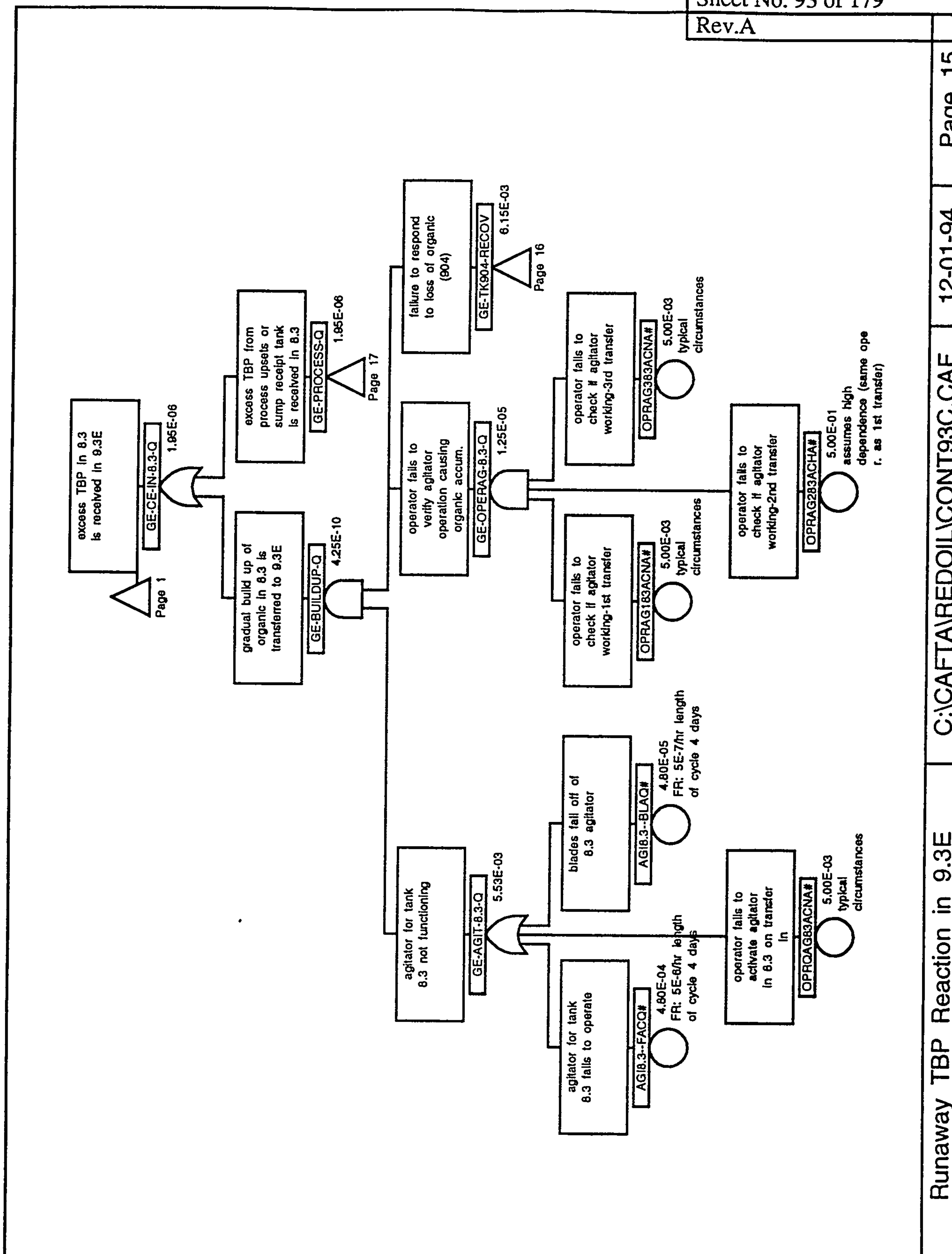

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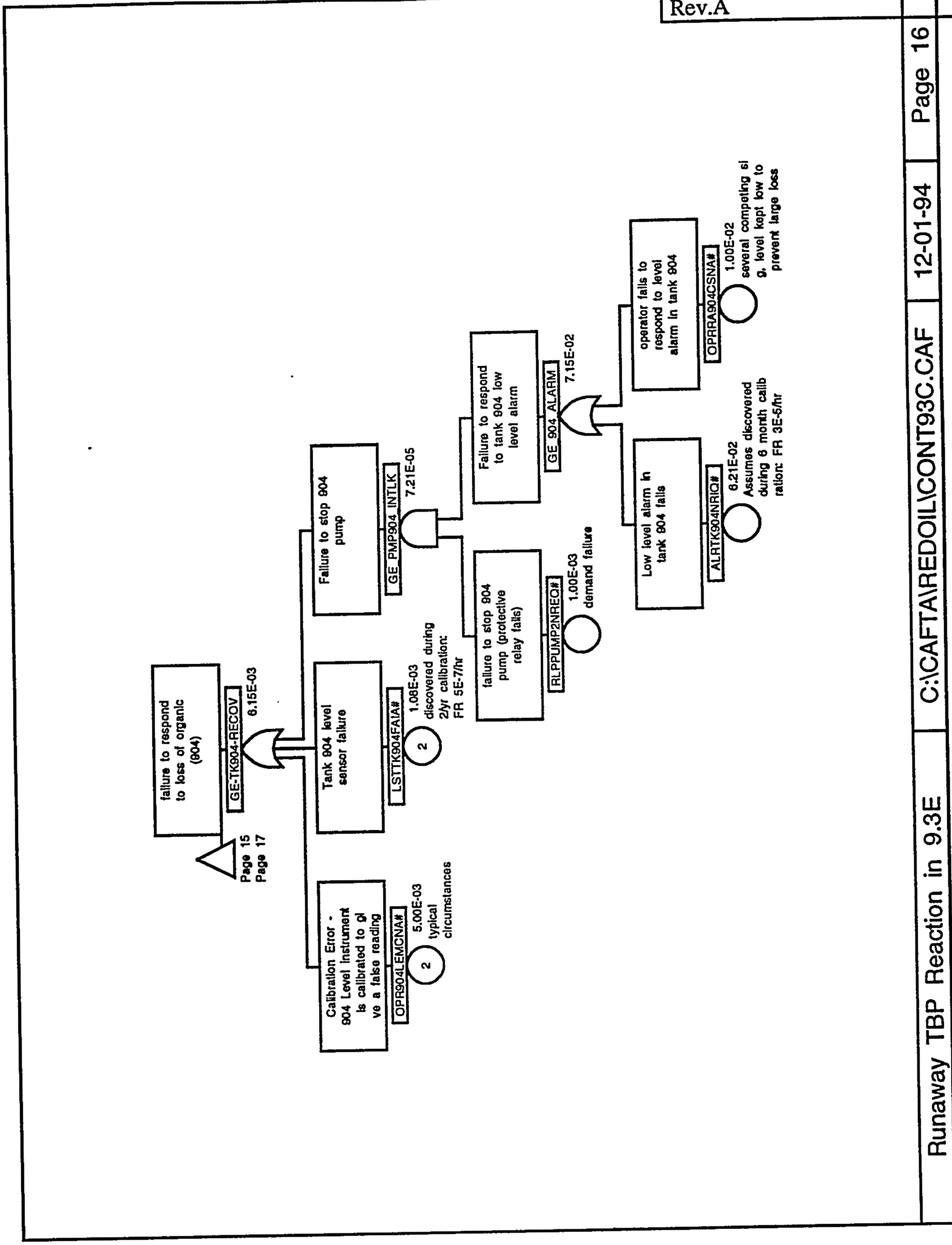

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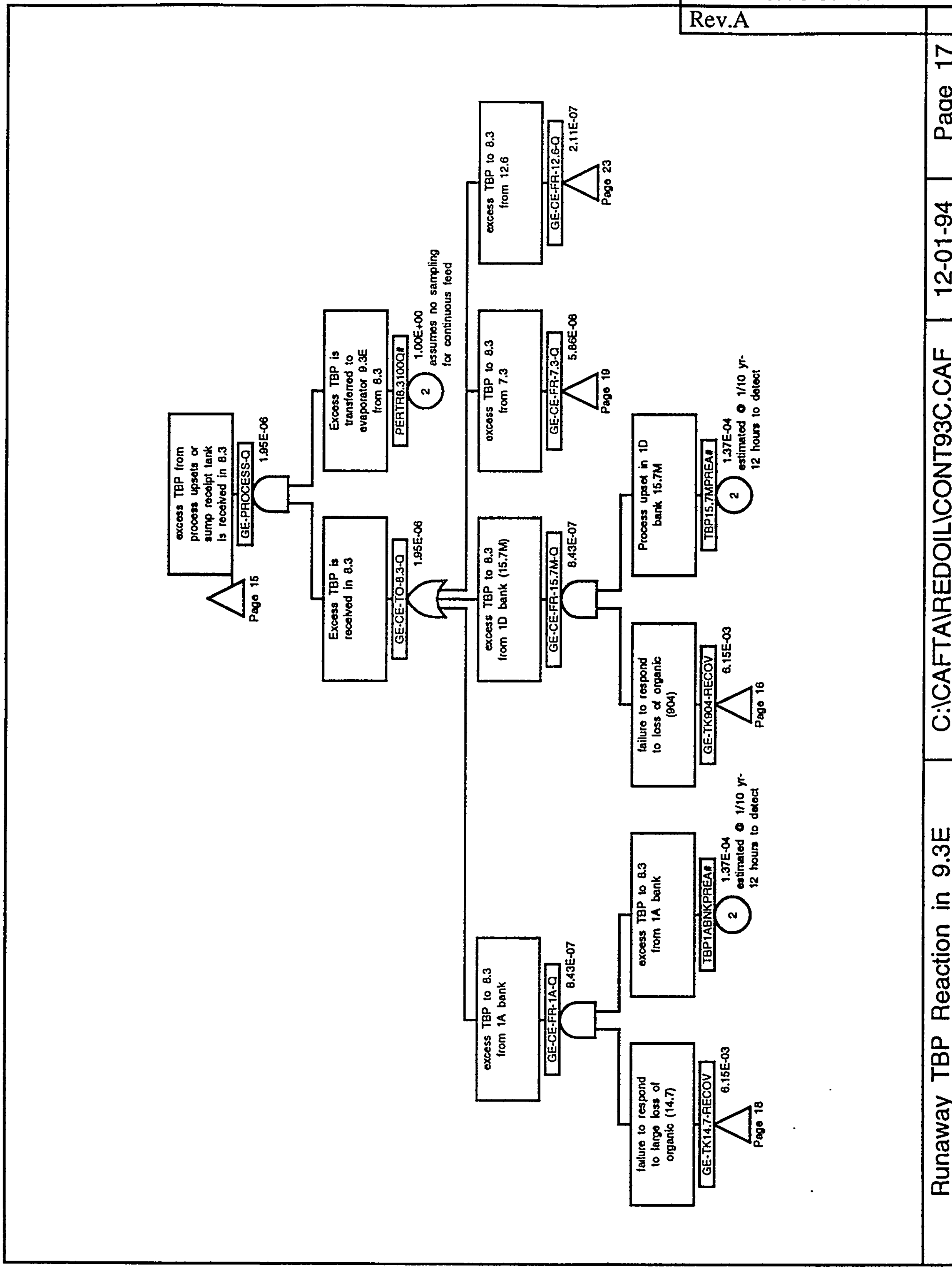

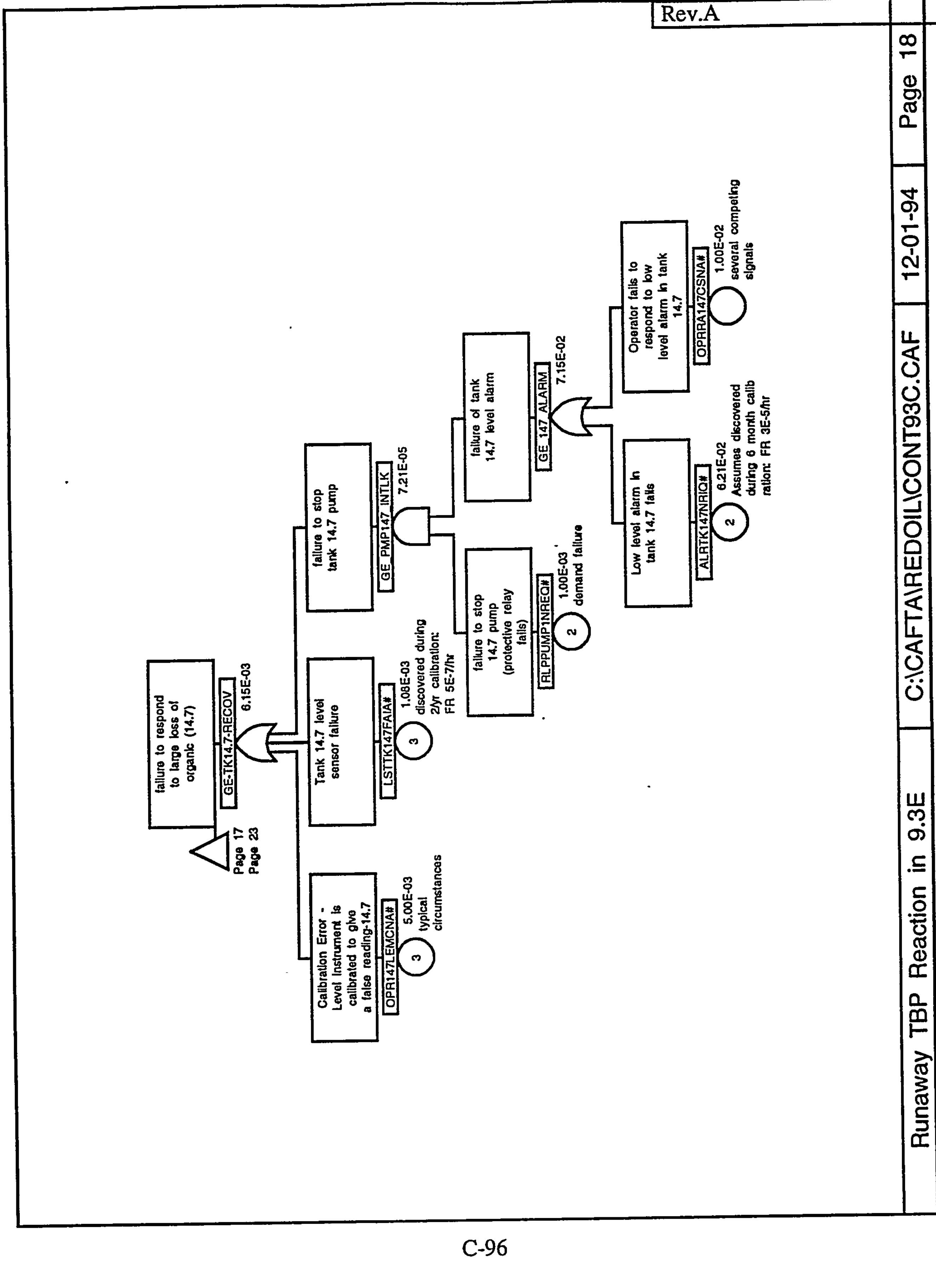
failure to respond to large loss of organic (14.7)
GE-TK14.7-RECOV
6.15E-03
Page 17
Page 23
Calibration Error - Level Instrument is calibrated to give a false reading-14.7
OPR147LEMCNA#
3
5.00E-03
typical circumstances
Tank 14.7 level sensor failure
LSTTK147FAIA#
3
1.08E-03
discovered during 2/yr calibration: FR 5E-7/hr
failure to stop tank 14.7 pump
GE_PMP147_INTLK
7.21E-05
failure to stop 14.7 pump (protective relay fails)
RLPPUMP1NREQ#
2
1.00E-03
demand failure
failure of tank 14.7 level alarm
GE_147_ALARM
7.15E-02
Low level alarm in tank 14.7 fails
ALRTK147NRIQ#
2
6.21E-02
Assumes discovered during 6 month calib ration: FR 3E-5/hr
Operator fails to respond to low level alarm in tank 14.7
OPRRA147CSNA#
1.00E-02
several competing signals
Runaway TBP Reaction in 9.3E
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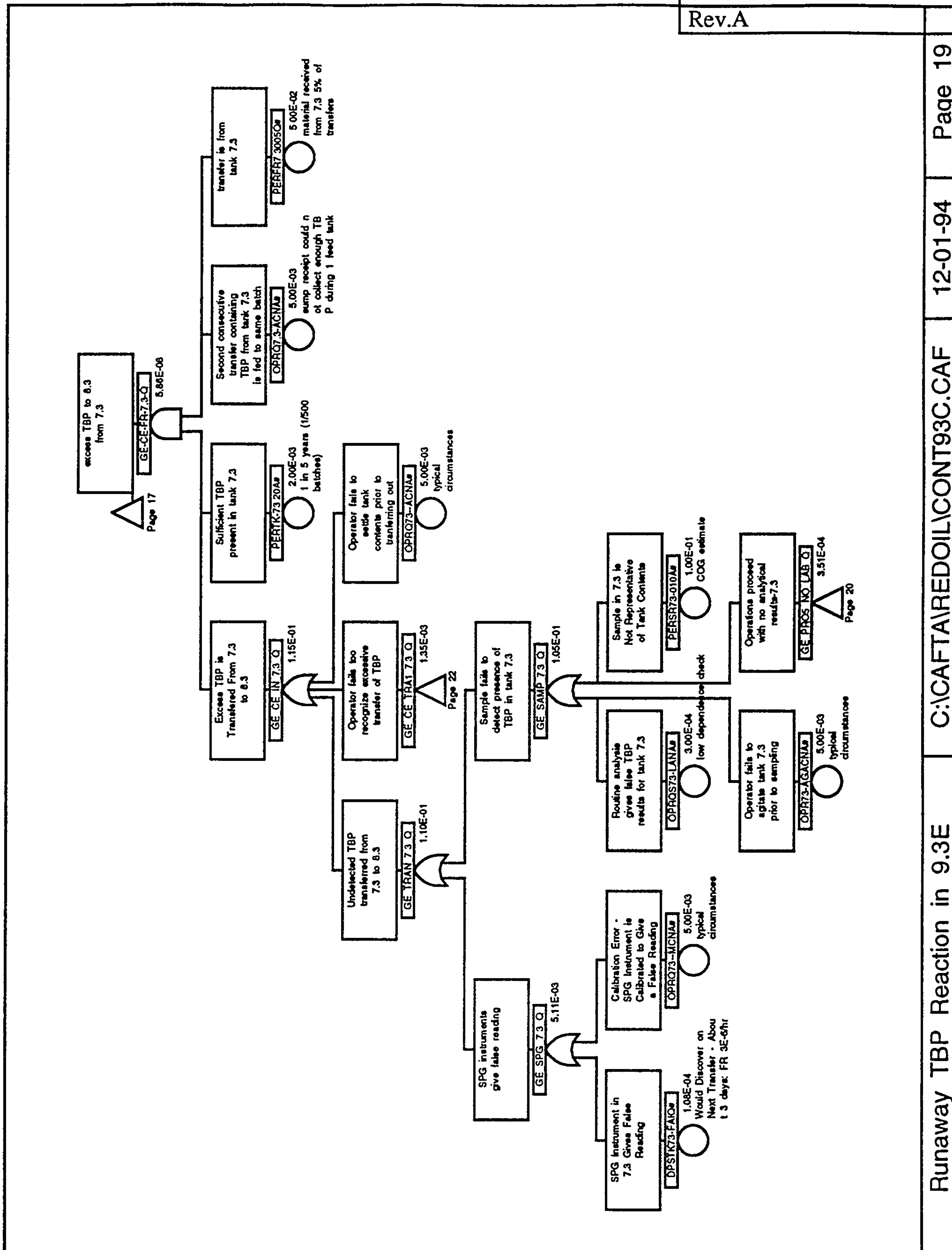

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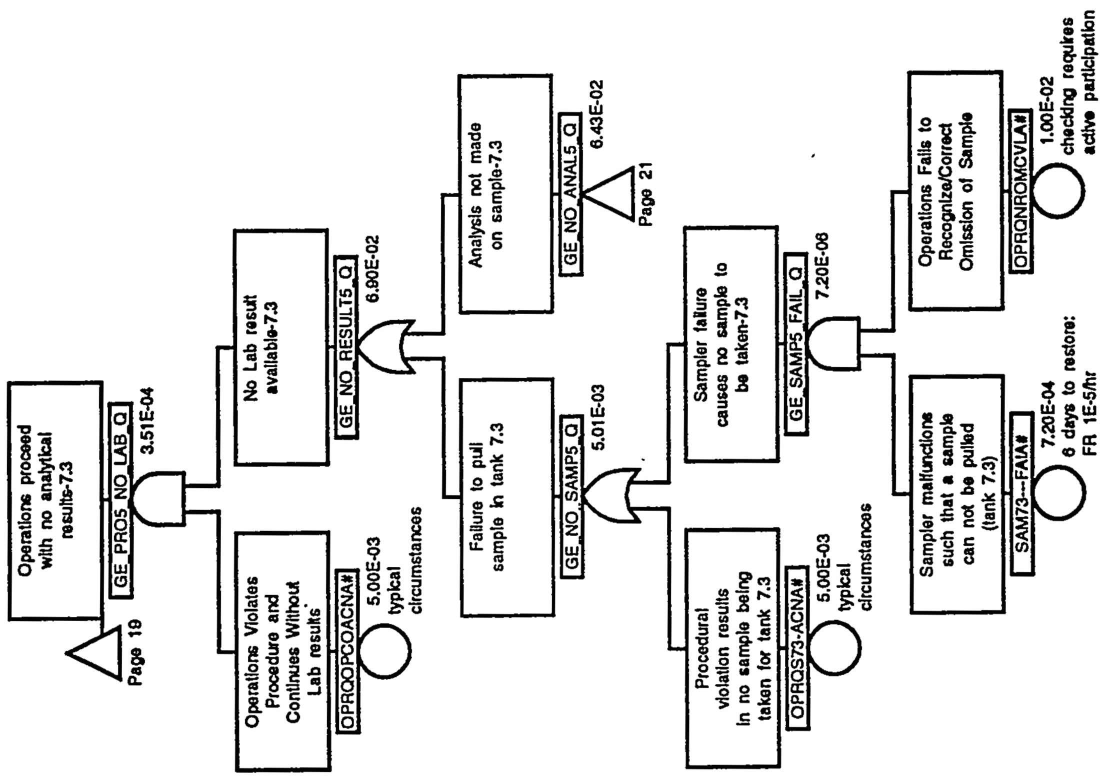

Runaway TBP Reaction in 9.3E	C:\CAFTA\REDOIL\CONT93C.CAF	12-01-94	Page 20

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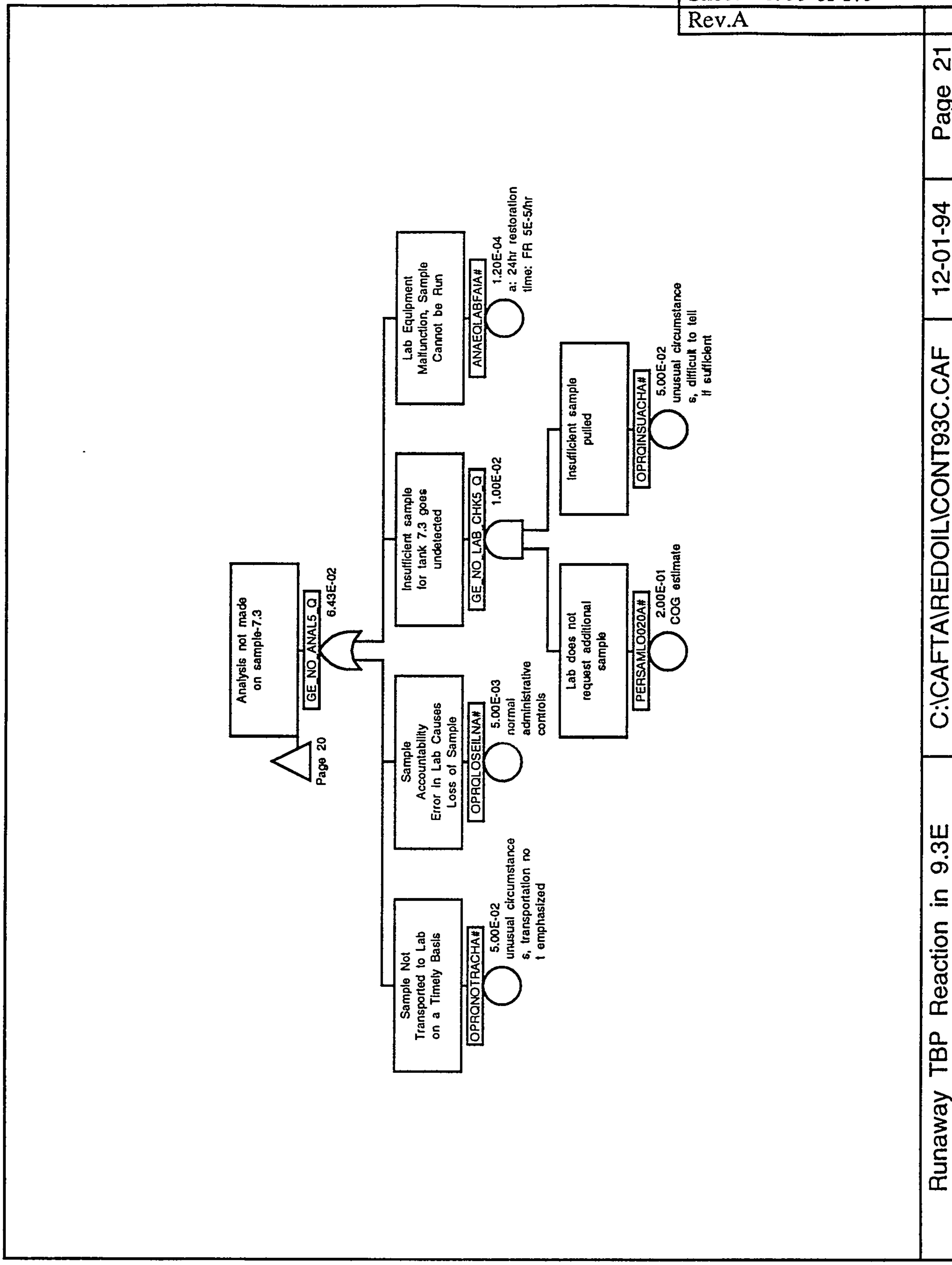

Calculation No. S-CLC-F-00146
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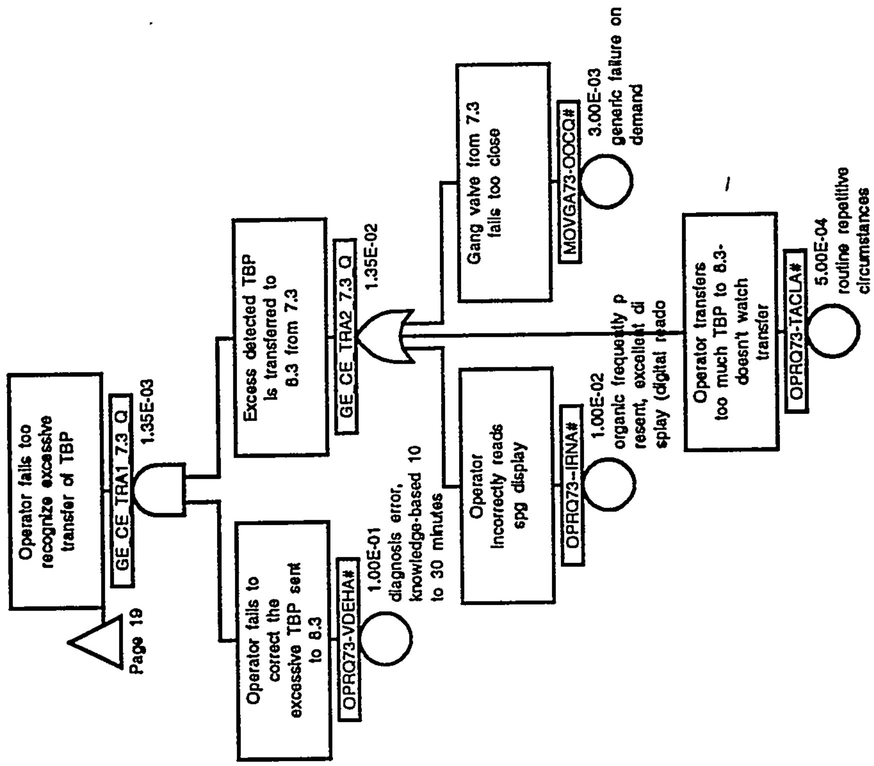

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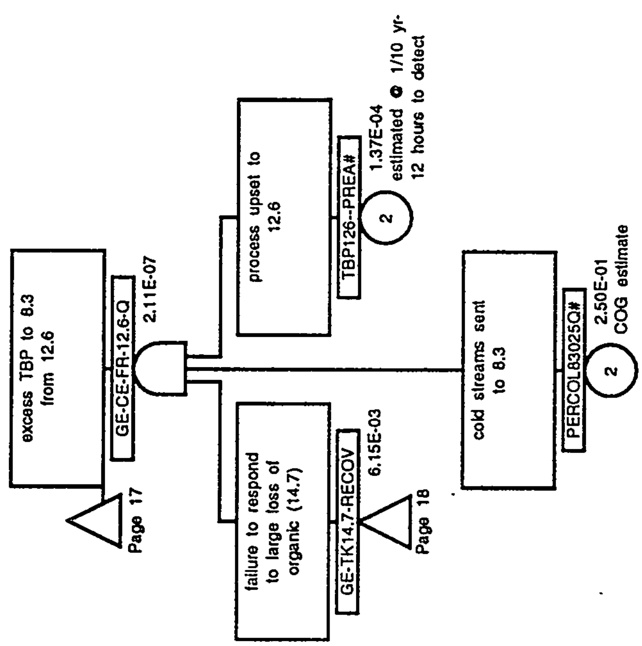

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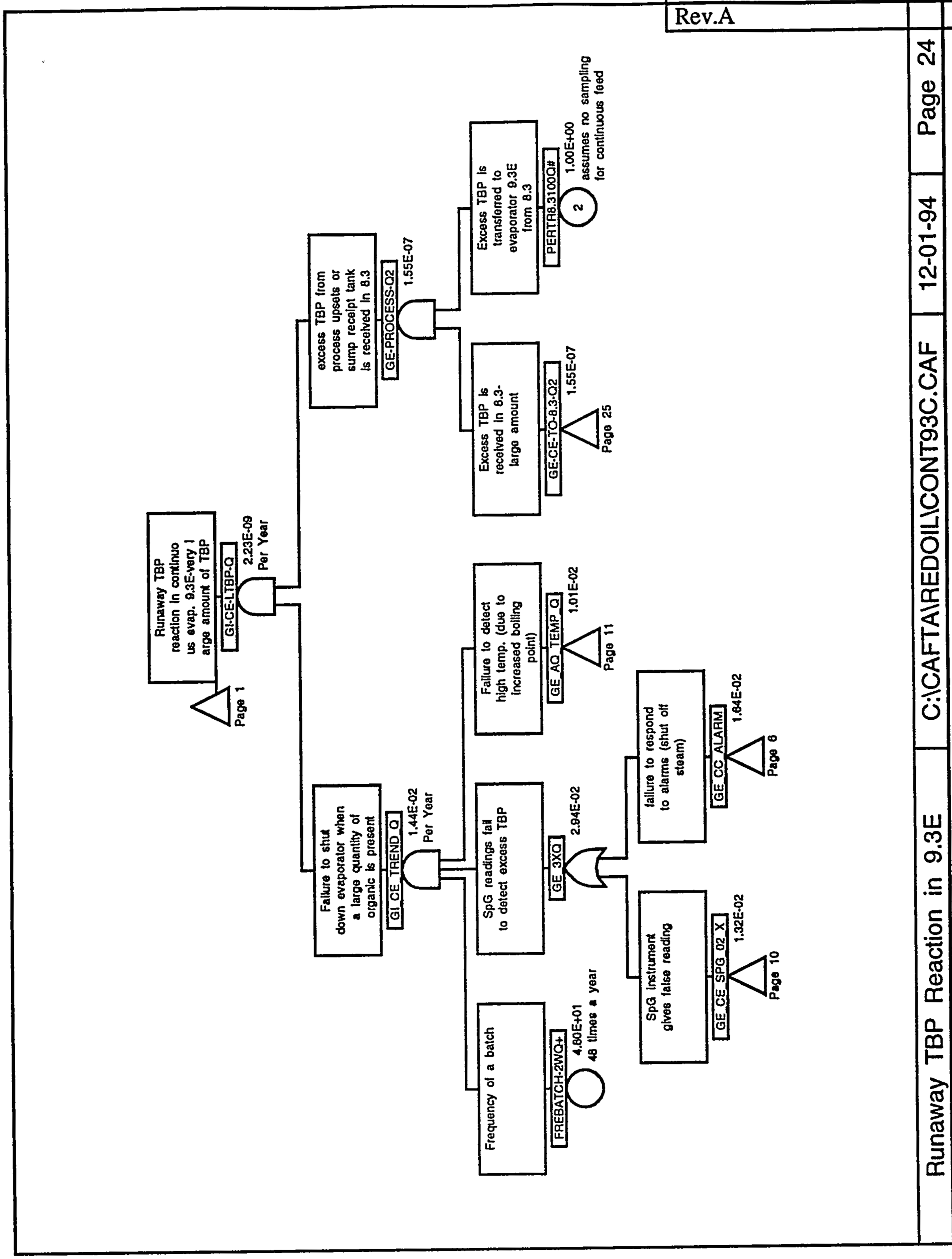

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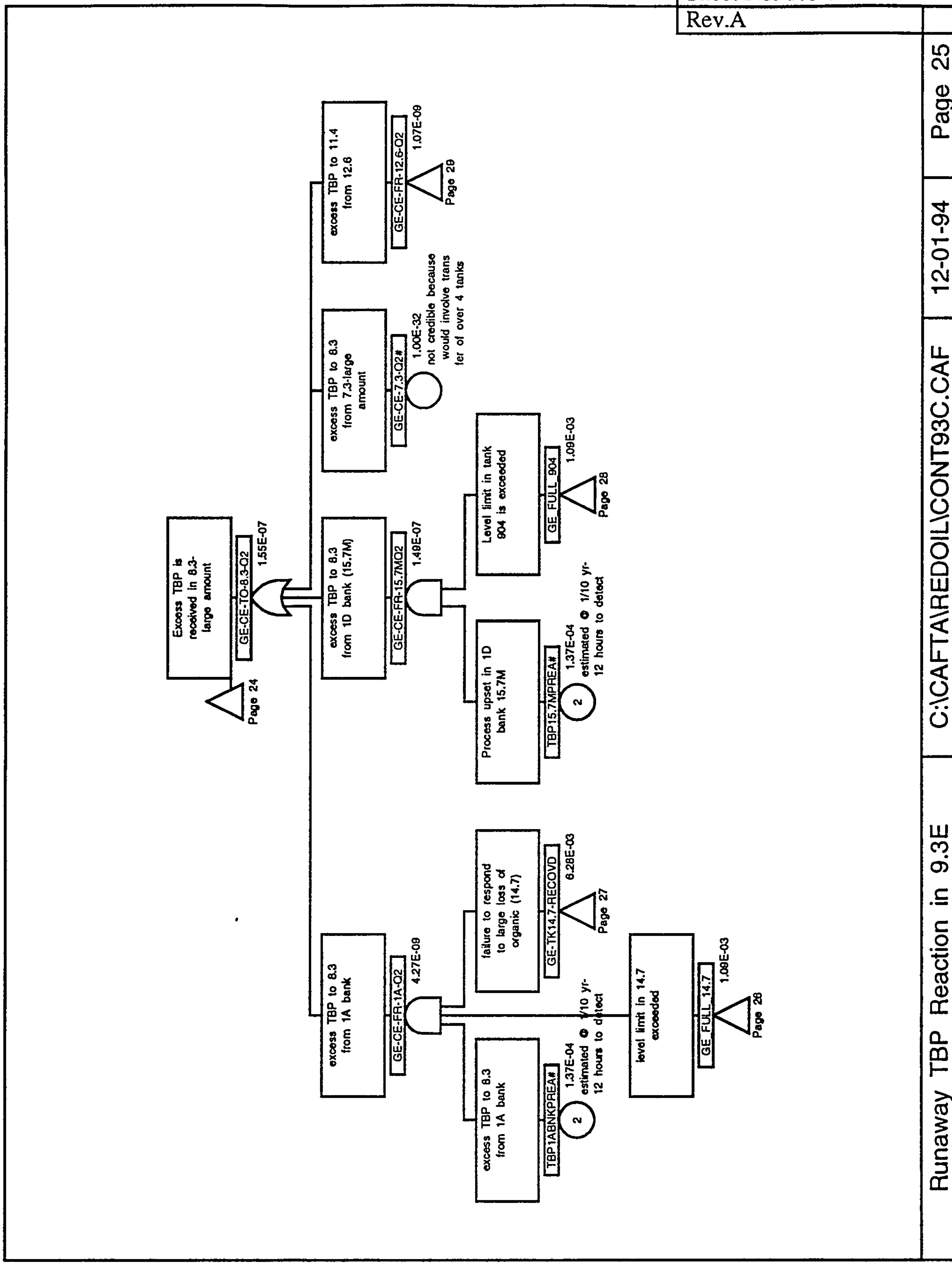

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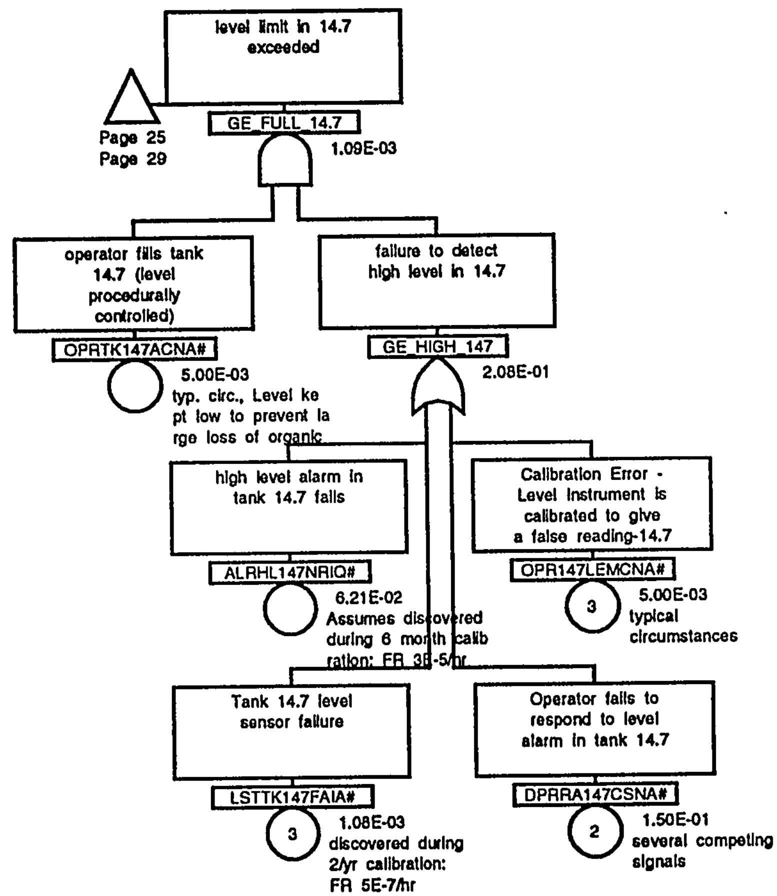

Runaway TBP Reaction in 9.3E	C:\CAFTA\REDOIL\CONT93C.CAF	12-01-94	Page 26

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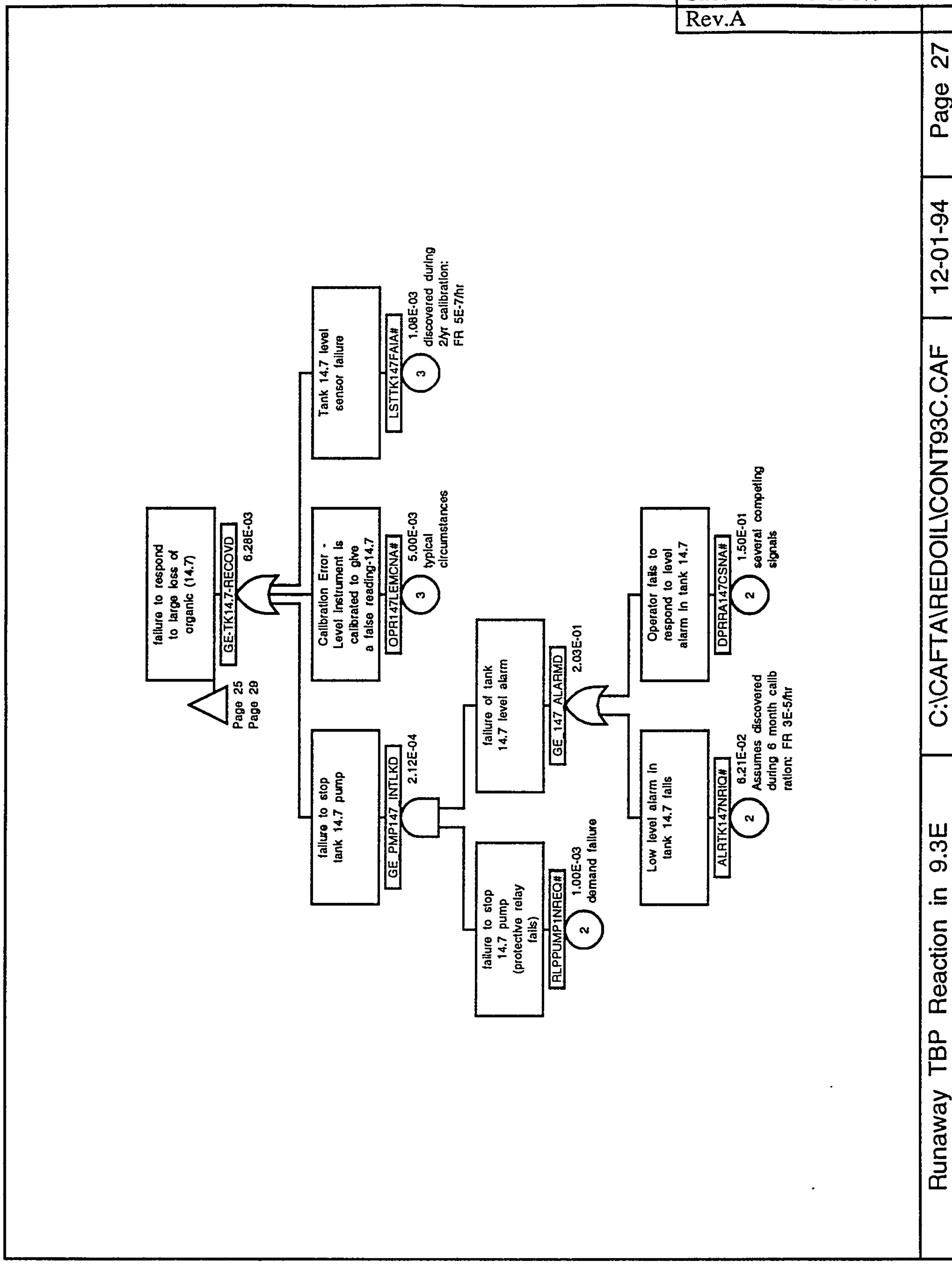

Calculation No. S-CLC-F-00146
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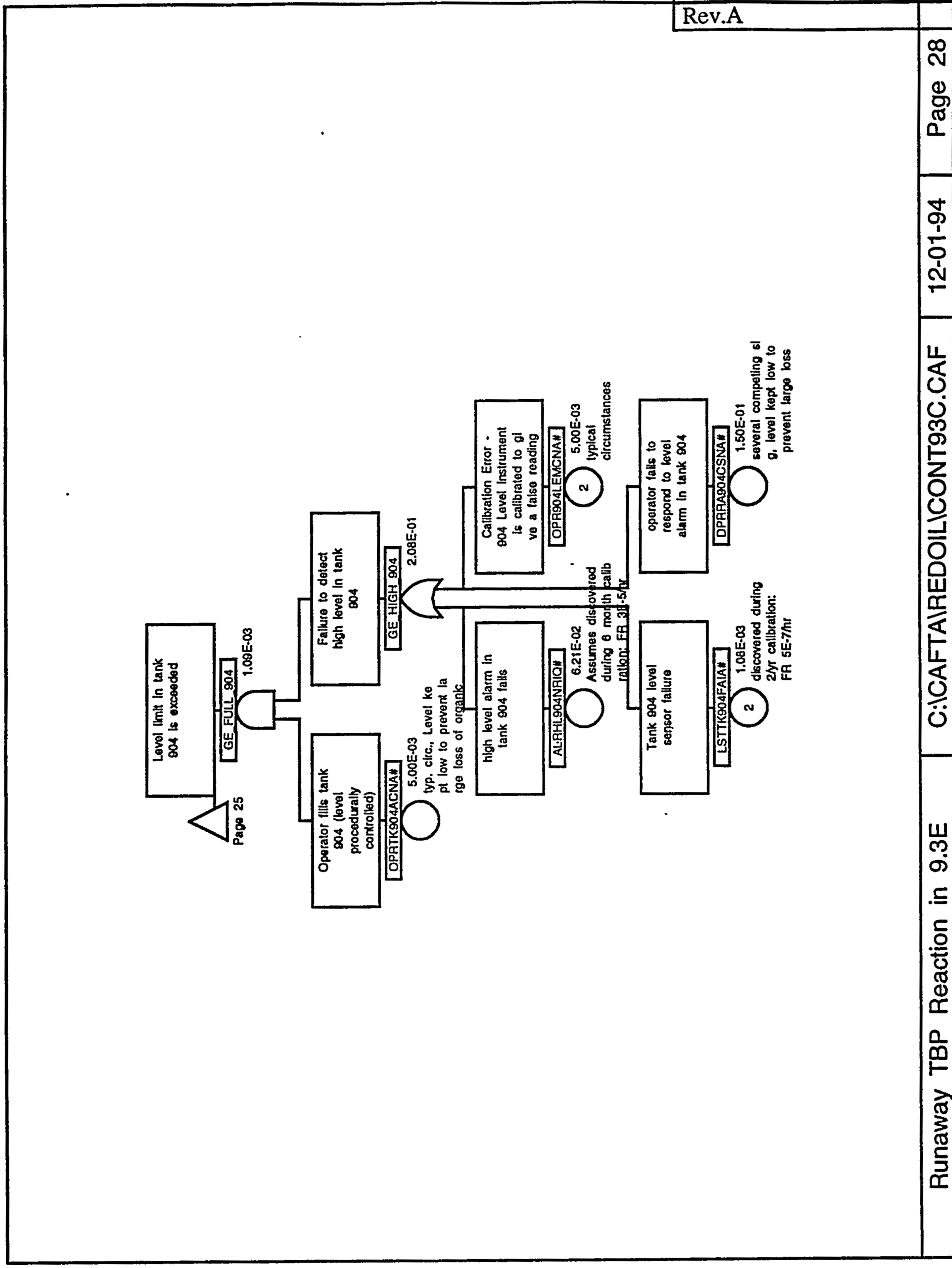

Calculation No. S-CLC-F-00146	
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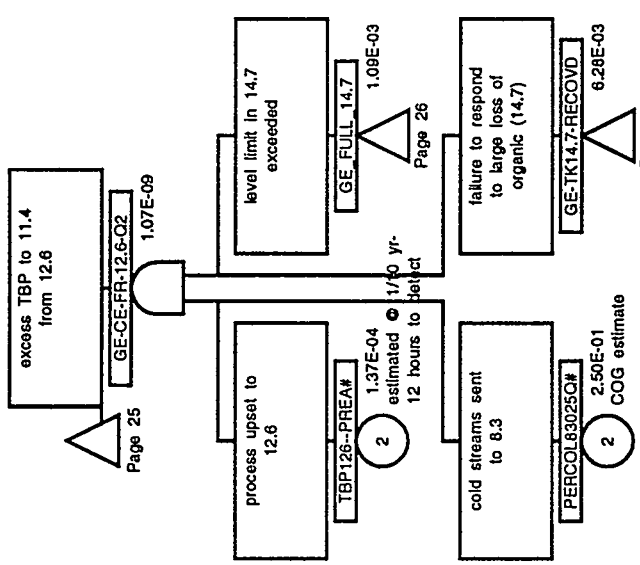

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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AGI8.3--BLAQ#	15		GE-OPERAG-8.3-Q	15		GE_CE_TRA2_7.3_Q	22		GI-CE-LTBP-Q	1	
AGI8.3--FACQ#	15		GE-PROCESS-Q	15		GE_FULL_14.7	25		GI-CE-LTBP-Q	24	
ALR-TLG-COMG#	6		GE-PROCESS-Q	17		GE_FULL_14.7	26		GI-CE-STPB-Q	1	
ALRFEEFLNRIQ#	5		GE-PROCESS-Q2	24		GE_FULL_14.7	29		GI-TOP-Q	1	
ALRHL147NRIQ#	26		GE-TK14.7-RECOV	17		GE_FULL_904	25		GI_1Q	1	
ALRHL904NRIQ#	28		GE-TK14.7-RECOV	18		GE_FULL_904	28		GI_2Q	1	
ALRTK147NRIQ#	18		GE-TK14.7-RECOV	23		GE_HIGH_147	26		GI_CAL_PRESS_Q	14	
ALRTK147NRIQ#	27		GE-TK14.7-RECOVD	25		GE_HIGH_904	28		GI_CE_LVL_Q	2	
ALRTK904NRIQ#	16		GE-TK14.7-RECOVD	27		GE_INTLKS1_Q	13		GI_CE_LVL_Q	3	
ANAEQLABFAIA#	21		GE-TK14.7-RECOVD	29		GE_INTLKS2_Q	13		GI_CE_TREND_Q	24	
CAVCESTMFOWQ#	8		GE-TK904-RECOV	15		GE_LVL_INTLK_Q	1		GI_CE_VALVE_Q	13	
CAVCESTMFOWQ+	13		GE-TK904-RECOV	16		GE_LVL_INTLK_Q	7		GI_FEED_PMP_Q	1	
DPRRA147CSNA#	26		GE-TK904-RECOV	17		GE_NO_ANAL5_Q	20		GI_FEED_PMP_Q	2	
DPRRA147CSNA#	27		GE_147_ALARM	18		GE_NO_ANAL5_Q	21		GI_HAT_OP_Q	4	
DPRRA904CSNA#	28		GE_147_ALARMD	27		GE_NO_LAB_CHK5_Q	21		GI_HAT_Q	2	
DPSTK73-FAIQ#	19		GE_3X	1		GE_NO_RESULT5_Q	20		GI_HAT_Q	4	
DPSTK9.3FAIQ#	10		GE_3X	5		GE_NO_SAMP5_Q	20		GI_HEAT1_CTRL1_Q	1	
FRE-PMP-ADJQ+	2		GE_3XQ	24		GE_OPR_PMP_Q	2		GI_HEAT1_CTRL1_Q	13	
FREBATCH-2WQ+	24		GE_904_ALARM	16		GE_PLUG_SPG	10		GI_MIS_PRE1_Q	14	
FRECPRS-2YRQ+	14		GE_AQ_TEMP_Q	1		GE_PMP147_INTLK	18		GI_MIS_PRE_Q	13	
GE-AGIT-8.3-Q	15		GE_AQ_TEMP_Q	11		GE_PMP147_INTLKD	27		GI_MIS_PRE_Q	14	
GE-BUILDUP-Q	15		GE_AQ_TEMP_Q	14		GE_PMP904_INTLK	16		GI_OPR_LVL_Q	3	
GE-CE-7.3-Q2#	25		GE_AQ_TEMP_Q	24		GE_PRE_INTLK_Q	13		GI_PMP_OP_Q	2	
GE-CE-FR-12.6-Q	17		GE_CC_ALARM	5		GE_PRO5_NO_LAB_Q	19		JPRFEED-RECQ+	1	
GE-CE-FR-12.6-Q	23		GE_CC_ALARM	6		GE_PRO5_NO_LAB_Q	20		LST-CE--FAIQ#	2	
GE-CE-FR-12.6-Q2	25		GE_CC_ALARM	8		GE_Q_SPG_INTLK	1		LST-CE--FAIQ#	7	
GE-CE-FR-12.6-Q2	29		GE_CC_ALARM	9		GE_Q_SPG_INTLK	9		LST-CE--FAIQ+	3	
GE-CE-FR-15.7M-Q	17		GE_CC_ALARM	24		GE_Q_SPG_INTLK	13		LSTCEHATCALQ+	4	
GE-CE-FR-15.7MQ2	25		GE_CE_INLK_Q	1		GE_Q_SPG_INTLK	14		LSTCEHATFAIQ#	5	
GE-CE-FR-1A-Q	17		GE_CE_INLK_Q	8		GE_SAMP5_FAIL_Q	20		LSTCEHATFAIQ+	4	
GE-CE-FR-1A-Q2	25		GE_CE_INLK_Q	11		GE_SAMP_7.3_Q	19		LSTLE-CECALQ+	3	
GE-CE-FR-7.3-Q	17		GE_CE_INLK_Q	13		GE_SPG_7.3_Q	19		LSTTK147FAIA#	18	
GE-CE-FR-7.3-Q	19		GE_CE_IN_7.3_Q	19		GE_TEM_INTLK_Q	11		LSTTK147FAIA#	26	
GE-CE-IN-8.3-Q	1		GE_CE_SPG_02_X	9		GE_TEM_INTLK_Q	12		LSTTK147FAIA#	27	
GE-CE-IN-8.3-Q	15		GE_CE_SPG_02_X	10		GE_TEM_INTLK_Q	13		LSTTK904FAIA#	16	
GE-CE-TO-8.3-Q	17		GE_CE_SPG_02_X	24		GE_TRAN_7.3_Q	19		LSTTK904FAIA#	28	
GE-CE-TO-8.3-Q2	24		GE_CE_TRA1_7.3_Q	19		GE_Y_LVL_INT_Q	1		MDPTK8.3FRCQ+	2	
GE-CE-TO-8.3-Q2	25		GE_CE_TRA1_7.3_Q	22		GI-CE-HEAT-Q	1		MOVGA73-OOCQ#	22	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
OPR147LEMCNA#	18		OPRRA147CSNA#	18							
OPR147LEMCNA#	26		OPRRA904CSNA#	16							
OPR147LEMCNA#	27		OPRTK147ACNA#	26							
OPR73-AGACNA#	19		OPRTK904ACNA#	28							
OPR904LEMCNA#	16		PER9.3OP013#	1							
OPR904LEMCNA#	28		PERCOL83025Q#	23							
OPRAG183ACNA#	15		PERCOL83025Q#	29							
OPRAG283ACHA#	15		PERFR7.3005Q#	19							
OPRAG383ACNA#	15		PERSAMLO020A#	21							
OPRCEHATMCNQ#	4		PERSR73-010A#	19							
OPRCEHATMCNQ#	5		PERTK-73.20A#	19							
OPRFEEFLCSNA#	5		PERTR8.3100Q#	17							
OPRPLUG-VRHA#	10		PERTR8.3100Q#	24							
OPRQ7.3-ACNA#	19		PSTSTEAMFAIQ#	13							
OPRQ73--ACNA#	19		PSTSTEAMFAIQ+	14							
OPRQ73--IRNA#	22		RLPPUMP1NREQ#	18							
OPRQ73--MCNA#	19		RLPPUMP1NREQ#	27							
OPRQ73-TACLA#	22		RLPPUMP2NREQ#	16							
OPRQ73-VDEHA#	22		SAM73---FAIA#	20							
OPRQAG83ACNA#	15		SPGCEVAPPLGQ#	10							
OPRQBLOCDENA#	6		TBP126--PREA#	23							
OPRQCETEIRNA#	12		TBP126--PREA#	29							
OPRQCPRSMCNA#	13		TBP15.7MPREA#	17							
OPRQCPRSMCNA#	14		TBP15.7MPREA#	25							
OPRQCSPGMCNA#	10		TBP1ABNKPREA#	17							
OPRQELE-MCNA#	2		TBP1ABNKPREA#	25							
OPRQELE-MCNA#	3		TSTCETE-FAIQ#	12							
OPRQELE-MCNA#	7		TUBCEAIRLEGQ#	10							
OPRQINSUACHA#	21										
OPRQLOSEILNA#	21										
OPRQNOTRACHA#	21										
OPRQNROMCVLA#	20										
OPRQOPCOACNA#	20										
OPRQPMP-DENA#	2										
OPRQPMPAVRNA#	2										
OPRQS73-ACNA#	20										
OPRQS73-LANA#	19										
OPRQVOL-IRNA#	2										

Cutsets for 9.3E Evaporator

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	GI-TOP-Q					2.36E-09
1.	DPRRA904CSNA#	operator fails to respond to level alarm in tank 904		0.15N	1.50E-01	4.93E-10
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
2.	DPRRA904CSNA#	operator fails to respond to level alarm in tank 904		0.15N	1.50E-01	3.79E-10
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRPLUG-VRHA#	Failure to notice that SpG instrumentation pegs low	1	1N 5.00E-02N	5.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	SPGCEVAPPLGQ#	Plugging of instrumentation causes a false SpG reading	3	2H 2D	1.54E-01	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
3.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	3.18E-10
	DPRRA904CSNA#	operator fails to respond to level alarm in tank 904		0.15N	1.50E-01	
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
4.	DPRRA904CSNA#	operator fails to respond to level alarm in tank 904		0.15N	1.50E-01	2.47E-1
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRQCSPGMCNA#	Calibration error - SpG instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
5.	ALRHL904NRIQ#	high level alarm in tank 904 fails	5	6M 3.00E-05 H	6.21E-02	2.04E-10
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
6.	ALRHL904NRIQ#	high level alarm in tank 904 fails	5	6M 3.00E-05 H	6.21E-02	1.57E-10
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRPLUG-VRHA#	Failure to notice that SpG instrumentation pegs low	1	1N 5.00E-02N	5.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	SPGCEVAPPLGQ#	Plugging of instrumentation causes a false SpG reading	3	2H 2D	1.54E-01	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
7.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.32E-10
	ALRHL904NRIQ#	high level alarm in tank 904 fails	5	6M 3.00E-05 H	6.21E-02	
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
8.	ALRHL904NRIQ#	high level alarm in tank 904 fails	5	6M 3.00E-05 H	6.21E-02	1.02E-10
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCSPGMCNA#	Calibration error - SpG instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
9.	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	2.34E-11
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
10.	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	2.34E-11
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
11.	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	1.64E-11
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK147ACNA#	operator fills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
12.	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	1.64E-11
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
13.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.51E-11
	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
14.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.51E-11
	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
15.	DPRRA904CSNA#	operator fails to respond to level alarm in tank 904		0.15N	1.50E-01	1.42E-11
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
	TUBCEAIRLEGQ#	Air leak causes a false SpG reading	3	40D 3.00E-07 H	2.88E-04	
16.	DPRRA904CSNA#	operator fails to respond to level alarm in tank 904		0.15N	1.50E-01	1.42E-11
	DPSTK9.3FAIQ#	SpG instrumentation gives a false reading	3	4D 3.00E-06 H	2.88E-04	
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
17.	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	1.26E-11
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG-VRHA#	Failure to notice that SpG instrumentation pegs low	1	1N 5.00E-02N	5.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK147ACNA#	operator fills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	SPGCEVAPPLGQ#	Plugging of instrumentation causes a false SpG reading	3	2H 2D	1.54E-01	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
18.	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	1.26E-11
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRPLUG-VRHA#	Failure to notice that SpG instrumentation pegs low	1	1N 5.00E-02N	5.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	SPGCEVAPPLGQ#	Plugging'of instrumentation causes a false SpG reading	3	2H 2D	1.54E-01	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
19.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.06E-11
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK147ACNA#	operator fills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
20.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	1.06E-11
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
21.	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	8.22E-12
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCSPGMCNA#	Calibration error - SpG instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
22.	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	8.22E-12
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCSPGMCNA#	Calibration error - SpG instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK147ACNA#	operator fills tank 14.7 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
23.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	7.80E-12
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N	
	OPRQPMPAVRNA#	operator fails to correct adjustment error during 2nd adjustment	1	1N 1.00E-02N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
24.	FRE-PMP-ADJQ+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	7.80E-12
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N	
	OPRQPMPAVRNA#	operator fails to correct adjustment error during 2nd adjustment	1	1N 1.00E-02N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
25.	ALRHL904NRIQ#	high level alarm in tank 904 fails	5	6M 3.00E-05 H	6.21E-02	5.88E-12
	DPSTK9.3FAIQ#	SpG instrumentation gives a false reading	3	4D 3.00E-06 H	2.88E-04	
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
26.	ALRHL904NRIQ#	high level alarm in tank 904 fails	5	6M 3.00E-05 H	6.21E-02	5.88E-12
	FREBATCH-2WQ+	Frequency of a batch		48Y	4.80E+01Y	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRTK904ACNA#	Operator fills tank 904 (level procedurally controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
	TUBCEAIRLEGQ#	Air leak causes a false SpG reading	3	40D 3.00E-07 H	2.88E-04	
27.	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	5.85E-12
	OPR147LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading-14.7	1	1N 5.0E-3 N	5.00E-03N	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	PERCOL83025Q#	cold streams sent to 8.3	1	1N 2.50E-01N	2.50E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP126--PREA#	process upset to 12.6	3	12H 0.1Y	1.37E-04	
28.	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	5.05E-12
	LSTTK147FAIA#	Tank 14.7 level sensor failure	5	6M 5.00E-07 H	1.08E-03	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP1ABNKPREA#	excess TBP to 8.3 from 1A bank	3	12H 0.1Y	1.37E-04	
29.	CAVCESTMFOWQ+	Pneumatic steam control valve fails open	4	2H 3.00E-06 H	6.00E-06	5.05E-12
	LSTTK904FAIA#	Tank 904 level sensor failure	5	6M 5.00E-07 H	1.08E-03	
	OPRQBLOCDENA#	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	1	1N 1.0E-2 N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N 1.00E+00N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	12H 0.1Y	1.37E-04	
30.	ALR-TLG-COMG#	Common cause evaporator alarm failure (sp g, level,temperature)	5	6M 3.00E-06H	6.45E-03	5.03E-1
	FRE-PMP-ADJQ+	Pump speed is adjusted	4	0.25H 4H	5.00E-01	
	OPR904LEMCNA#	Calibration Error - 904 Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRQCETEIRNA#	Evaporator Temperature Sensor is Out of Calibration	1	1N 1.0E-2 N	1.00E-02N	
	OPRQELE-MCNA#	Calibration Error - Level Instrument is calibrated to give a high signal	1	1N 5.0E-3 N	5.00E-03N	
	OPRQPMPAVRNA#	operator fails to correct adjustment error during 2nd adjustment	1	1N 1.00E-02N	1.00E-02N	
	PER9.3OP013#	continuous evaporator 9.3E is in operation	1	1N 1.30E-01N	1.30E-01N	

Cutsets for 9.3E Evaporator (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	PERTR8.3100Q#	Excess TBP is transferred to evaporator 9.3E from 8.3	1	1N	1.00E+00N	
	TBP15.7MPREA#	Process upset in 1D bank 15.7M	3	1.00E+00N 12H 0.1Y	1.37E-04	

Basic Event Data for 9.3E Evaporator

Event	C	Input	Calc.	Description	Source
AGI8.3--BLAQ#	3	4D 5E-7H	4.80E-05	blades fall off of 8.3 agitator	FR: 5E-7/hr length of cycle 4 days
AGI8.3--FACQ#	3	4D 5.00E-06H	4.80E-04	agitator for tank 8.3 fails to operate	FR: 5E-6/hr length of cycle 4 days
ALR-TLG-COMG#	5	6M 3.00E-06H	6.45E-03	Common cause evaporator alarm failure (sp g, level,temperature)	single alarm failure * 0.1 beta factor
ALRFEEFLNRIQ#	5	3M 3.00E-05 H	3.17E-02	hat low feed flow alarm failure	FR: 3E-5/hr, calib. every 3 months
ALRHL147NRIQ#	5	6M 3.00E-05 H	6.21E-02	high level alarm in tank 14.7 fails	Assumes discovered during 6 month calibration: FR 3E-5/hr
ALRHL904NRIQ#	5	6M 3.00E-05 H	6.21E-02	high level alarm in tank 904 fails	Assumes discovered during 6 month calibration: FR 3E-5/hr
ALRTK147NRIQ#	5	6M 3.00E-05 H	6.21E-02	Low level alarm in tank 14.7 fails	Assumes discovered during 6 month calibration: FR 3E-5/hr
ALRTK904NRIQ#	5	6M 3.00E-05 H	6.21E-02	Low level alarm in tank 904 fails	Assumes discovered during 6 month calibration: FR 3E-5/hr
ANAEQLABFAIA#	3	24H 5.00E-06 H	1.20E-04	Lab Equipment Malfunction, Sample Cannot be Run	a: 24hr restoration time: FR 5E-5/hr
CAVCESTMFOWQ#	5	2H 3.00E-06 H	3.00E-06	Pneumatic steam control valve fails open	2 hours to restore, round sheet every hour: FR 3E-6/hr
CAVCESTMFOWQ+	4	2H 3.00E-06 H	6.00E-06	Pneumatic steam control valve fails open	2 hours to restore, round sheet every hour: FR 3E-6/hr
DPRRA147CSNA#		0.15N	1.50E-01	Operator fails to respond to level alarm in tank 14.7	several competing signals
DPRRA904CSNA#		0.15N	1.50E-01	operator fails to respond to level alarm in tank 904	several competing sig, level kept low to prevent large loss of organic
DPSTK73-FAIQ#	5	3D 3.00E-06 H	1.08E-04	SPG Instrument in 7.3 Gives False Reading	Would Discover on Next Transfer - About 3 days: FR 3E-6/hr
DPSTK9.3FAIQ#	3	4D 3.00E-06 H	2.88E-04	SpG instrumentation gives a false reading	4 days to restore, discovered at next tank filling: FR 3E-6/hr
FRE-PMP-ADJQ+	4	0.25H 4H	5.00E-01	Pump speed is adjusted	Adjusted 4 times per hour, discovered within 15 minutes
FREBATCH-2WQ+		48Y	4.80E+01Y	Frequency of a batch	48 times a year
FRECPRS-2YRQ+	4	1H 0.5Y	5.71E-05	Steam pressure switch is calibrated	1/200 batches (2 yrs), 1 hour to calibrate
GE-CE-7.3-Q2#		1e-32N	1.00E-32	excess TBP to 8.3 from 7.3-large amount	not credible because would involve transfer of over 4 tanks full
JPRFEED-RECQ+	4	96H 1.00E-08 H	9.60E-07	Large leak in jumper causes failure to feed evaporator	Would Discover by end of cycle (4 days)
LST-CE--FAIQ#	5	8H 5.00E-07 H	2.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: FR 5E-7/hr
LST-CE--FAIQ+	4	8H 5.00E-07 H	4.00E-06	Continous evaporator level instrument fails high	Assume 8 hours for repair: FR 5E-7/hr
LSTCEHATCALQ+	4	6M 2.0Y	4.97E-01	Frequency hat level instrumentation is calibrated	calib. 4/yr, not discovered until next calibration
LSTCEHATFAIQ#	5	3M 5.00E-07 H	5.40E-04	Level instrument in hackman hat fails high	FR: 3E-5/hr, discovered @ next calibration (3 months)
LSTCEHATFAIQ+	4	3M 5.00E-07 H	1.08E-03	Level instrument in hackman hat fails high	FR: 3E-5/hr, discovered @ next calibration (3 months)

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Basic Event Data for 9.3E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
LSTLE-CECALQ+	4	4H 2.0Y	9.12E-04	Frequency of continous evaporator level instrumentation calibration	4 hours for calibration: calibrated 2/yr
LSTTK147FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 14.7 level sensor failure	discovered during 2/yr calibration: FR 5E-7/hr
LSTTK904FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 904 level sensor failure	discovered during 2/yr calibration: FR 5E-7/hr
MDPTK8.3FRCQ+	4	96H 1.00E-04 H	9.51E-03	Continous evaporator feed pump fails	Will discover by end of cycle
MOVGA73-OOCQ#	1	1N 3.00E-03 N	3.00E-03N	Gang valve from 7.3 fails too close	generic failure on demand
OPR147LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is calibrated to give a false reading-14.7	typical circumstances
OPR73-AGACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to agitate tank 7.3 prior to sampling	typical circumstances
OPR904LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - 904 Level instrument is calibrated to give a false reading	typical circumstances
OPRAG183ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to check if agitator working-1st transfer	typical circumstances
OPRAG283ACHA#		0.5N	5.00E-01	operator fails to check if agitator working-2nd transfer	assumes high dependence (same oper. as 1st transfer)
OPRAG383ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to check if agitator working-3rd transfer	typical circumstances
OPRCEHATMCNQ#	1	1N 5.0E-3 N	5.00E-03N	Calibration error- level inst. in hat set to give high signal	typical circumstances
OPRFEEFLCSNA#	1	1N 1E-2N	1.00E-02N	operator fails to respond to low feed flow (increase feed or shut down)	several competing signals
OPRPLUG-VRHA#	1	1N 5.00E-02N	5.00E-02N	Failure to notice that SpG instrumentation pegs low	a: checked hourly (roundsheet)
OPRQ7.3-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Second consecutive transfer containing TBP from tank 7.3 is fed to same batch	sump receipt could not collect enough TBP during 1 feed tank run time
OPRQ73--ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to settle tank contents prior to tranferring out	typical circumstances
OPRQ73--IRNA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrectly reads spg display	organic frequently present, excellent display (digital readout, indicator lamp)
OPRQ73--MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - SPG Instrument is Calibrated to Give a False Reading	typical circumstances
OPRQ73-TACLA#	1	1N 5.0E-4 N	5.00E-04N	Operator transfers too much TBP to 8.3-doesn't watch transfer	routine repetitive circumstances
OPRQ73-VDEHA#	1	1N 1.0E-1 N	1.00E-01N	Operator fails to correct the excessive TBP sent to 8.3	diagnosis error, knowledge-based 10 to 30 minutes
OPRQAG83ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fails to activate agitator in 8.3 on transfer in	typical circumstances
OPRQBLOCDENA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to 9.3E temp, level,SpG alarms (close block valve)	knowledge based, 10 to 30 minutes

Basic Event Data for 9.3E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
OPRQCETEIRNA#	1	1N 1.0E-2 N	1.00E-02N	Evaporator Temperature Sensor is Out of Calibration	good display (graph)
OPRQCPRSMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Pressure switch for steam gives a false signal	typical circumstances
OPRQCSPGMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration error - SpG instrumentation gives false reading	typical circumstances
OPRQELE-MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level Instrument is calibrated to give a high signal	typical circumstances
OPRQINSUACHA#	1	1N 5.0E-2 N	5.00E-02N	Insufficient sample pulled	unusual circumstances, difficult to tell if sufficient
OPRQLOSEILNA#	1	1N 5.0E-3 N	5.00E-03N	Sample Accountability Error in Lab Causes Loss of Sample	normal administrative controls
OPRQNOTRACHA#	1	1N 5.0E-2 N	5.00E-02N	Sample Not Transported to Lab on a Timely Basis	unusual circumstances, transportation not emphasized
OPRQNROMCVLA#	1	1N 1.0E-2 N	1.00E-02N	Operations Fails to Recognize/Correct Omission of Sample	checking requires active participation
OPRQOPCOACNA#	1	1N 5.0E-3 N	5.00E-03N	Operations Violates Procedure and Continues Without Lab results	typical circumstances
OPRQPMP-DENA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrectly diagnoses pump speed	diagnosis error, knowledge-based 30 to 120 minutes
OPRQPMPAVRNA#	1	1N 1.00E-02N	1.00E-02N	operator fails to correct adjustment error during 2nd adjustment	good layout, procedure driven, checks to ensure proper spg or level
OPRQS73-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Procedural violation results in no sample being taken for tank 7.3	typical circumstances
OPRQS73-LANA#	1	1N 3.0E-4 N	3.00E-04N	Routine analysis gives false TBP results for tank 7.3	low dependence check
OPRQVOL-IRNA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrectly reads flow or level indication	good display (graph)
OPRRA147CSNA#	1	1N 1E-2N	1.00E-02N	Operator fails to respond to low level alarm in tank 14.7	several competing signals
OPRRA904CSNA#	1	1N 1E-2N	1.00E-02N	operator fails to respond to level alarm in tank 904	several competing sig, level kept low to prevent large loss of organic
OPRTK147ACNA#	1	1N 5.0E-3 N	5.00E-03N	operator fills tank 14.7 (level procedurally controlled)	typ. circ., Level kept low to prevent large loss of organic
OPRTK904ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fills tank 904 (level procedurally controlled)	typ. circ., Level kept low to preven[t] large loss of organic
PER9.3OP013#	1	1N 1.30E-01N	1.30E-01N	continuous evaporator 9.3E is in operation	operated 4 days/month (2.5 hot & 1.5 cold)
PERCOL83025Q#	1	1N 2.50E-01N	2.50E-01N	cold streams sent to 8.3	COG estimate
PERFR7.3005Q#	1	1N 5.00E-02N	5.00E-02N	transfer is from tank 7.3	material received from 7.3 5% of transfers
PERSAMLO020A#	1	1N 2.00E-01N	2.00E-01N	Lab does not request additional sample	COG estimate
PERSR73-010A#	1	1N 1.00E-01N	1.00E-01N	Sample in 7.3 is Not Representative of Tank Contents	COG estimate
PERTK-73.20A#	1	1N 2.00E-03N	2.00E-03N	Sufficient TBP present in tank 7.3	1 in 5 years (1/500 batches)

Basic Event Data for 9.3E Evaporator (CONT.)

Event	C	Input	Calc.	Description	Source
PERTR8.3100Q#	1	1N 1.00E+00N	1.00E+00N	Excess TBP is transferred to evaporator 9.3E from 8.3	assumes no sampling for continuous feed
PSTSTEAMFAIQ#	3	4D 1.00E-06 H	9.60E-05	Steam pressure switch fails	discovered by next cycle: FR 1E-6/hr
PSTSTEAMFAIQ+	4	4D 1.00E-06 H	9.60E-05	Steam pressure switch fails	discovered by next cycle: FR 1E-6/hr
RLPPUMP1NREQ#	1	1N 1E-3N	1.00E-03N	failure to stop 14.7 pump (protective relay fails)	demand failure
RLPPUMP2NREQ#	1	1N 1E-3N	1.00E-03N	failure to stop 904 pump (protective relay fails)	demand failure
SAM73---FAIA#	5	6D 1.00E-05 H	7.20E-04	Sampler malfunctions such that a sample can not be pulled (tank 7.3)	6 days to restore: FR 1E-5/hr
SPGCEVAPPLGQ#	3	2H 2D	1.54E-01	Plugging of instrumentation causes a false SpG reading	2 hours to detect and restore, round sheet every hour
TBP126--PREA#	3	12H 0.1Y	1.37E-04	process upset to 12.6	estimated @ 1/10 yr- 12 hours to detect
TBP15.7MPREA#	3	12H 0.1Y	1.37E-04	Process upset in 1D bank 15.7M	estimated @ 1/10 yr- 12 hours to detect
TBP1ABNKPREA#	3	12H 0.1Y	1.37E-04	excess TBP to 8.3 from 1A bank	estimated @ 1/10 yr- 12 hours to detect
TSTCETE-FAIQ#	3	4D 1.00E-06 H	9.60E-05	Continous Evaporator Temperature Sensor Has Failed	Assumes Discovered at next run: FR 1E-6/hr
TUBCEAIRLEGQ#	3	40D 3.00E-07 H	2.88E-04	Air leak causes a false SpG reading	10 ft long x 4 days to restore, detected @ end of cycle

Data Type Codes for 9.3E Evaporator

Type Code	Rate	Description	Source	EF	D
AGI BLA	5E-7H	agitator blade failure (estimate)	WSRC-TR-93-262,AGI-FA-C/10		
AGI FAC	5.00E-06H	Agitator, Failure (Chemical)	WSRC-TR-93-262, AGI-FA-C		
ALR COM	3.00E-06H	common cause alarm failure (single * 0.1 beta factor)		10	L
ALR NRI	3.00E-05 H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
ANA FAI	5.00E-06 H	Analyzer, Failure (Instr. & Control)	WSRC-TR-93-262, ANA-FA-I	10	L
CAV FOW	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Water)	WSRC-TR-93-262, CAV-FO-W	10	L
DPS FAI	3.00E-06 H	Sensor/Transmit., Transdu./Proc. Sw., Differ. Pres., Failure (Instr. & Control)	WSRC-TR-93-262, DPS-FA-I	10	L
FRE 2YR	0.5Y	Frequency	a: every 2 years (COG)		
FRE ADJ	4H	Speed of Feed Pump Adjusted 3 Times per shift	Operations personnel		
JPR REC	1.00E-08 H	Jumper, Rupture (external) (Chemical)	WSRC-TR-93-262, JPR-RE-C	30	L
LST CAL	2.0Y	Level Instrument Calibration Frequency	Assumed Value		
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
MDP FRC	1.00E-04 H	Pump, Motor-Driven, Fails to run (Chemical)	WSRC-TR-93-262, MDP-FR-C	10	L
MOV OOC	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, MOV-OO-C	10	L
OPR ACH	5.0E-2 N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High	5	L
OPR ACL	5.0E-4 N	Failure of Administrative Control	WSRC-TR-93-581, Table 4, Item 1, Low	10	L
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR CSN	1E-2N	failure to respond to compelling signal (nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal		
OPR CVL	1.0E-2 N	Checker verification error	WSRC-TR-93-581, Table 4, Item 8, Low	5	L
OPR DEH	1.0E-1 N	Diagnosis error (High)	WSRC-TR-93-581, Table 4, Item 30, High	3	L
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR ILN	5.0E-3 N	Incorrect labeling or tagging (Nominal)	WSRC-TR-93-581, Table 4, Item 10, Nominal	10	L
OPR IRN	1.0E-2 N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal	5	L
OPR LAN	3.0E-4 N	Laboratory analysis error (Nominal)	WSRC-TR-93-581, Table 4, Item 19, Nominal	10	
OPR MCN	5.0E-3 N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	
OPR VRH	5.00E-02N	Failure to verify within control room (High)	WSRC-TR-93-581, Table 4, Item 3, High		
OPR VRN	1.00E-02N	Failure to verify within control room (Nominal)	WSRC-TR-93-581, Table 4, Item 3, Nominal	5	L
PER .20	2.00E-03N	0.2% chance			
PER 005	5.00E-02N	5% chance			
PER 010	1.00E-01N	10% chance			
PER 013	1.30E-01N	13% chance			
PER 020	2.00E-01N	20% chance			
PER 025	2.50E-01N	25% chance			
PER 100	1.00E+00N	100% chance			

Data Type Codes for 9.3E Evaporator (CONT.)

Type Code	Rate	Description	Source	EF	D
PST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Sw., Press., Failure (Instr. & Control)	WSRC-TR-93-262, PST-FA-I	3	L
RLP NRE	1E-3N	Relay, protective,fails to open/close	WSRC-TR-93-262,RLE-NR-E	10	1
SAM FAI	1.00E-05 H	Sampler, Failure (Instr. & Control)	WSRC-TR-93-262, SAM-FA-I	10	L
SPG PLG	2D	TUBE PLUGS	Estimate by facility sep. tech (Chostner) - Plugs frequently		
TBP PRE	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L
TUB LEG	3.00E-07 H	Tube, Leakage (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, TUB-LE-G	10	L

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APPENDIX E - 7.6E & 7.7 EVAPORATOR FAULT TREE AND DATA

The following abbreviations appear on the fault tree print out and in the basic event file for the fault tree:

FR=Failure Rate

a:= assumption

COG= cognizant engineer estimate/information

TRUNC= Truncation limit of cutset evaluator

The Beta Factor method used to estimate common cause alarm failure is explained in Reference 15.

NOTE: Events in this tree with a probability of "1E-32" are incredible. They do not contribute to the top event frequency and were included only to show that they had been considered. The number "1E-32" was used because it is the smallest number CAFTA is capable of handling.

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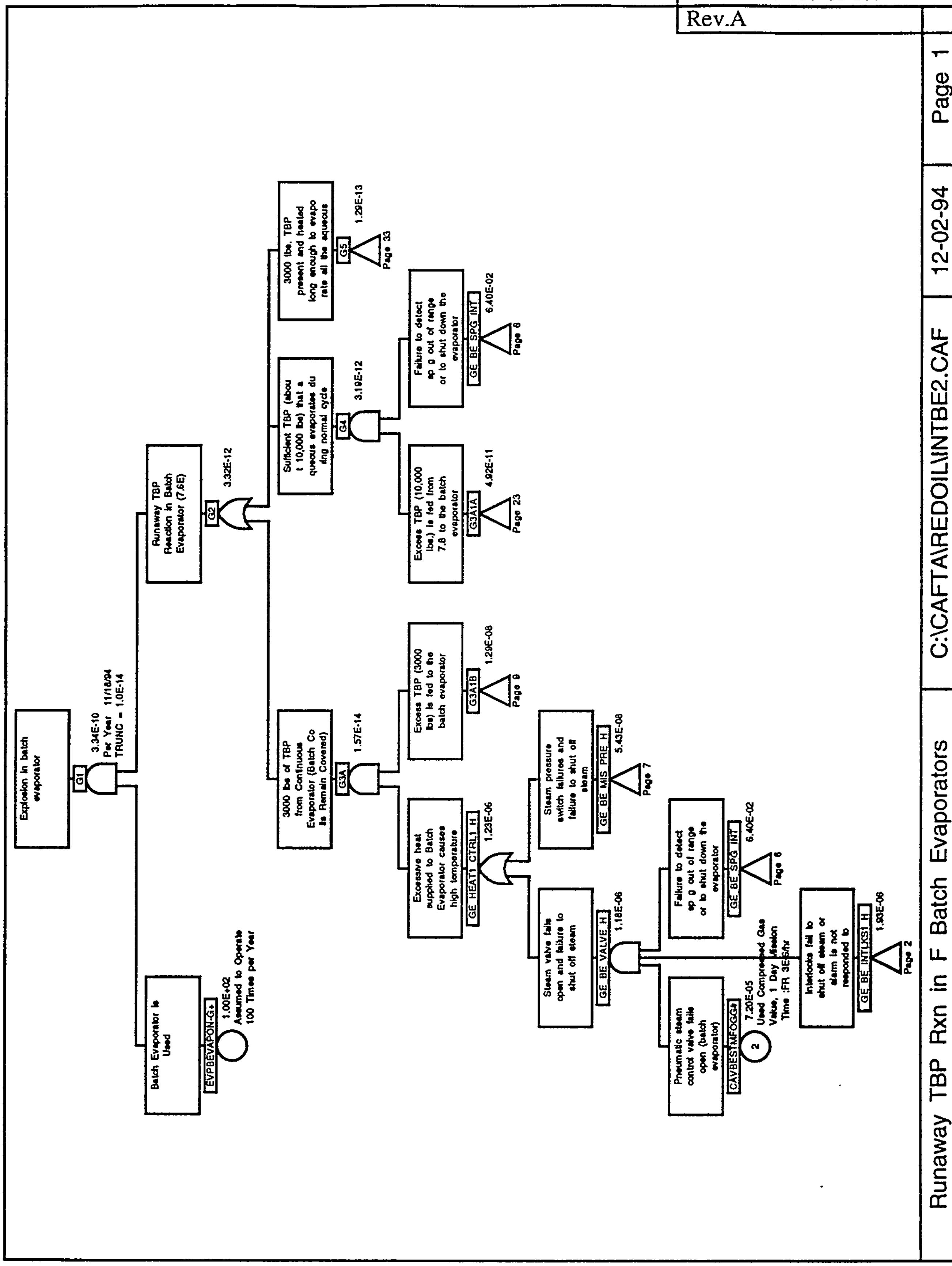

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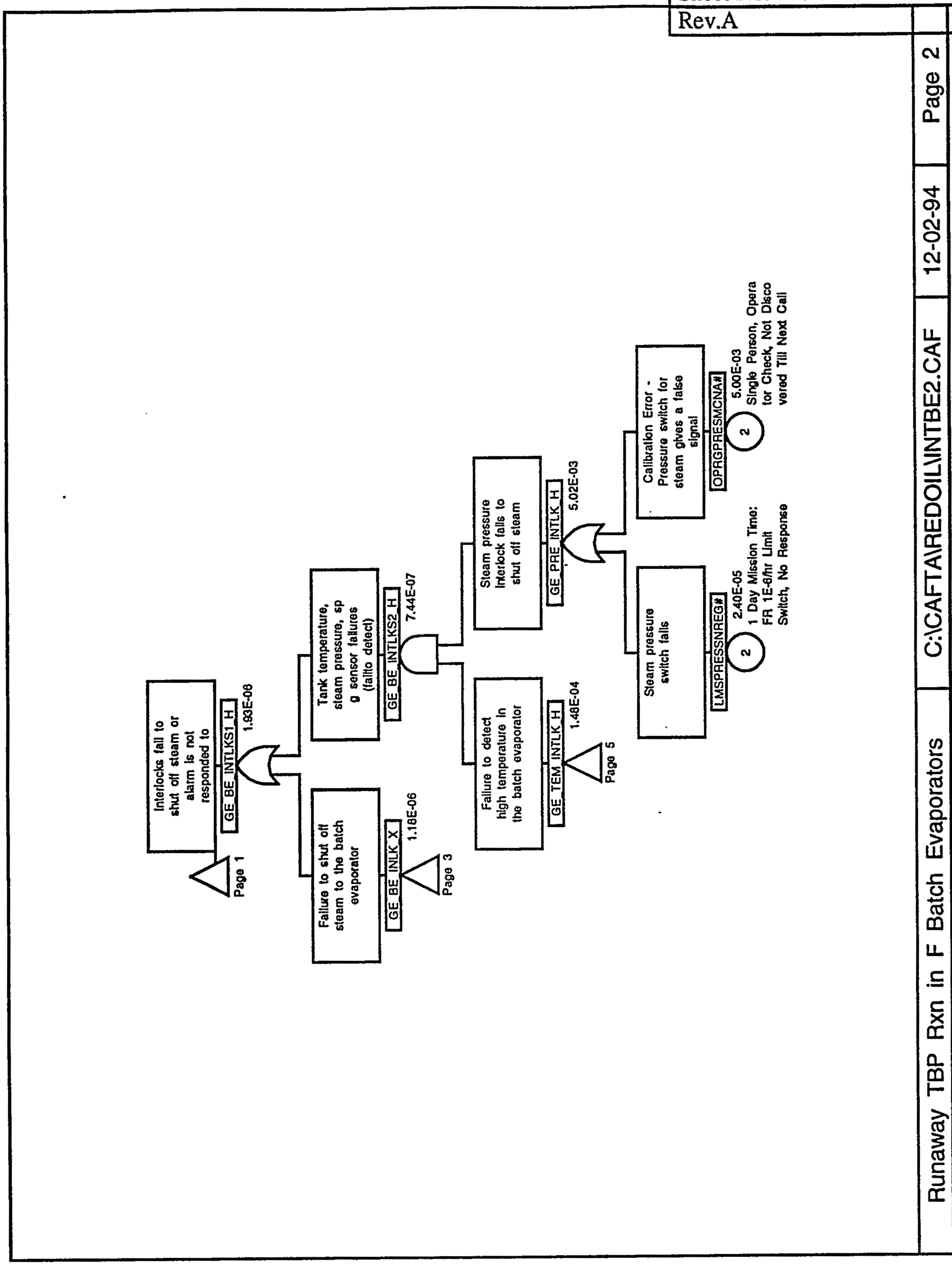

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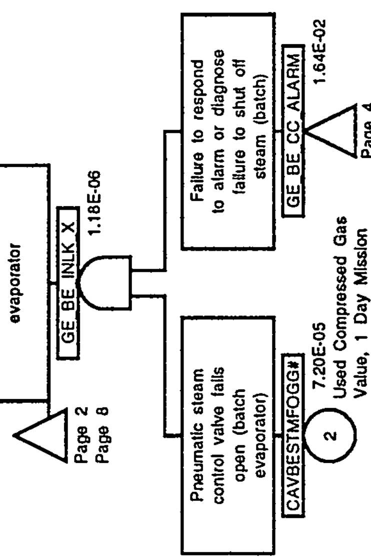

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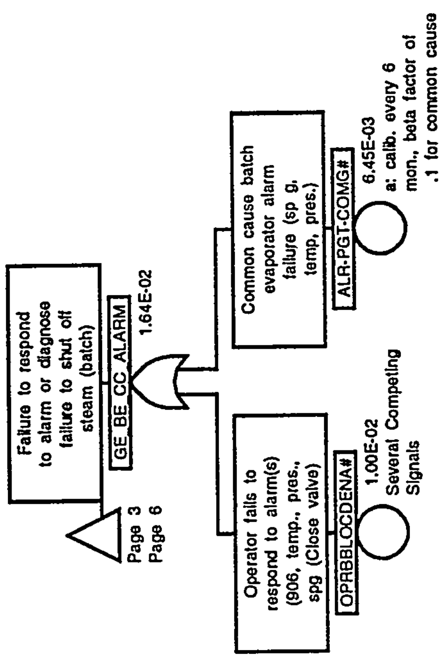

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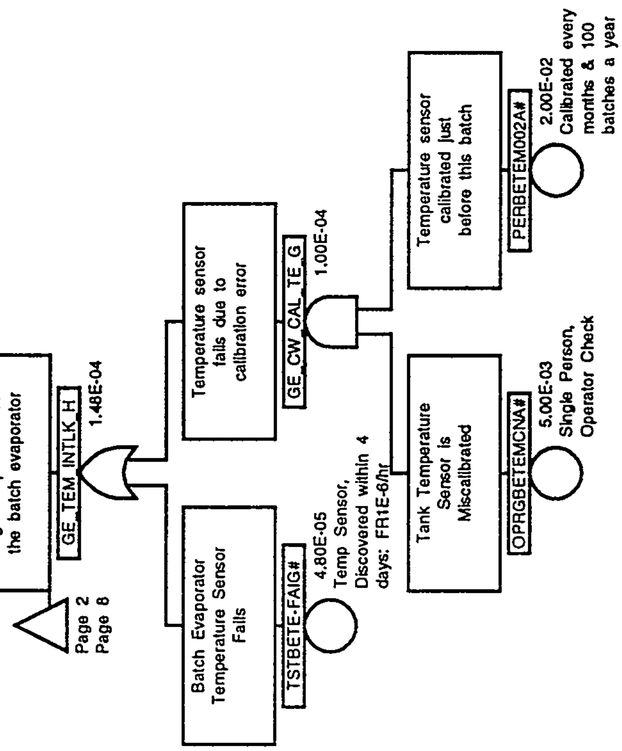

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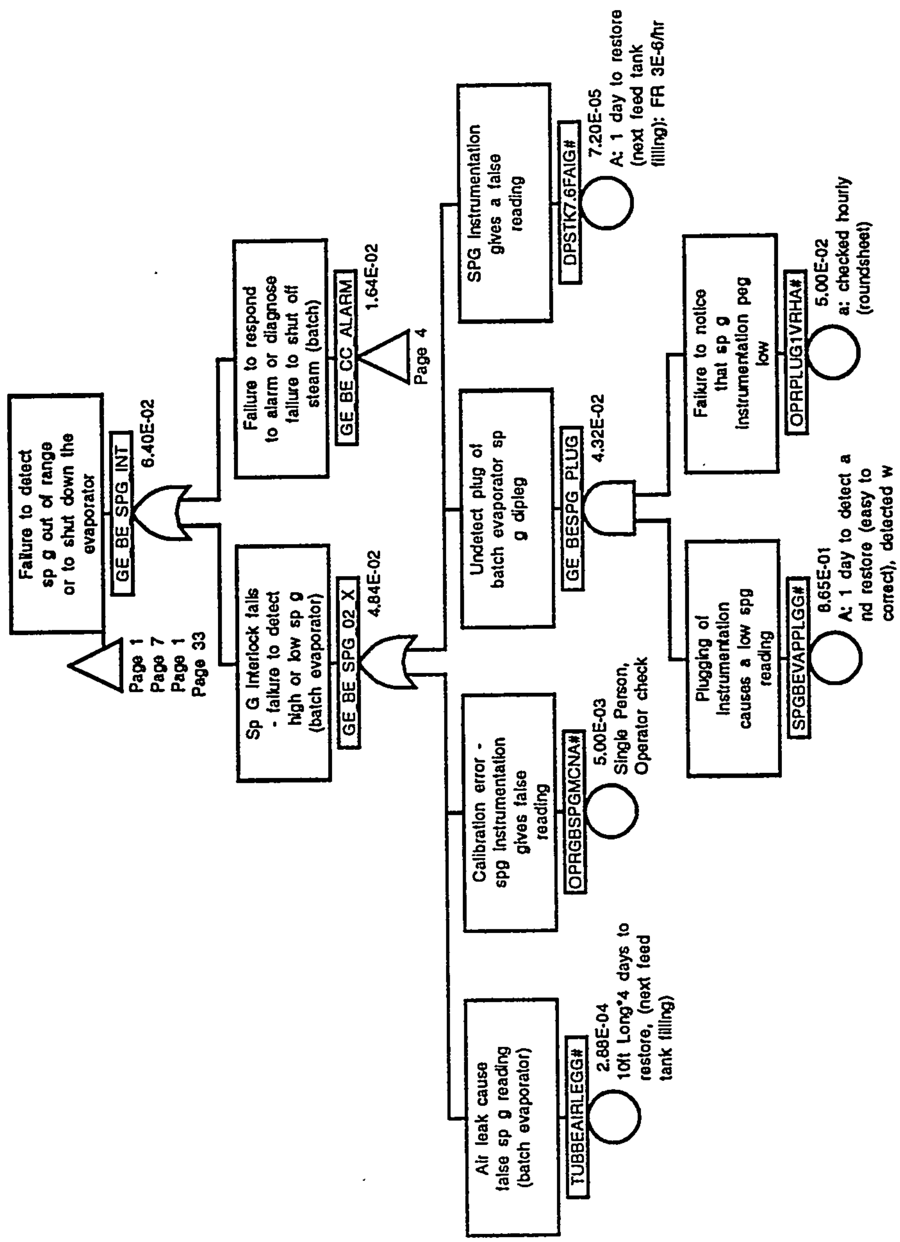

Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 6

Calculation No. S-CLC-F-00146
Sheet No. 133 of 179
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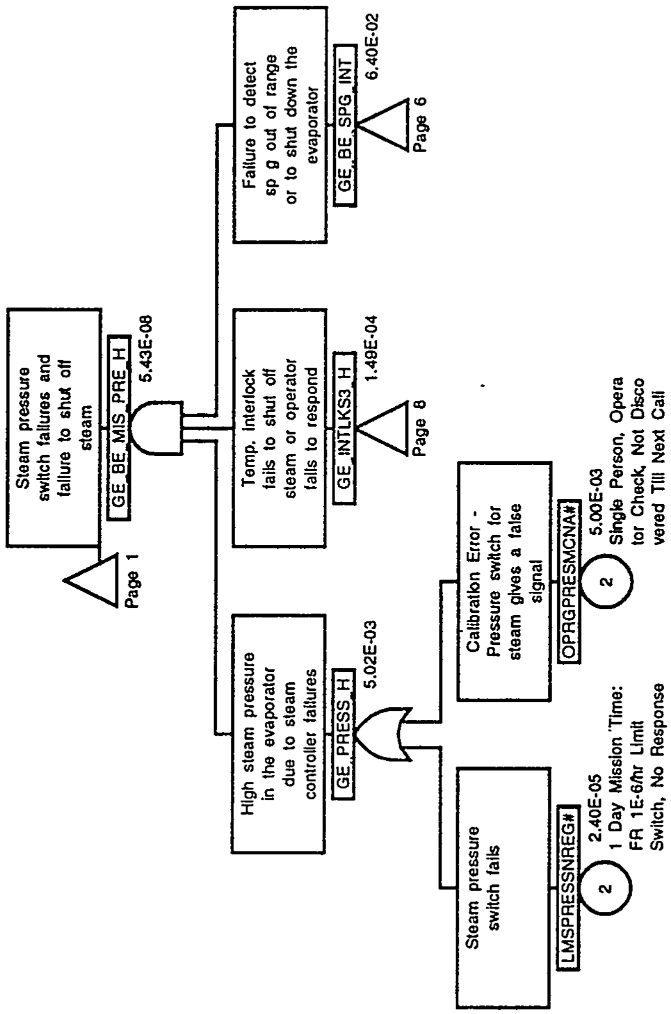

Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 7

Calculation No. S-CLC-F-00146	
Sheet No. 134 of 179	
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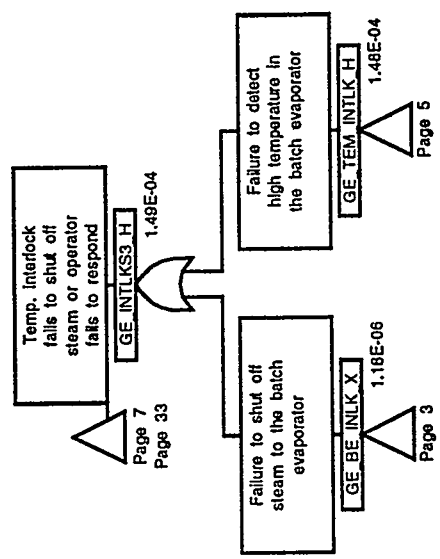
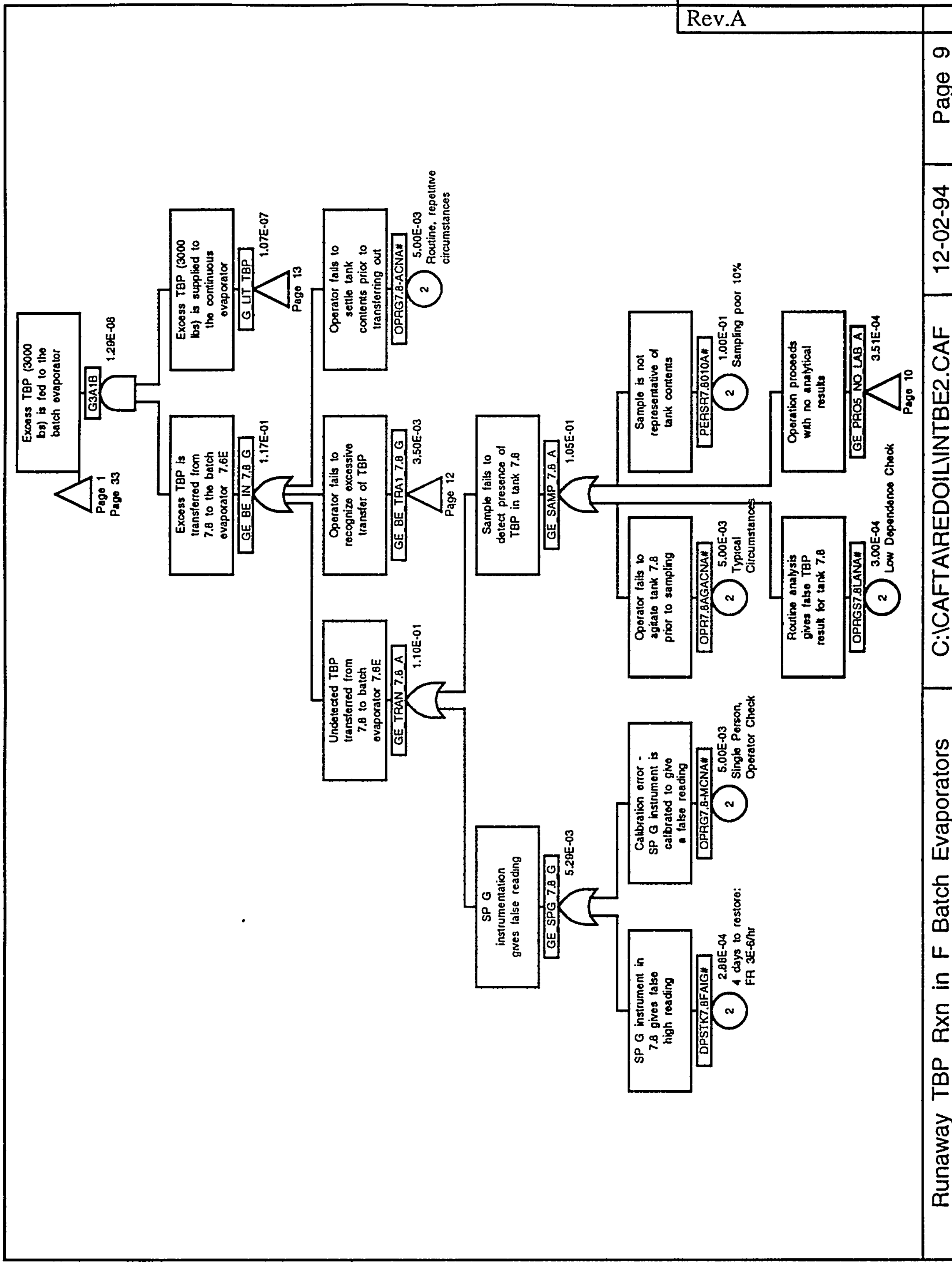
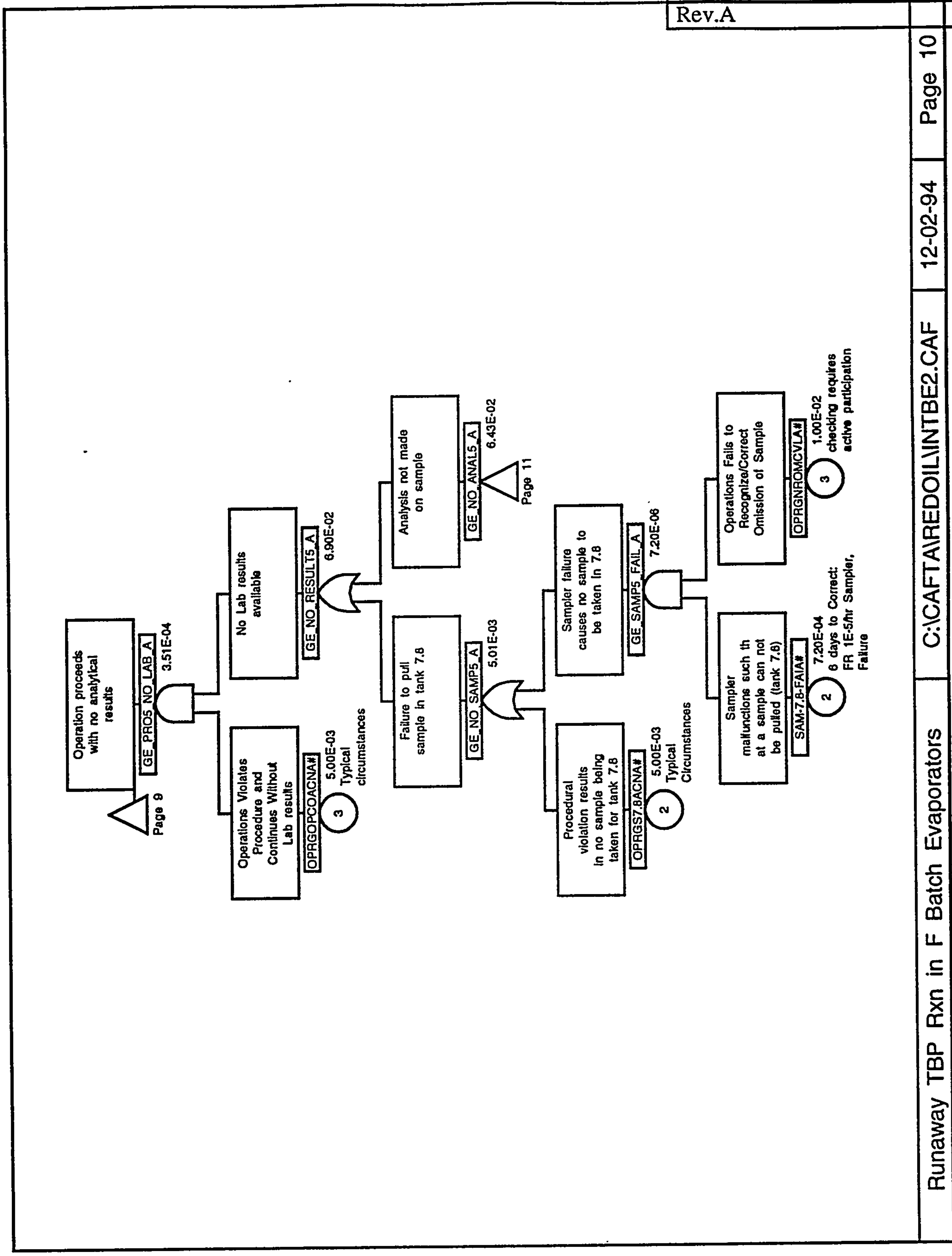
Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 8



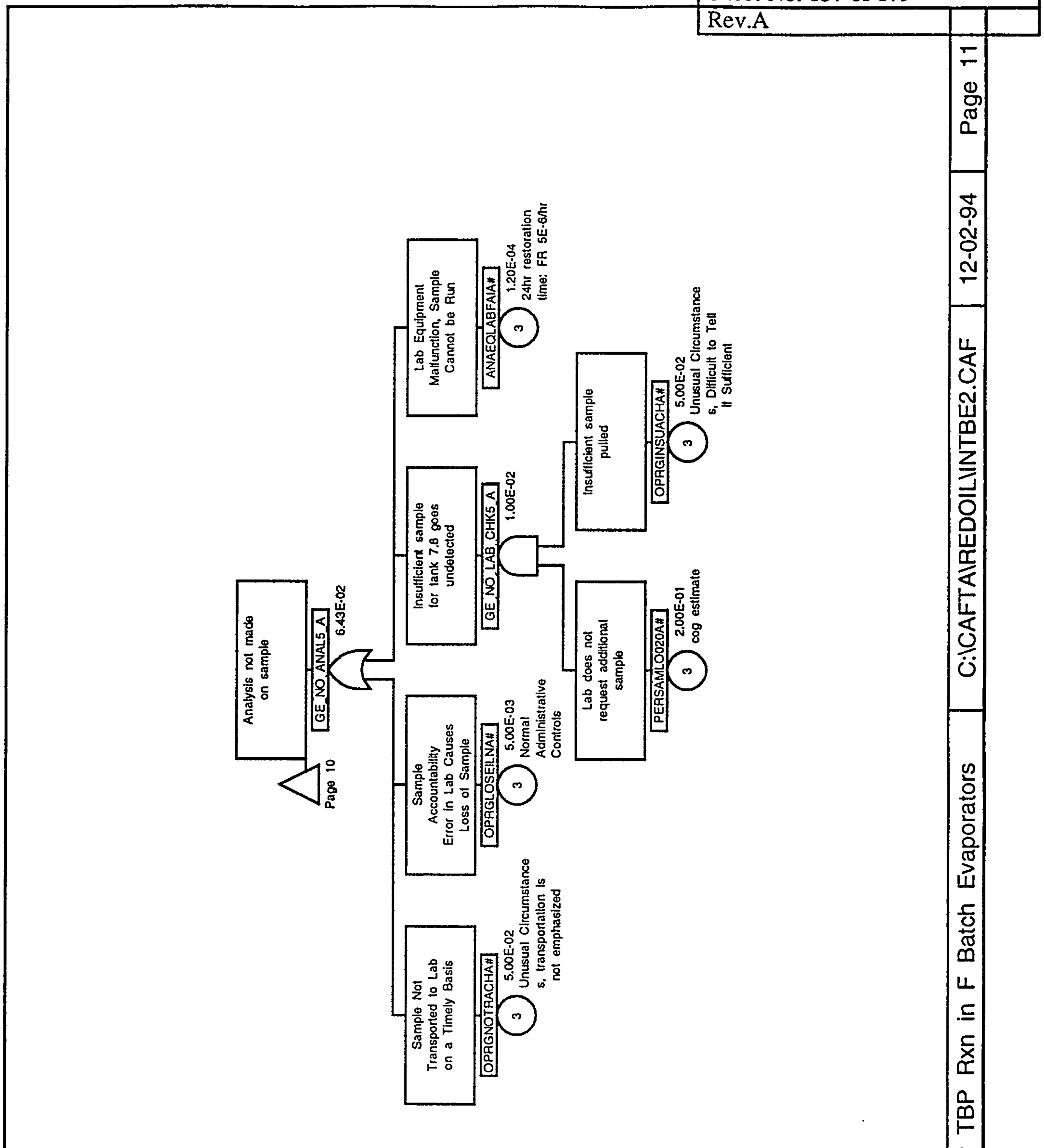
Calculation No. S-CLC-F-00146
Sheet No. 135 of 179
Rev.A



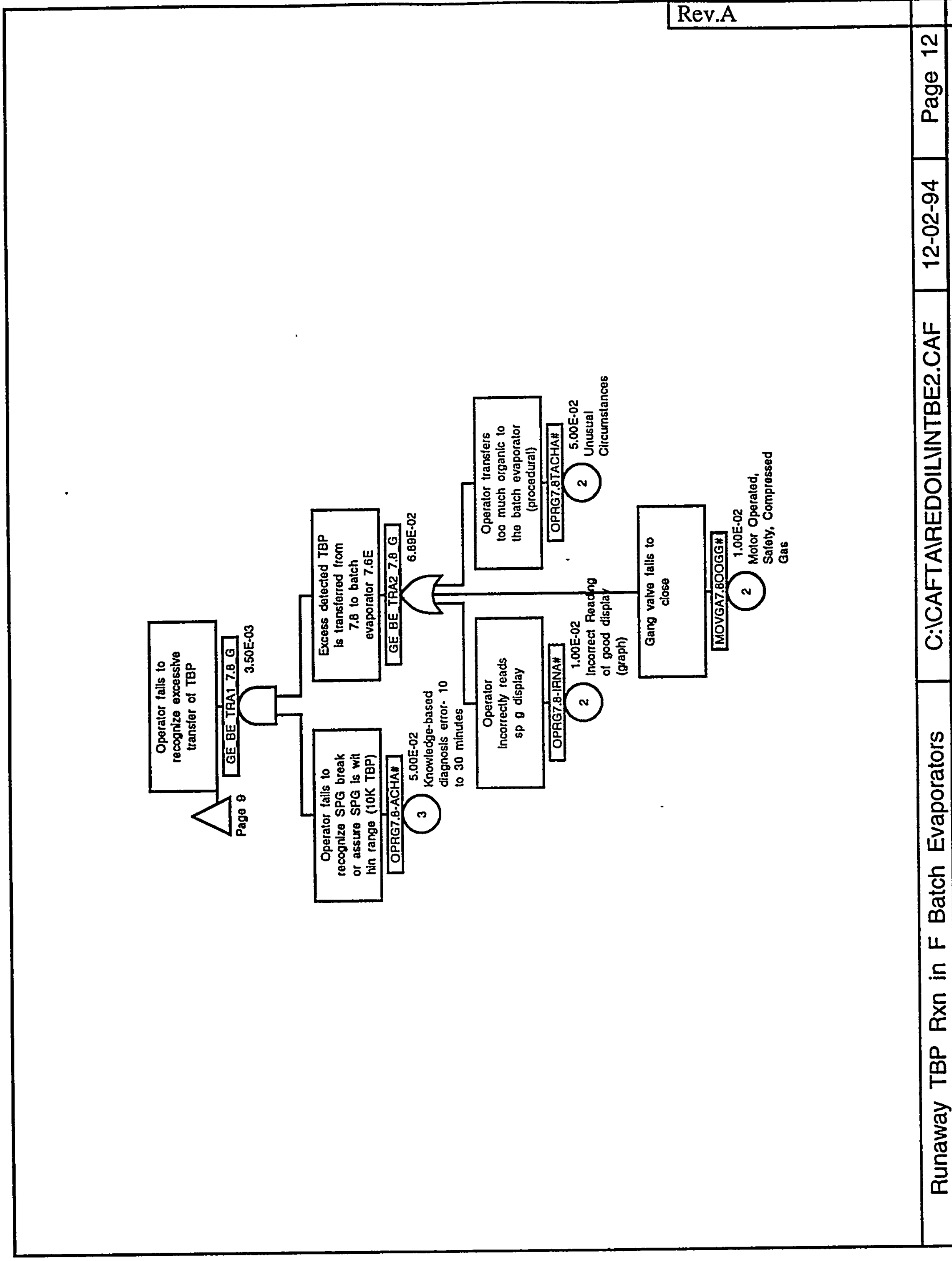
Calculation No. S-CLC-F-00146	
Sheet No. 136 of 179	
Rev.A	



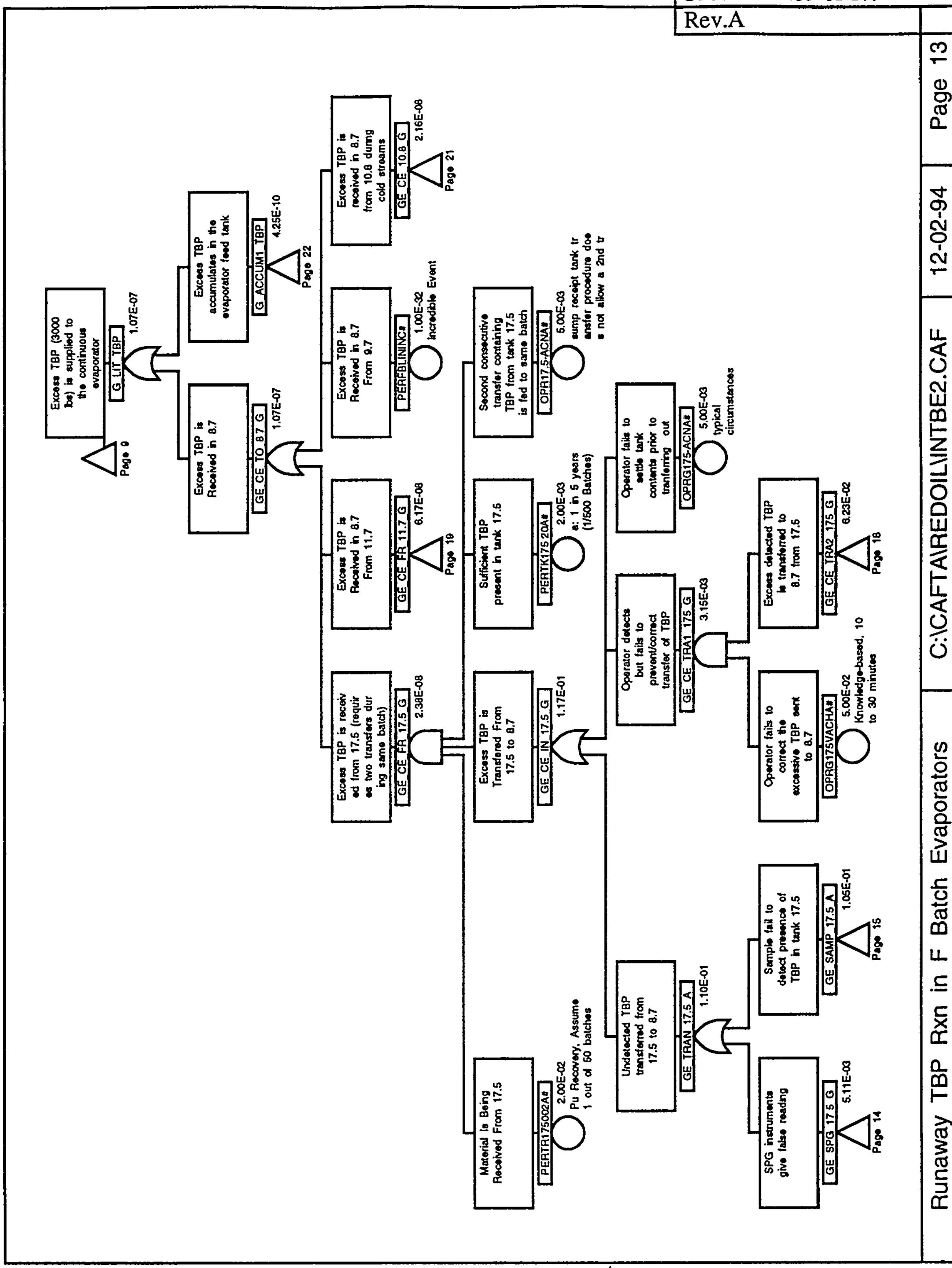
Calculation No. S-CLC-F-00146	
Sheet No. 137 of 179	
Rev.A	



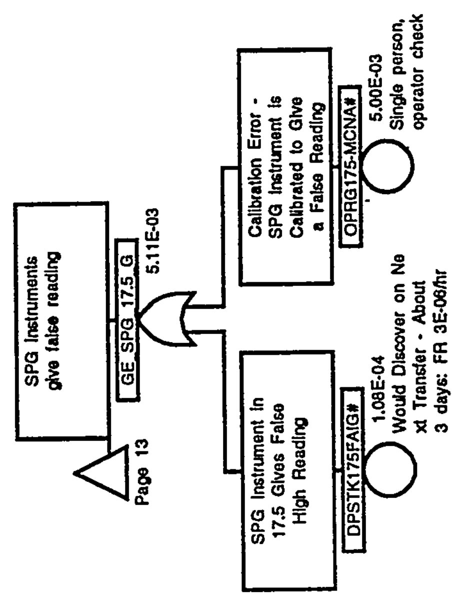
Calculation No. S-CLC-F-00146	
Sheet No. 138 of 179	
Rev.A	



Calculation No. S-CLC-F-00146
Sheet No. 139 of 179
Rev.A



Calculation No. S-CLC-F-00146	
Sheet No. 140 of 179	
Rev.A	



Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 14

Calculation No. S-CLC-F-00146
Sheet No. 141 of 179
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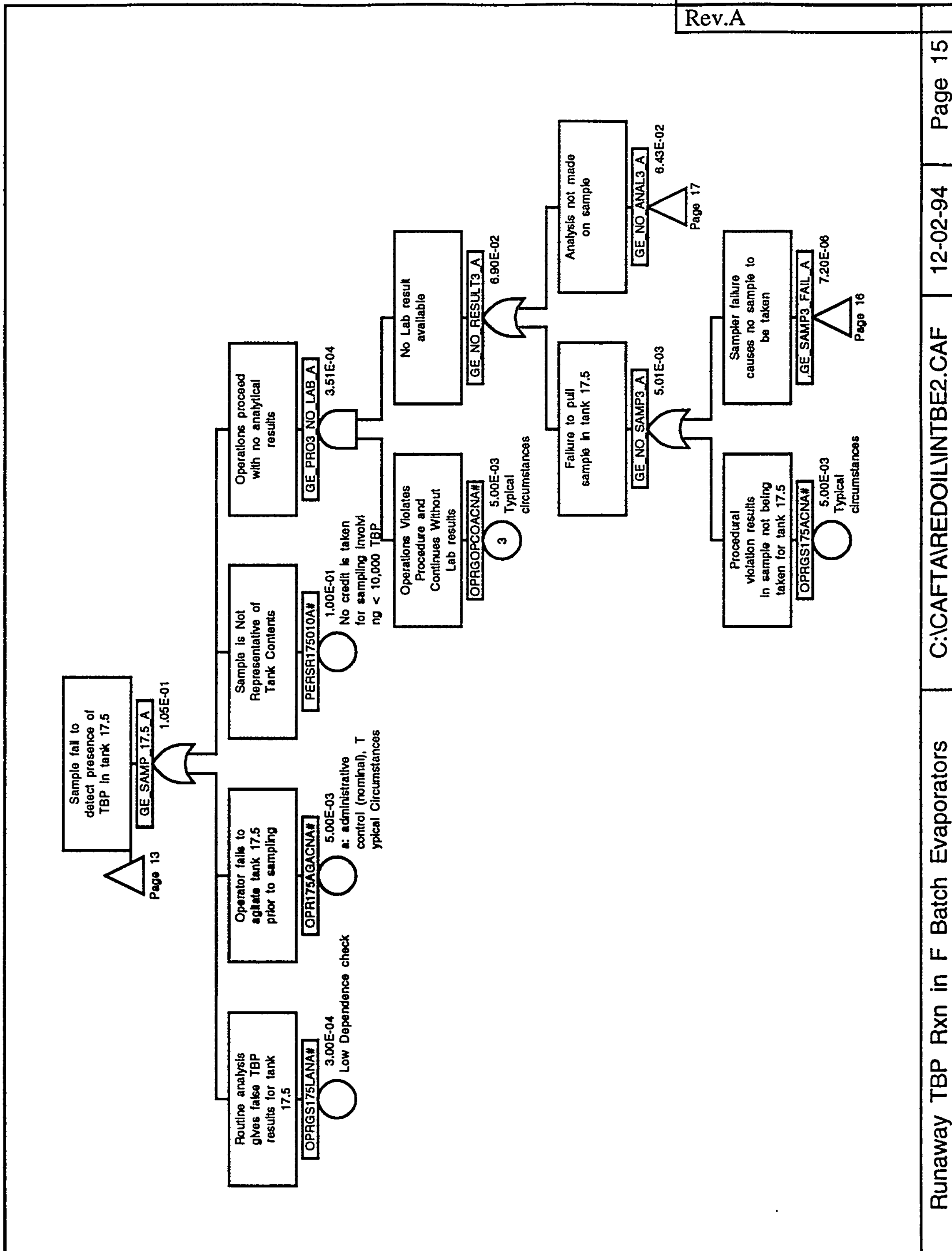

Calculation No. S-CLC-F-00146	
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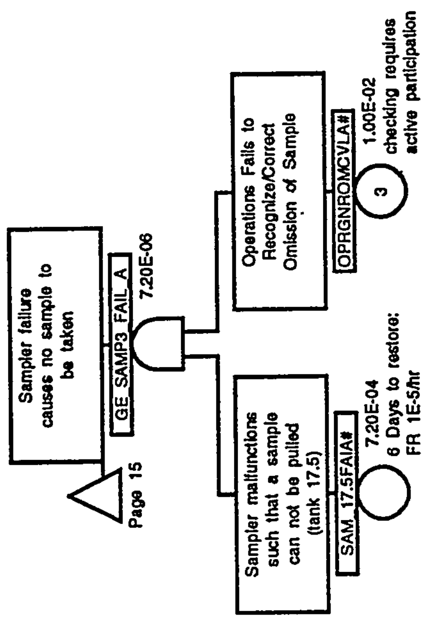
Rev.A	



Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 16

Calculation No. S-CLC-F-00146
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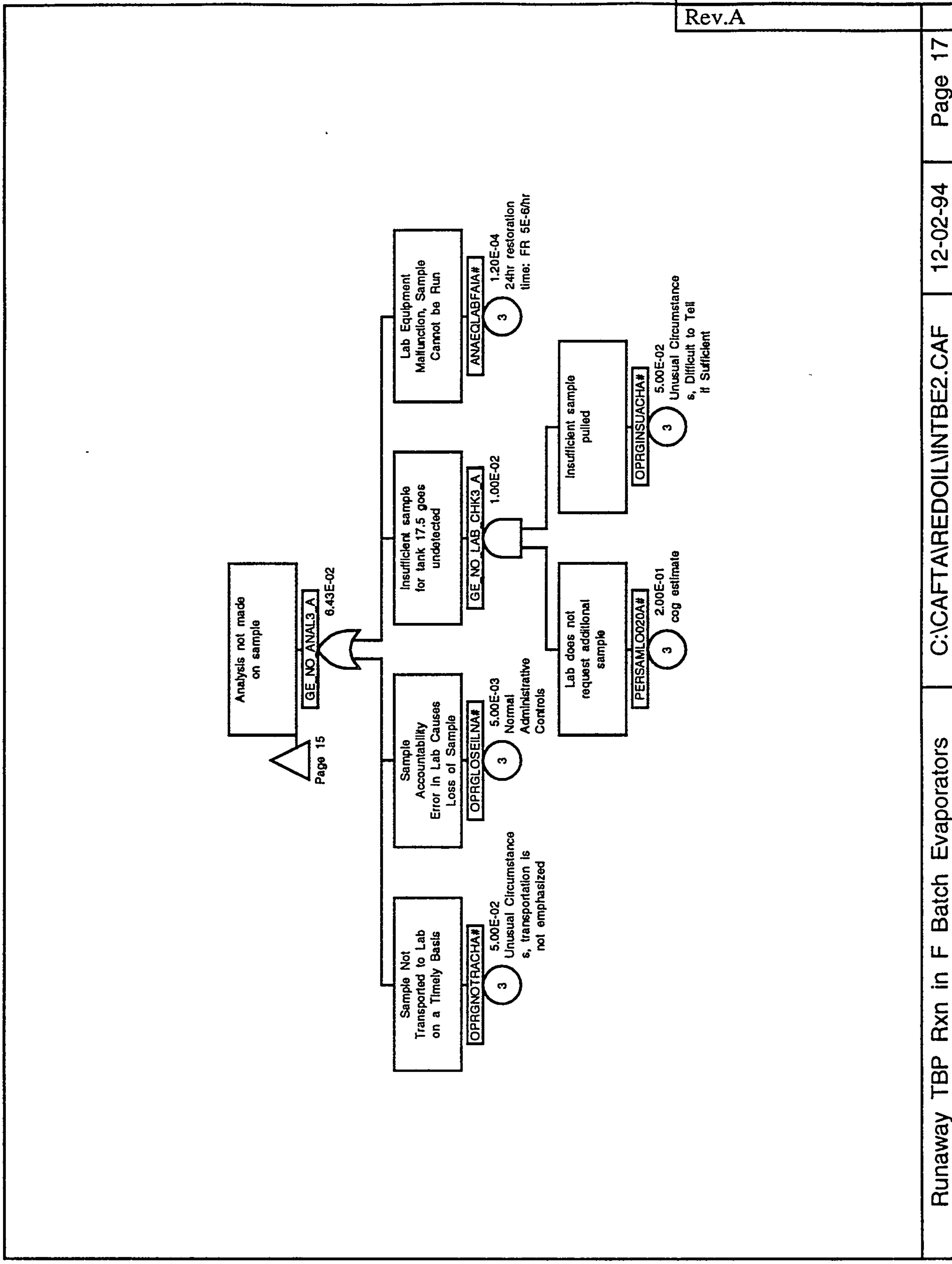

Calculation No. S-CLC-F-00146
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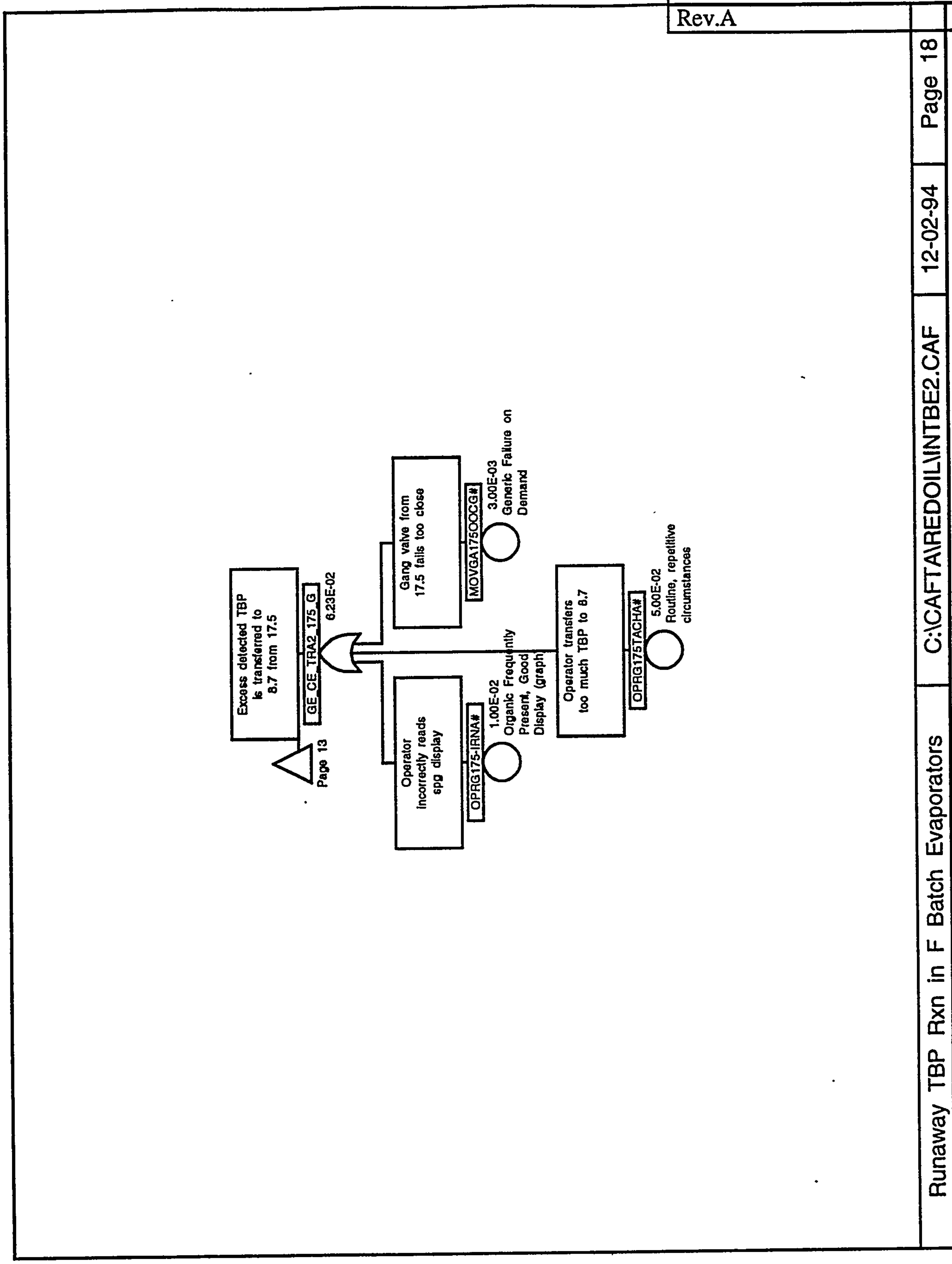
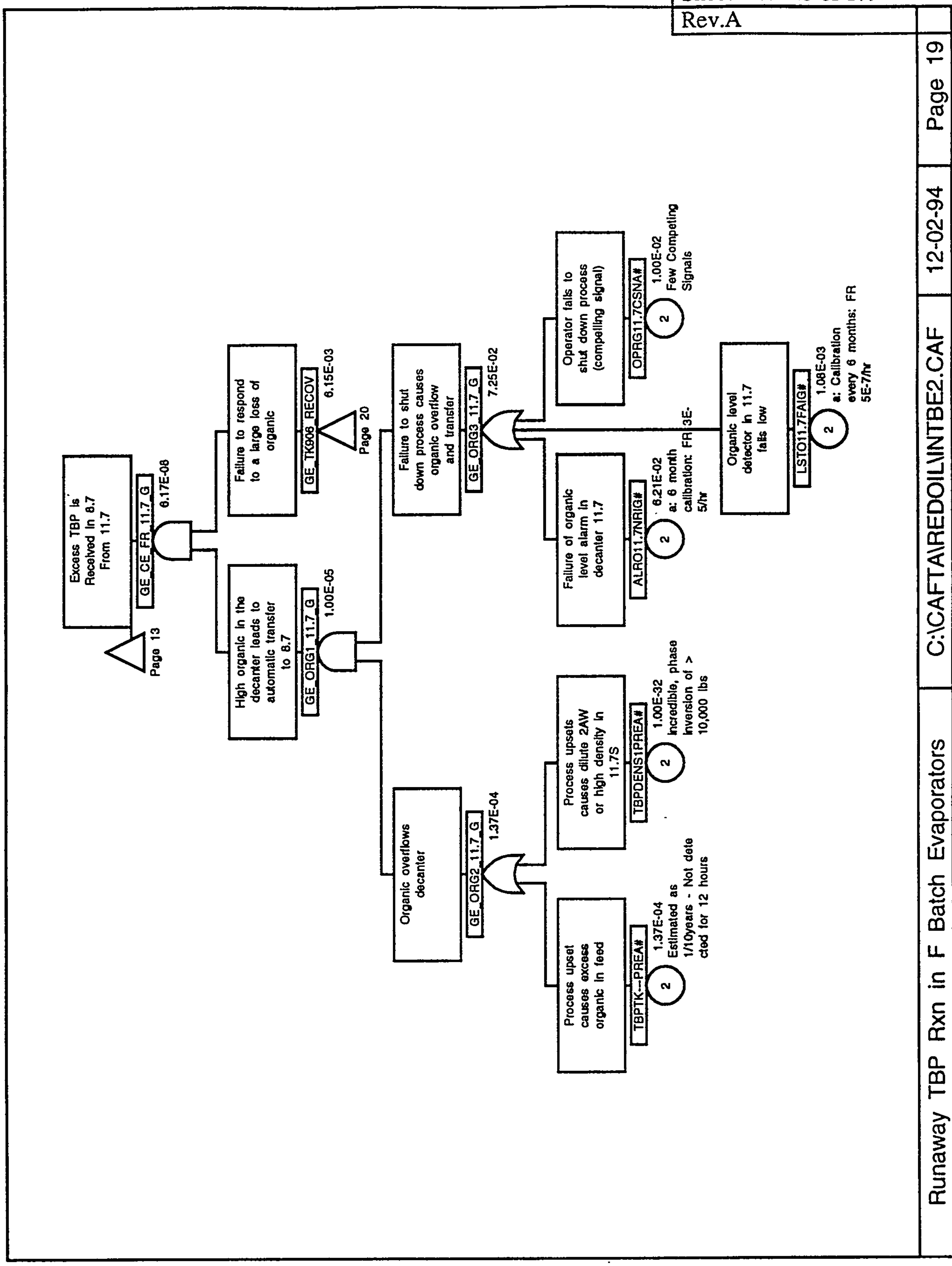
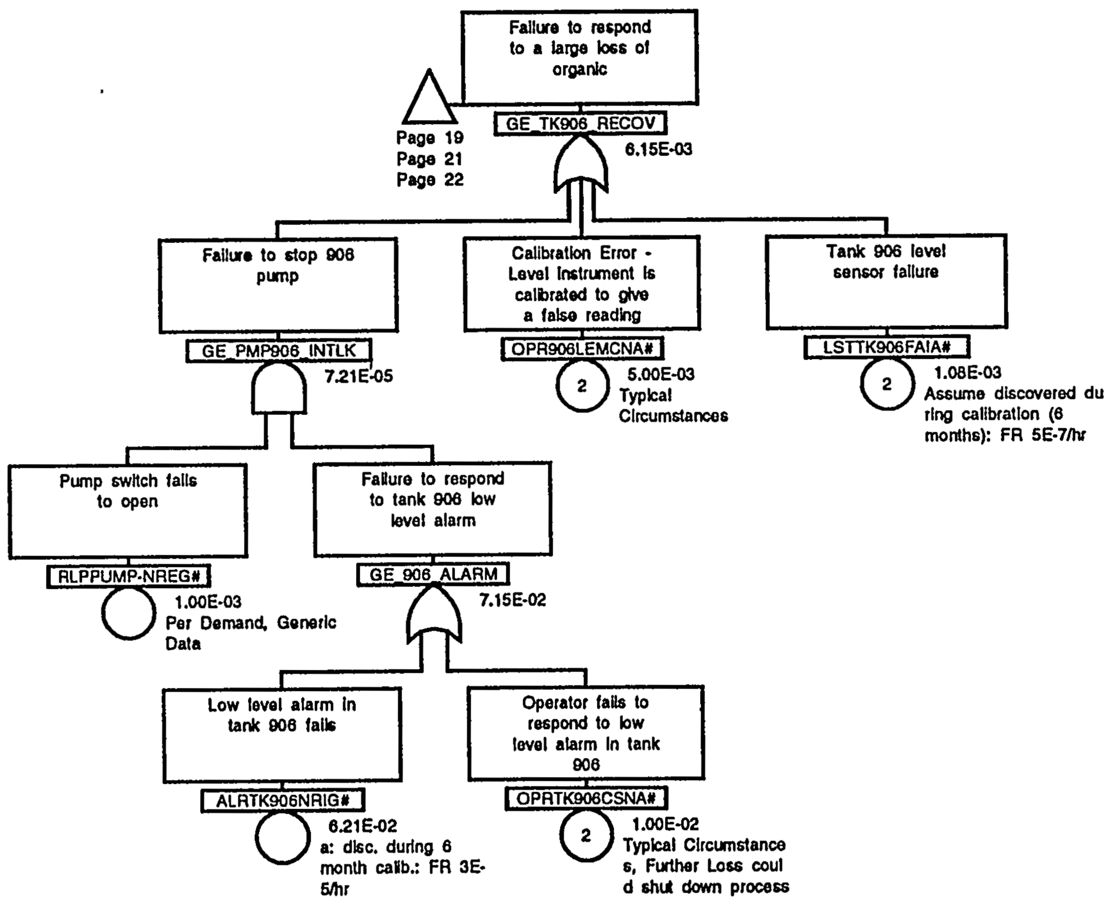
Rev.A



Calculation No. S-CLC-F-00146
Sheet No. 145 of 179
Rev.A





Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\INTBE2.CAF	12-02-94	Page 20

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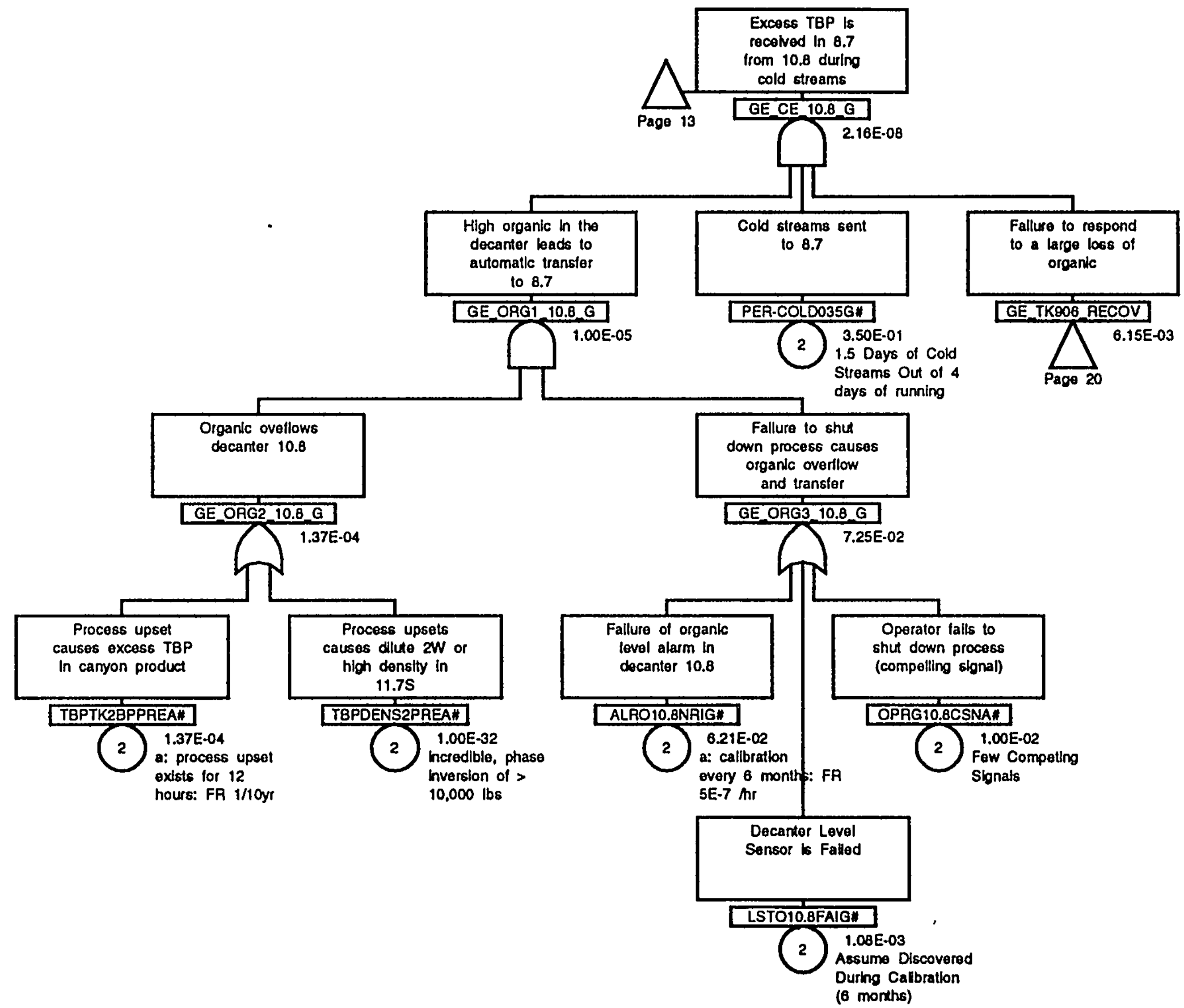
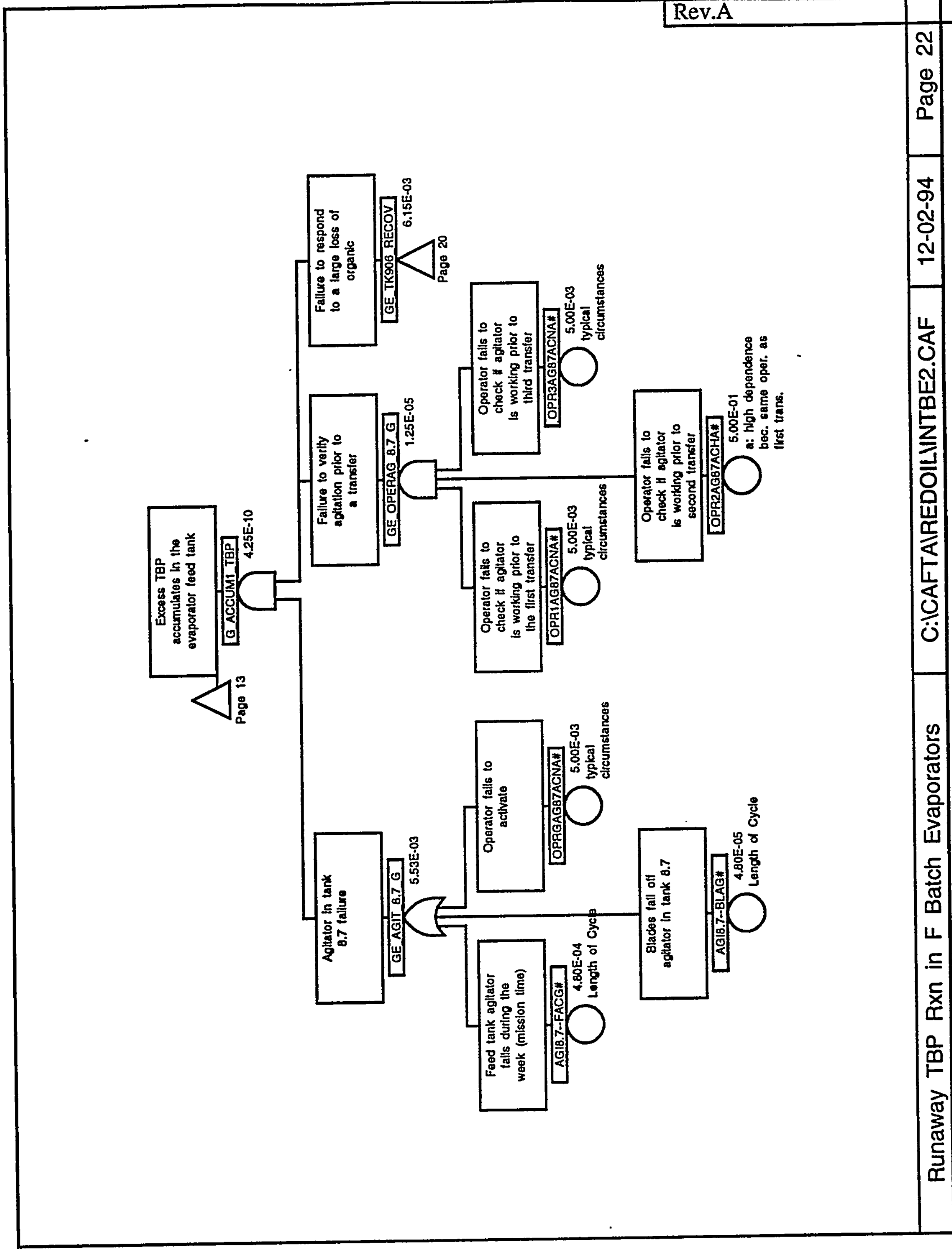


Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\INTBE2.CAF	12-02-94	Page 21


Excess TBP accumulates in the evaporator feed tank
G_ACCUM1_TBP
4.25E-10
Page 13
Failure to respond to a large loss of organic
GE_TK906_RECOV
6.15E-03
Page 20
Failure to verify agitation prior to a transfer
GE_OPERAG_8.7_G
1.25E-05
Operator fails to check if agitator is working prior to third transfer
OPR3AG87ACNA#
5.00E-03
typical circumstances
Operator fails to check if agitator is working prior to the first transfer
OPR1AG87ACNA#
5.00E-03
typical circumstances
Operator fails to check if agitator is working prior to second transfer
OPR2AG87ACHA#
5.00E-01
a: high dependence bec. same oper. as first trans.
Agitator in tank 8.7 failure
GE_AGIT_8.7_G
5.53E-03
Operator fails to activate
OPRGAG87ACNA#
5.00E-03
typical circumstances
Feed tank agitator fails during the week (mission time)
AGI8.7--FACG#
4.80E-04
Length of Cycle
Blades fall off agitator in tank 8.7
AGI8.7--BLAG#
4.80E-05
Length of Cycle
Runaway TBP Rxn in F Batch Evaporators
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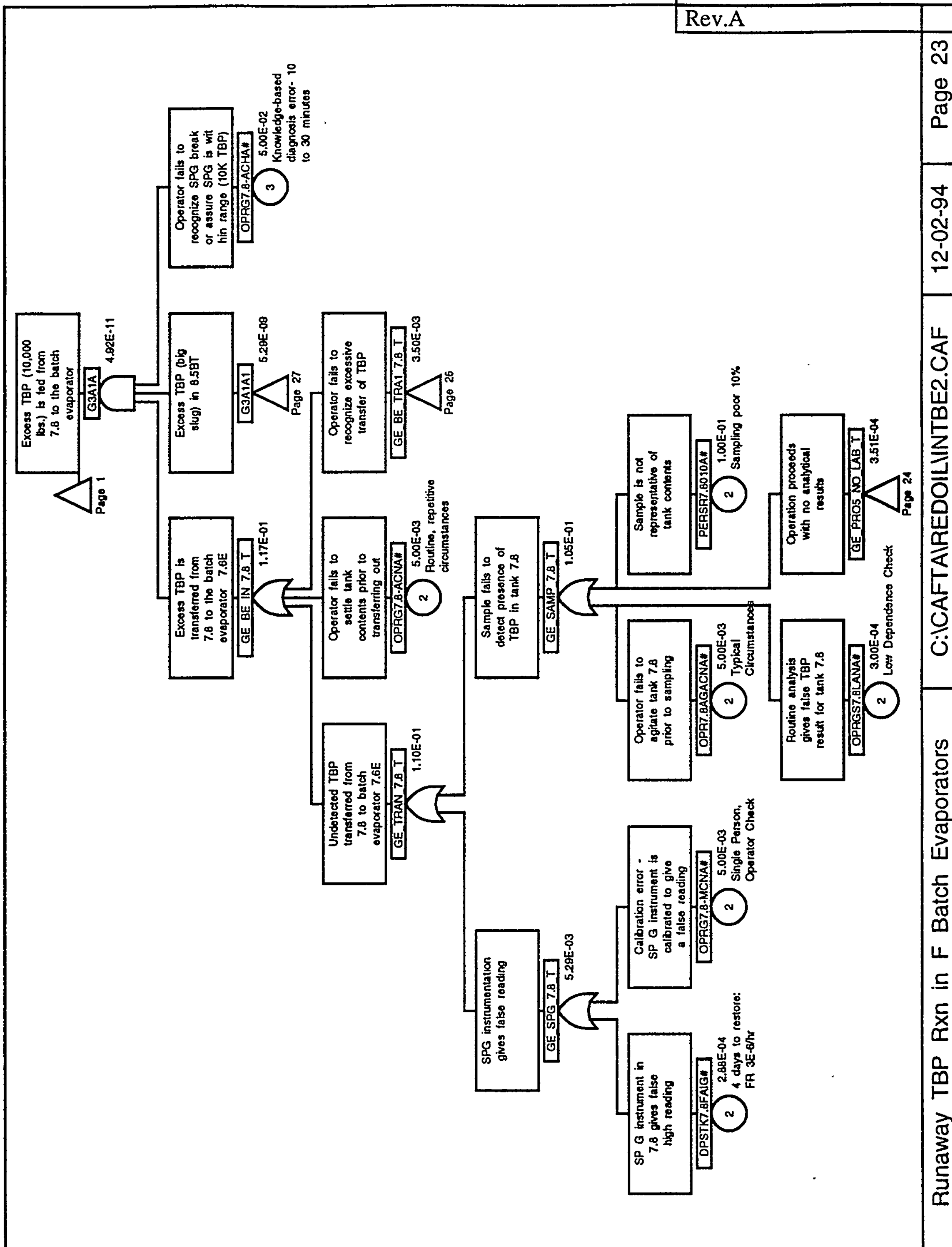

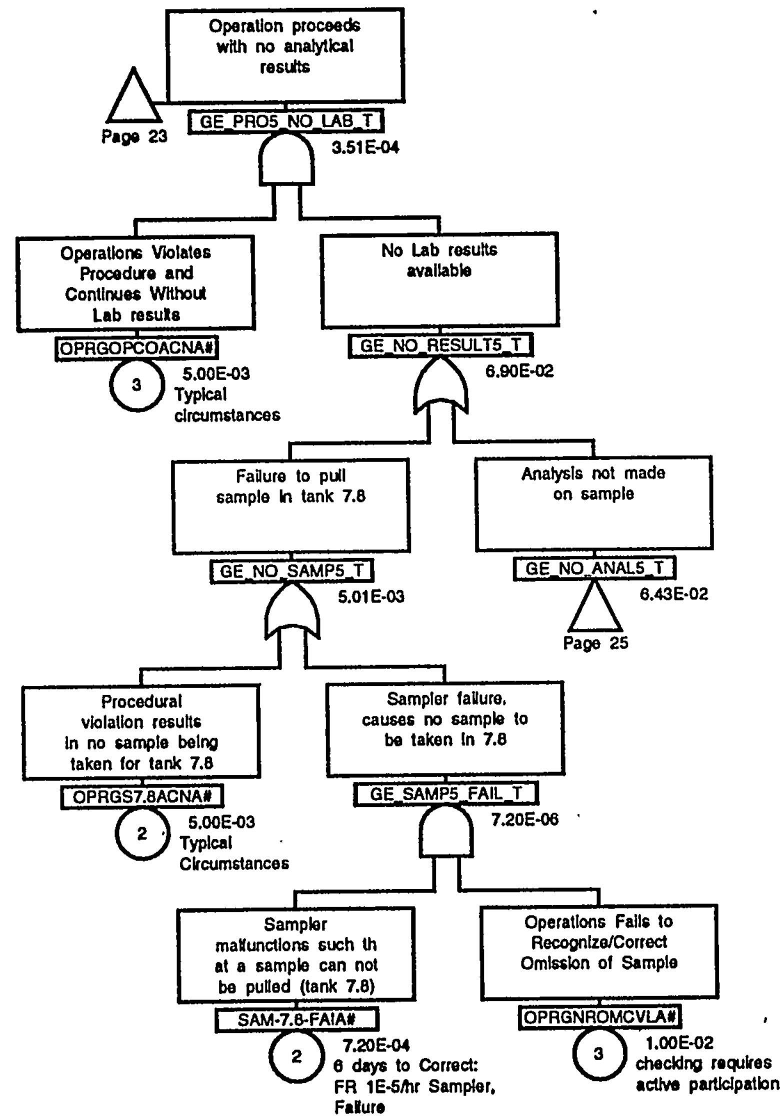

Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\INTBE2.CAF	12-02-94	Page 24

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Sheet No. 151 of 179
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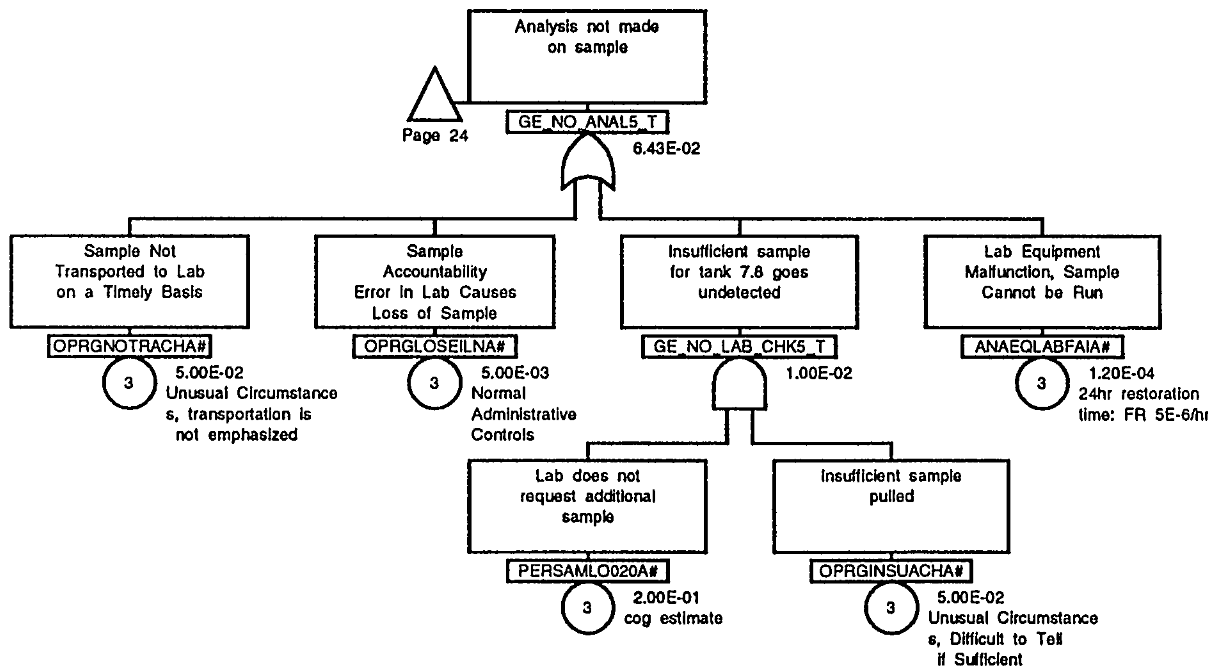
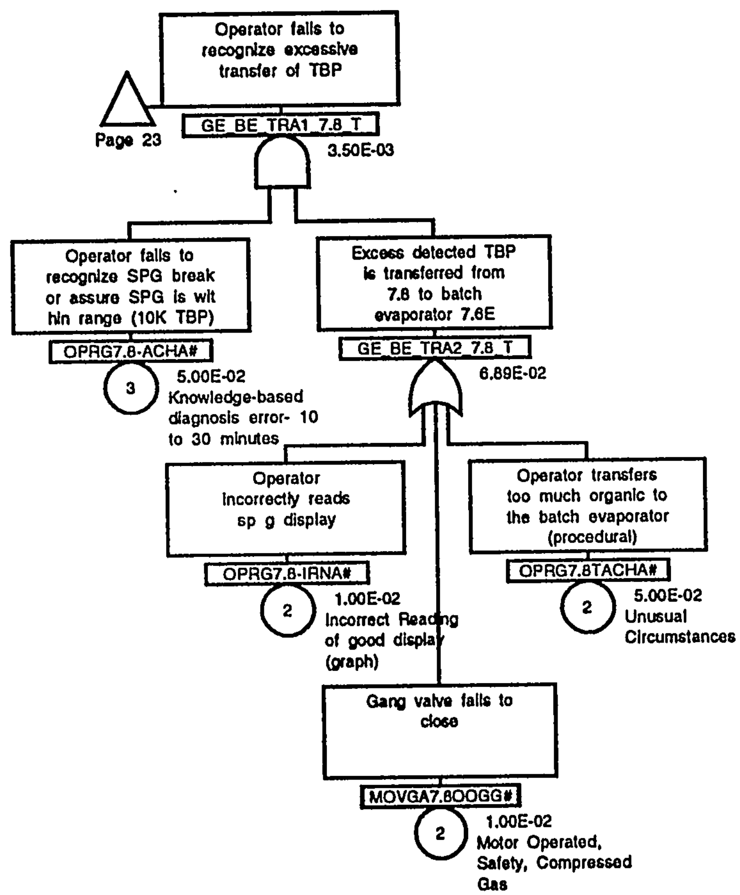


Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\INTBE2.CAF	12-02-94	Page 25



Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\INTBE2.CAF	12-02-94	Page 26

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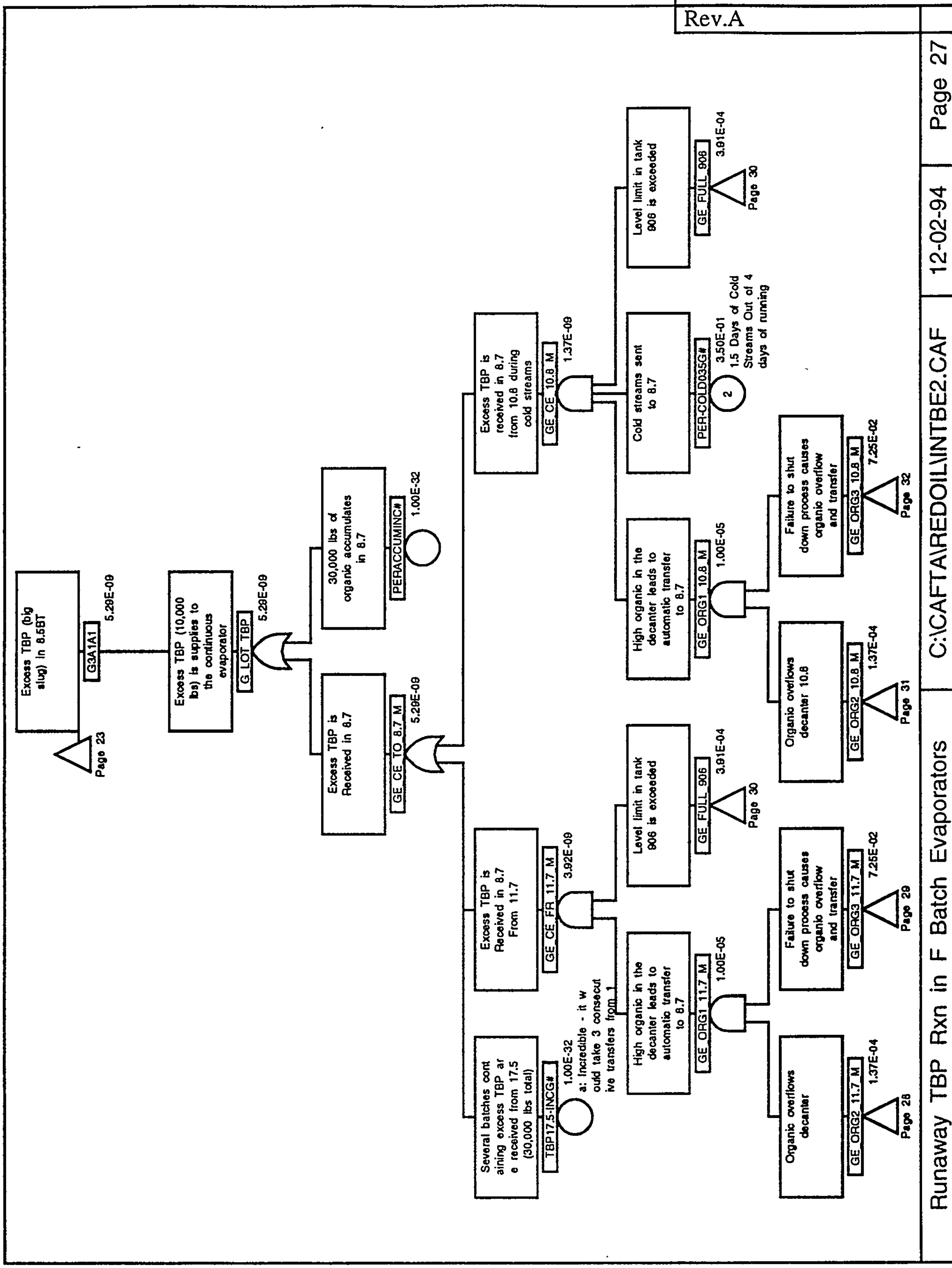
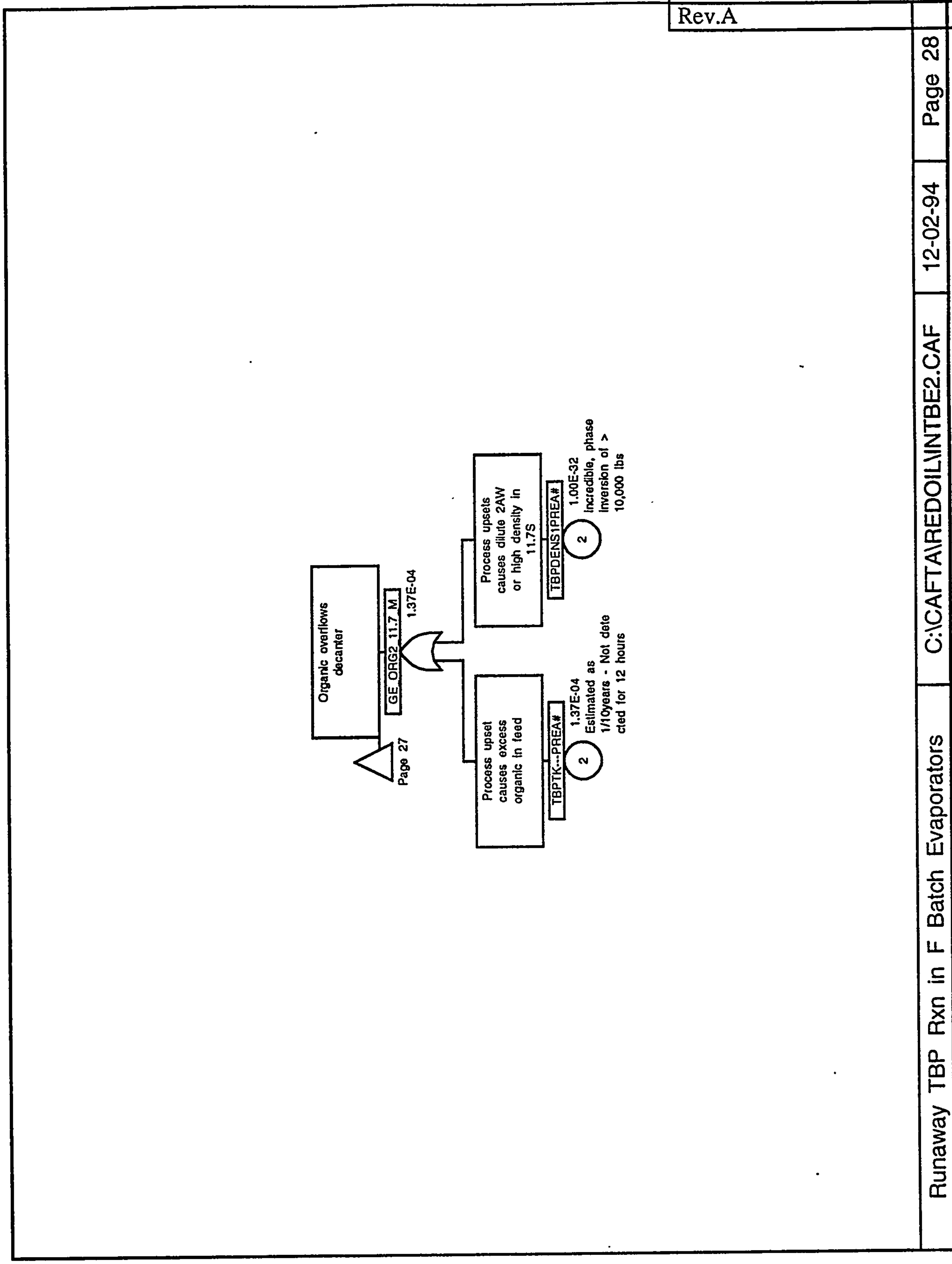
Rev.A

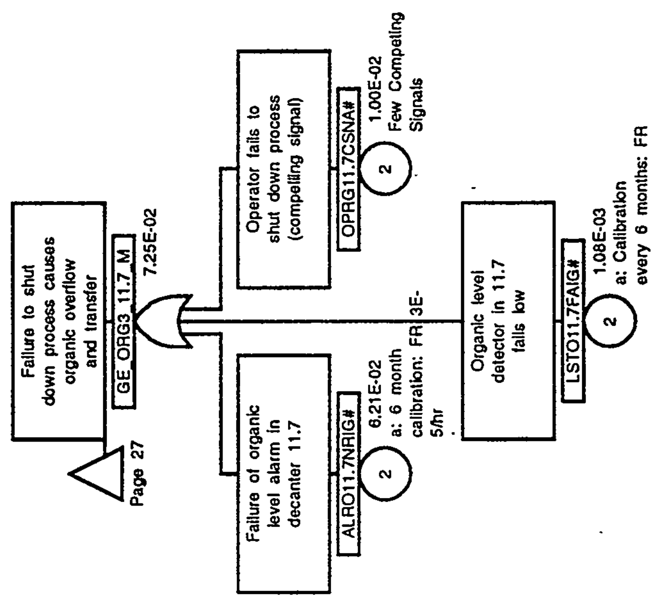


Calculation No. S-CLC-F-00146
Sheet No. 154 of 179
Rev.A

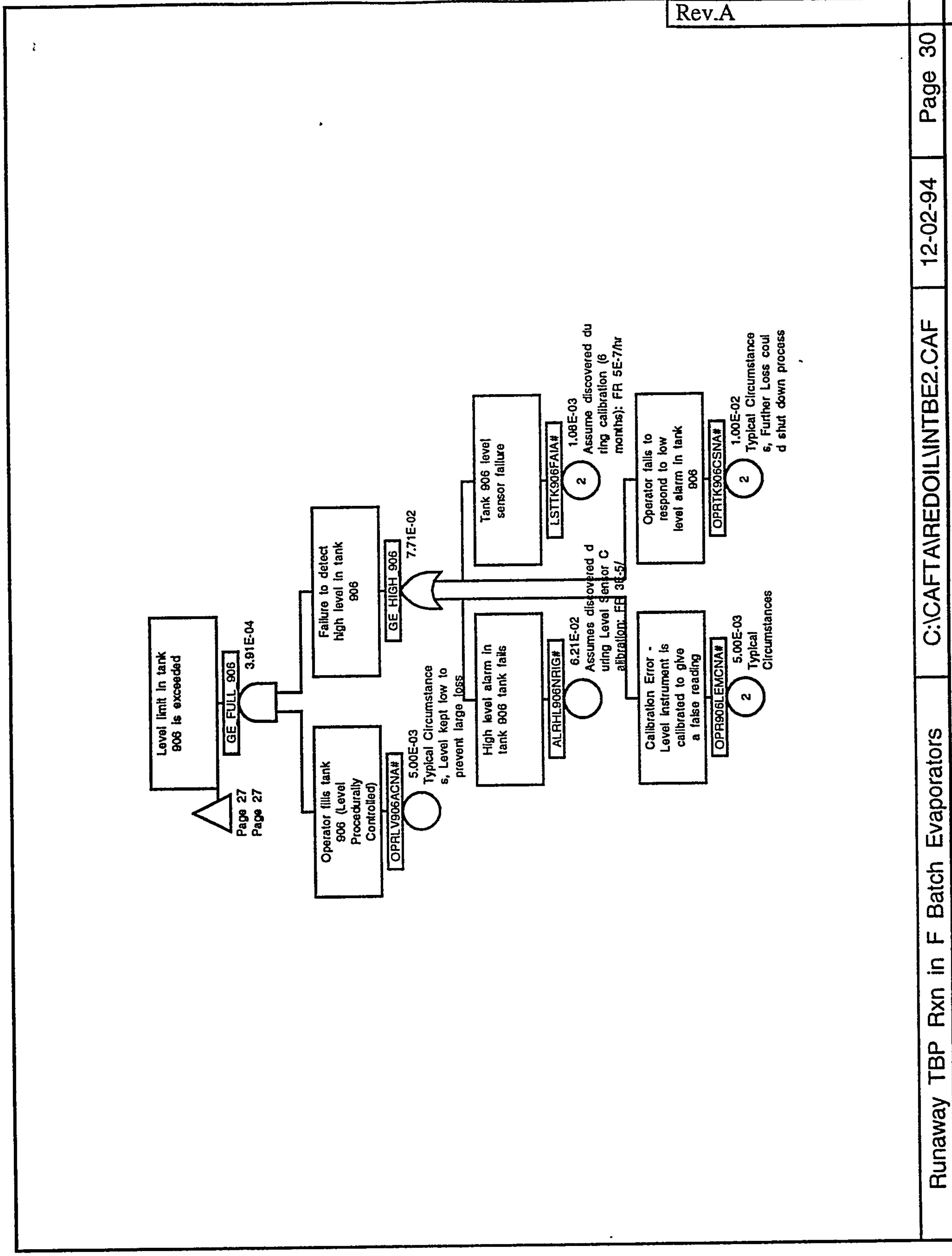


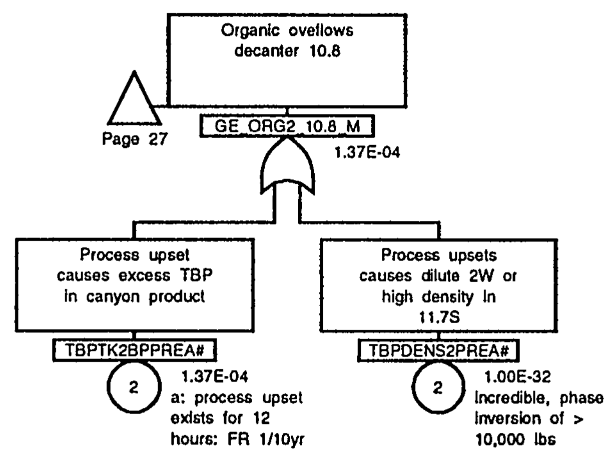
Calculation No. S-CLC-F-00146
Sheet No. 155 of 179
Rev.A

Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 29



Calculation No. S-CLC-F-00146
Sheet No. 156 of 179
Rev.A





Runaway TBP Rxn in F Batch Evaporators	C:\CAFTA\REDOIL\INTBE2.CAF	12-02-94	Page 31

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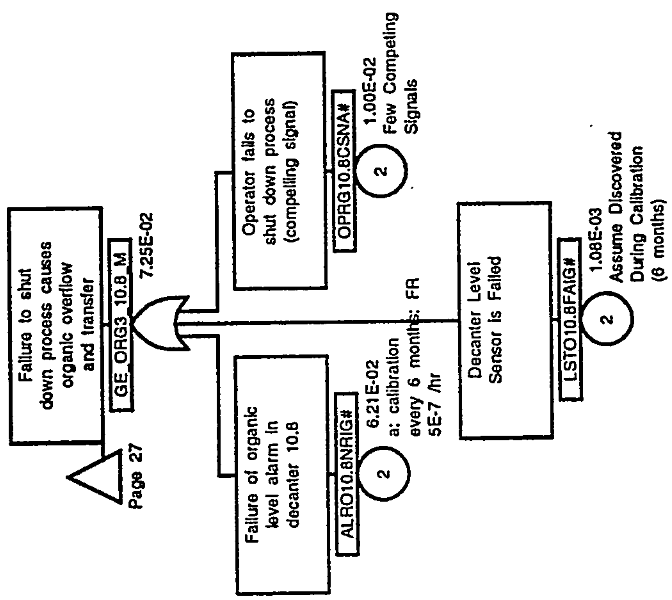

Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 32

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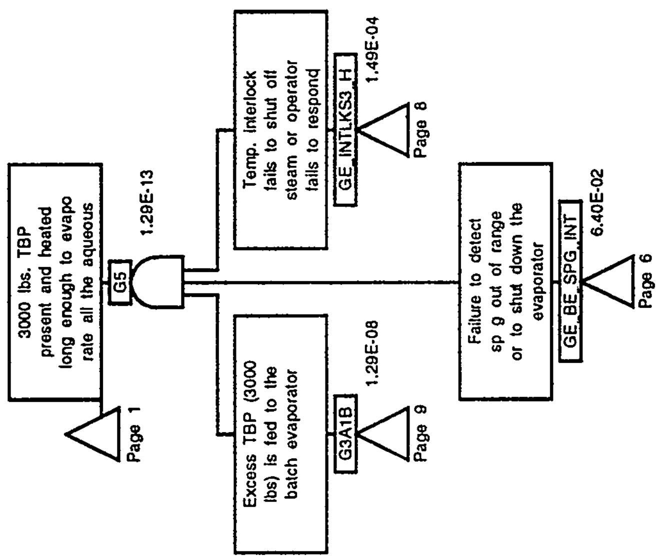

Runaway TBP Rxn in F Batch Evaporators | C:\CAFTA\REDOIL\INTBE2.CAF | 12-02-94 | Page 33

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AGI8.7--BLAG#	22		GE_BE_INLK_X	2		GE_FULL_906	27		GE_ORG3_11.7_M	29	
AGI8.7--FACG#	22		GE_BE_INLK_X	3		GE_FULL_906	30		GE_PMP906_INTLK	20	
ALR-PGT-COMG#	4		GE_BE_INLK_X	8		GE_HEAT1_CTRL1_H	1		GE_PRESS_H	7	
ALRHL906NRIG#	30		GE_BE_INTLKS1_H	1		GE_HIGH_906	30		GE_PRE_INTLK_H	2	
ALRO10.8NRIG#	21		GE_BE_INTLKS1_H	2		GE_INTLKS3_H	7		GE_PRO3_NO_LAB_A	15	
ALRO10.8NRIG#	32		GE_BE_INTLKS2_H	2		GE_INTLKS3_H	8		GE_PRO5_NO_LAB_A	9	
ALRO11.7NRIG#	19		GE_BE_IN_7.8_G	9		GE_INTLKS3_H	33		GE_PRO5_NO_LAB_A	10	
ALRO11.7NRIG#	29		GE_BE_IN_7.8_T	23		GE_NO_ANAL3_A	15		GE_PRO5_NO_LAB_T	23	
ALRTK906NRIG#	20		GE_BE_MIS_PRE_H	1		GE_NO_ANAL3_A	17		GE_PRO5_NO_LAB_T	24	
ANAEQLABFAIA#	11		GE_BE_MIS_PRE_H	7		GE_NO_ANAL5_A	10		GE_SAMP3_FAIL_A	15	
ANAEQLABFAIA#	17		GE_BE_SPG_02_X	6		GE_NO_ANAL5_A	11		GE_SAMP3_FAIL_A	16	
ANAEQLABFAIA#	25		GE_BE_SPG_INT	1		GE_NO_ANAL5_T	24		GE_SAMP5_FAIL_A	10	
CAVBESTMFOGG#	1		GE_BE_SPG_INT	1		GE_NO_ANAL5_T	25		GE_SAMP5_FAIL_T	24	
CAVBESTMFOGG#	3		GE_BE_SPG_INT	6		GE_NO_LAB_CHK3_A	17		GE_SAMP_17.5_A	13	
DPSTK175FAIG#	14		GE_BE_SPG_INT	7		GE_NO_LAB_CHK5_A	11		GE_SAMP_17.5_A	15	
DPSTK7.6FAIG#	6		GE_BE_SPG_INT	33		GE_NO_LAB_CHK5_T	25		GE_SAMP_7.8_A	9	
DPSTK7.3FAIG#	9		GE_BE_TRA1_7.8_G	9		GE_NO_RESULT3_A	15		GE_SAMP_7.8_T	23	
DPSTK7.3FAIG#	23		GE_BE_TRA1_7.8_G	12		GE_NO_RESULT5_A	10		GE_SPG_17.5_G	13	
EVPBEVAPON-G+	1		GE_BE_TRA1_7.8_T	23		GE_NO_RESULT5_T	24		GE_SPG_17.5_G	14	
G1	1		GE_BE_TRA1_7.8_T	26		GE_NO_SAMP3_A	15		GE_SPG_7.8_G	9	
G2	1		GE_BE_TRA2_7.8_G	12		GE_NO_SAMP5_A	10		GE_SPG_7.8_T	23	
G3A	1		GE_BE_TRA2_7.8_T	26		GE_NO_SAMP5_T	24		GE_TEM_INTLK_H	2	
G3A1A	1		GE_BE_VALVE_H	1		GE_OPERAG_8.7_G	22		GE_TEM_INTLK_H	5	
G3A1A	23		GE_CE_10.8_G	13		GE_ORG1_10.8_G	21		GE_TEM_INTLK_H	8	
G3A1A1	23		GE_CE_10.8_G	21		GE_ORG1_10.8_M	27		GE_TK906_RECOV	19	
G3A1A1	27		GE_CE_10.8_M	27		GE_ORG1_11.7_G	19		GE_TK906_RECOV	20	
G3A1B	1		GE_CE_FR_11.7_G	13		GE_ORG1_11.7_M	27		GE_TK906_RECOV	21	
G3A1B	9		GE_CE_FR_11.7_G	19		GE_ORG2_10.8_G	21		GE_TK906_RECOV	22	
G3A1B	33		GE_CE_FR_11.7_M	27		GE_ORG2_10.8_M	27		GE_TRAN_17.5_A	13	
G4	1		GE_CE_FR_17.5_G	13		GE_ORG2_10.8_M	31		GE_TRAN_7.8_A	9	
G5	1		GE_CE_IN_17.5_G	13		GE_ORG2_11.7_G	19		GE_TRAN_7.8_T	23	
G5	33		GE_CE_TO_8.7_G	13		GE_ORG2_11.7_M	27		G_ACCUM1_TBP	13	
GE_906_ALARM	20		GE_CE_TO_8.7_M	27		GE_ORG2_11.7_M	28		G_ACCUM1_TBP	22	
GE_AGIT_8.7_G	22		GE_CE_TRA1_175_G	13		GE_ORG3_10.8_G	21		G_LIT_TBP	9	
GE_BESPG_PLUG	6		GE_CE_TRA2_175_G	13		GE_ORG3_10.8_M	27		G_LIT_TBP	13	
GE_BE_CC_ALARM	3		GE_CE_TRA2_175_G	18		GE_ORG3_10.8_M	32		G_LOT_TBP	27	
GE_BE_CC_ALARM	4		GE_CW_CAL_TE_G	5		GE_ORG3_11.7_G	19		LMSPRESSNREG#	2	
GE_BE_CC_ALARM	6		GE_FULL_906	27		GE_ORG3_11.7_M	27		LMSPRESSNREG#	7	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
LSTO10.8FAIG#	21		OPRG7.8TACHA#	26		PERSAMLO020A#	25				
LSTO10.8FAIG#	32		OPRGAG87ACNA#	22		PERSR175010A#	15				
LSTO11.7FAIG#	19		OPRGBETEMCNA#	5		PERSR7.8010A#	9				
LSTO11.7FAIG#	29		OPRGBSPGMCNA#	6		PERSR7.8010A#	23				
LSTTK906FAIA#	20		OPRGINSUACHA#	11		PERTK175.20A#	13				
LSTTK906FAIA#	30		OPRGINSUACHA#	17		PERTR175002A#	13				
MOVGA1750OCG#	18		OPRGINSUACHA#	25		RLPPUMP-NREG#	20				
MOVGA7.8OOGG#	12		OPRGLOSEILNA#	11		SAM-7.8-FAIA#	10				
MOVGA7.8OOGG#	26		OPRGLOSEILNA#	17		SAM-7.8-FAIA#	24				
OPR17.5-ACNA#	13		OPRGLOSEILNA#	25		SAM_17.5FAIA#	16				
OPR175AGACNA#	15		OPRGNOTRACHA#	11		SPGBEVAPPLGG#	6				
OPR1AG87ACNA#	22		OPRGNOTRACHA#	17		TBP17.5-INCG#	27				
OPR2AG87ACHA#	22		OPRGNOTRACHA#	25		TBPDENS1PREA#	19				
OPR3AG87ACNA#	22		OPRGNROMCVLA#	10		TBPDENS1PREA#	28				
OPR7.8AGACNA#	9		OPRGNROMCVLA#	16		TBPDENS2PREA#	21				
OPR7.8AGACNA#	23		OPRGNROMCVLA#	24		TBPDENS2PREA#	31				
OPR906LEMCNA#	20		OPRGOPCOACNA#	10		TBPTK---PREA#	19				
OPR906LEMCNA#	30		OPRGOPCOACNA#	15		TBPTK---PREA#	2[illegible]				
OPRBBLOCDENA#	4		OPRGOPCOACNA#	24		TBPTK2BPPREA#	21				
OPRG10.8CSNA#	21		OPRGPRESMCNA#	2		TBPTK2BPPREA#	31				
OPRG10.8CSNA#	32		OPRGPRESMCNA#	7		TSTBETE-FAIG#	5				
OPRG11.7CSNA#	19		OPRGS175ACNA#	15		TUBBEAIRLEGG#	6				
OPRG11.7CSNA#	29		OPRGS175LANA#	15							
OPRG175-ACNA#	13		OPRGS7.8ACNA#	10							
OPRG175-IR[illegible]	18		OPRGS7.8ACNA#	24							
OPRG175-MCN[illegible]	14		OPRGS7.8LANA#	9							
OPRG175TACHA#	18		OPRGS7.8LANA#	23							
OPRG175VACHA#	13		OPRLV906ACNA#	30							
OPRG7.8-ACHA#	12		OPRPLUG1VRHA#	6							
OPRG7.8-ACHA#	23		OPRTK906CSNA#	20							
OPRG7.8-ACHA#	26		OPRTK906CSNA#	30							
OPRG7.8-ACNA#	9		PER-COLD035G#	21							
OPRG7.8-ACNA#	23		PER-COLD035G#	27							
OPRG7.8-IRNA#	12		PERACCUMINC#	27							
OPRG7.8-IRNA#	26		PERBETEM002A#	5							
OPRG7.8-MCNA#	9		PERFBLININC#	13							
OPRG7.8-MCNA#	23		PERSAMLO020A#	11							
OPRG7.8TACHA#	12		PERSAMLO020A#	17							

Cutsets for 7.6E & 7.7E Evaporators

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	G1					3.34E-10
1.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	5.71E-11
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
2.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.85E-11
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
3.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.00E-1
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
4.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	1.32E-11
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPREBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
5.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	9.99E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
6.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	9.19E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
7.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	9.19E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
8.	ALR-PGT-COMG#	Common cause batch evaporator alarm failure (sp g, temp, pres.)	5	6M 3.00E-06H	6.45E-03	8.52E-12
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
9.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	6.60E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRBBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
10.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	6.60E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRGESPGMCNA#	Calibration error - spg instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
11.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	5.71E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	MOVGA7.8OOGG#	Gang valve fails to close	1	1N 1.00E-02 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	

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Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
12.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	5.71E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8-IRNA#	Operator incorrectly reads sp g display	1	1N 1.0E-2 N	1.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
13.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	4.62E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRBBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
14.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	4.60E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
15.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	4.60E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
16.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	4.60E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	

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Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
17.	ALR-PGT-COMG#	Common cause batch evaporator alarm failure (sp g, temp, pres.)	5	6M 3.00E-06H	6.45E-03	4.26E-12
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
18.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	3.30E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG53PGMCNA#	Calibration error - spg instrumentation gives false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
19.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	3.22E-1
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG10.8CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
20.	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	3.22E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
21.	ALR-BGT-COMG#	Common cause batch evaporator alarm failure (sp g, temp, pres.)	[illegible]	6M 3.00E-06H	6.45E-03	[illegible]
	ALRHL906NRIG#	High level alarm in tank 906 tank fails	[illegible]	6M 3.00E-05H	6.21E-02	
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
22.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.85E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8-ACNA#	Operator fails to settle tank contents prior to transferring out	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
23.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.85E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPR7.8AGACNA#	Operator fails to agitate tank 7.8 prior to sampling	1	1N 5.0E-3 N	5.00E-03N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
24.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.85E-12
	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8-MCNA#	Calibration error - SP G instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq.(/yr)
25.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.31E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPRBBLOCDENA#	Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
26.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.31E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	[illegible]	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	[illegible]	
	OPRGBSPGMCNA#	Calibration error - spg instrumentation gives false reading	1	1N 5.0E-3 N	[illegible]	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	
27.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	2.30E-12
	EVPBEVAPON-G+	Batch Evaporator is Used		100Y	1.00E+02Y	
	OPR906LEMCNA#	Calibration Error - Level instrument is calibrated to give a false reading	1	1N 5.0E-3 N	5.00E-03N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator (procedural)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
28.	ALRO11.7NRIG#	Failure of organic level alarm in decanter 11.7	5	6M 3.00E-05H	6.21E-02	2.13E-12
	EVPBEVAPON-G+ OPRBBLOCDENA#	Batch Evaporator is Used Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	1	100Y 1N 1:0E-2 N	1.00E+02Y 1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	1	1N 1.0E-2 N	1.00E-02N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
29.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.13E-12
	EVPBEVAPON-G+ OPRBBLOCDENA#	Batch Evaporator is Used Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	1	100Y 1N 1,0E-2 N	1.00E+02Y 1.00E-02N	
	OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	1	1N 1.0E-2 N	1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	PERSR7.8010A#	Sample is not representative of tank contents	1	1N 1.00E-01N	1.00E-01N	
	TBPTK---PREA#	Process upset causes excess organic in feed	3	12H 0.1Y	1.37E-04	
30.	ALRHL906NRIG#	High level alarm in tank 906 tank fails	5	6M 3.00E-05H	6.21E-02	2.00E-12
	ALRO10.8NRIG#	Failure of organic level alarm in decanter 10.8	5	6M 3.00E-05H	6.21E-02	
	EVPBEVAPON-G+ MOVGA7.800GG#	Batch Evaporator is Used Gang valve fails to close	1	100Y 1N 1.00E-02 N	1.00E+02Y 1.00E-02N	
	OPRG7.8-ACHA#	Operator fails to recognize SPG break or assure SPG is within range (10K TBP)	1	1N 5.0E-2 N	5.00E-02N	

Cutsets for 7.6E & 7.7E Evaporators (CONT.)

Set No.	Event Name	Description	C	B.E. Input	Calc. Result	Cutset Freq. (/yr)
	OPRLV906ACNA#	Operator fills tank 906 (Level Procedurally Controlled)	1	1N 5.0E-3 N	5.00E-03N	
	OPRPLUG1VRHA#	Failure to notice that sp g instrumentation peg low	1	1N .05N	5.00E-02N	
	PER-COLD035G#	Cold streams sent to 8.7	1	1N 3.50E-01N	3.50E-01N	
	SPGBEVAPPLGG#	Plugging of instrumentation causes a low spg reading	3	1D 2.0D	8.65E-01	
	TBPTK2BPPREA#	Process upset causes excess TBP in canyon product	3	12H 0.1Y	1.37E-04	

Basic Event Data for 7.6E & 7.7E Evaporators

Event	C	Input	Calc.	Description	Source
AGI8.7--BLAG#	3	4D 5.0E-7H	4.80E-05	Blades fall off agitator in tank 8.7	Length of Cycle
AGI8.7--FACG#	3	4D 5.0E-6H	4.80E-04	Feed tank agitator fails during the week (mission time)	Length of Cycle
ALR-PGT-COMG#	5	6M 3.00E-06H	6.45E-03	Common cause batch evaporator alarm failure (sp g, temp, pres.)	a: calib. every 6 mon., beta factor of .1 for common cause
ALRHL906NRIG#	5	6M 3.00E-05H	6.21E-02	High level alarm in tank 906 tank fails	Assumes discovered during Level Sensor Calibration: FR 3E-5/hr
ALRO10.8NRIG#	5	6M 3.00E-05H	6.21E-02	Failure of organic level alarm in decanter 10.8	a: calibration every 6 months: FR 5E-7 /hr
ALRO11.7NRIG#	5	6M 3.00E-05H	6.21E-02	Failure of organic level alarm in decanter 11.7	a: 6 month calibration: FR 3E-5/hr
ALRTK906NRIG#	5	6M 3.00E-05H	6.21E-02	Low level alarm in tank 906 fails	a: disc. during 6 month calib.: FR 3E-5/hr
ANAEQLABFAIA#	3	24H 5.00E-06 H	1.20E-04	Lab Equipment Malfunction, Sample Cannot be Run	24hr restoration time: FR 5E-6/hr
CAVBESTMFOGG#	3	24H 3.00E-06 H	7.20E-05	Pneumatic steam control valve fails open (batch evaporator)	Used Compressed Gas Value, 1 Day Mission Time :FR 3E-6/hr
DPSTK175FAIG#	5	3D 3.00E-06 H	1.08E-04	SPG Instrument in 17.5 Gives False High Reading	Would Discover on Next Transfer - About 3 days: FR 3E-06/hr
DPSTK7.6FAIG#	3	1D 3.00E-06 H	7.20E-05	SPG instrumentation gives a false reading	A: 1 day to restore (next feed tank filling): FR 3E-6/hr
DPSTK7.8FAIG#	3	4D 3.00E-06 H	2.88E-04	SP G instrument in 7.8 gives false high reading	4 days to restore: FR 3E-6/hr
EVPBEVAPOH-G+		100Y	1.00E+02Y	Batch Evaporator is Used	Assumed to Operate [illegible] Times per Year
LMSPRESSNREG#	3	24H 1.00E-06 H	2.40E-05	Steam pressure switch fails	1 Day Mission Time: FR 1E-6/hr Limit Switch, No Response
LSTO10.8FAIG#	5	6M 5.00E-07 H	1.08E-03	Decanter Level Sensor is Failed	Assume Discovered During Calibration (6 months)
LSTO11.7FAIG#	5	6M 5.00E-07 H	1.08E-03	Organic level detector in 11.7 fails low	a: Calibration every 6 months: FR 5E-7/hr
LSTTK906FAIA#	5	6M 5.00E-07 H	1.08E-03	Tank 906 level sensor failure	Assume discovered during calibration (6 months): FR 5E-7/hr
MOVGA175OOCG#	1	1N 3.00E-03 N	3.00E-03N	Gang valve from 17.5 fails too close	Generic Failure on Demand
MOVGA7.8OOGG#	1	1N 1.00E-02 N	1.00E-02N	Gang valve fails to close	Motor Operated, Safety, Compressed Gas
OPR17.5-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Second consecutive transfer containing TBP from tank 17.5 is fed to same batch	sump receipt tank transfer procedure does not allow a 2nd transfer
OPR175AGACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to agitate tank 17.5 prior to sampling	a: administrative control (nominal) Typical Circumstances
OPR1AG87ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to check if agitator is working prior to the first transfer	typical circumstances
OPR2AG87ACHA#		0.5N	5.00E-01	Operator fails to check if agitator is working prior to second transfer	a: high dependence bec. same oper. as first trans.
OPR3AG87ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to check if agitator is working prior to third transfer	typical circumstances

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Basic Event Data for 7.6E & 7.7E Evaporators (CONT.)

Event	C	Input	Calc.	Description	Source
OPR7.8AGACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to agitate tank 7.8 prior to sampling	Typical Circumstances
OPR906LEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Level instrument is calibrated to give a false reading	Typical Circumstances
OPRBBLOCDENA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to alarm(s) (906, temp., pres., spg (Close valve)	Several Competing Signals
OPRG10.8CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to shut down process (compelling signal)	Few Competing Signals
OPRG11.7CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to shut down process (compelling signal)	Few Competing Signals
OPRG175-ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to settle tank contents prior to tranferring out	typical circumstances
OPRG175-IRNA#	1	1N 1.0E-2 N	1.00E-02N	Operator incorrectly reads spg display	Organic Frequently Present, Good Display (graph)
OPRG175-MCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - SPG Instrument is Calibrated to Give a False Reading	Single person, operator check
OPRG175TACHA#	1	1N 5.0E-2 N	5.00E-02N	Operator transfers too much TBP to 8.7	Routine, repetitive circumstances
OPRG175VACHA#	1	1N 5.0E-2 N	5.00E-02N	Operator fails to correct the excessive TBP sent to 8.7	Knowledge-based, 10 to 30 minutes
OPRG7.8 [illegible]	[illegible]	1N 5.0E-2 N	[illegible]	Operator fails to [illegible] or assure SPG is within range (10K TBP)	Knowledge-based diagnosis error [illegible] to 30 minutes
OPRG7.8-ACNA#	1	1N [illegible] N	5.00E-03N	Operator fails to settle tank contents prior to transferring out	Routine, repetitive circumstances
OPRG7.8-IRNA#	1	1N 1.0E-2 N	1.[illegible]	Operator incorrectly reads [illegible] display	Incorrect Reading of good display (graph)
OPRG7.8-MCNA#	1	1N 5.0E-3 N	5.00E-0[illegible]	Calibration error - SPG instrument is calibrated to give a false reading	Single Person, Operator Check
OPRG7.8TACHA#	1	1N 5.0E-2 N	5.00E-02N	Operator transfers too much organic to the batch evaporator (procedural)	Unusual Circumstances
OPRGAG87ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fails to activate	typical circumstances
OPRGBETEMCNA#	1	1N 5.0E-3 N	5.00E-03N	Tank Temperature Sensor is Miscalibrated	Single Person, Operator Check
OPRGBSPGMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration error - spg instrumentation gives false reading	Single Person, Operator check
OPRGINSUACHA#	1	1N 5.0E-2 N	5.00E-02N	Insufficient sample pulled	Unusual Circumstances, Difficult to Tell if Sufficient
OPRGLOSEILNA#	1	1N 5.0E-3 N	5.00E-03N	Sample Accountability Error in Lab Causes Loss of Sample	Normal Administrative Controls
OPRGNOTRACHA#	1	1N 5.0E-2 N	5.00E-02N	Sample Not Transported to Lab on a Timely Basis	Unusual Circumstances, transportation is not emphasized
OPRGNROMCVLA#	1	1N 1.0E-2 N	1.00E-02N	Operations Fails to Recognize/Correct Omission of Sample	checking requires active participation
OPRGOPCOACNA#	1	1N 5.0E-3 N	5.00E-03N	Operations Violates Procedure and Continues Without Lab results	Typical circumstances

Basic Event Data for 7.6E & 7.7E Evaporators (CONT.)

Event	C	Input	Calc.	Description	Source
OPRGPRESMCNA#	1	1N 5.0E-3 N	5.00E-03N	Calibration Error - Pressure switch for steam gives a false signal	Single Person, Operator Check, Not Discovered Till Next Calibration
OPRGS175ACNA#	1	1N 5.0E-3 N	5.00E-03N	Procedural violation results in sample not being taken for tank 17.5	Typical circumstances
OPRGS175LANA#	1	1N 3.0E-4 N	3.00E-04N	Routine analysis gives false TBP results for tank 17.5	Low Dependence check
OPRGS7.8ACNA#	1	1N 5.0E-3 N	5.00E-03N	Procedural violation results in no sample being taken for tank 7.8	Typical Circumstances
OPRGS7.8LANA#	1	1N 3.0E-4 N	3.00E-04N	Routine analysis gives false TBP result for tank 7.8	Low Dependence Check
OPRLV906ACNA#	1	1N 5.0E-3 N	5.00E-03N	Operator fills tank 906 (Level Procedurally Controlled)	Typical Circumstances, Level kept low to prevent large loss of organic
OPRPLUG1VRHA#	1	1N .05N	5.00E-02N	Failure to notice that sp g instrumentation peg low	a: checked hourly (roundsheet)
OPRTK906CSNA#	1	1N 1.0E-2 N	1.00E-02N	Operator fails to respond to low level alarm in tank 906	Typical Circumstances, Further Loss could shut down process
PER-COLD035G#	1	1N 3.50E-01N	3.50E-01N	Cold streams sent to 8.7	1.5 Days of Cold Streams Out of 4 days of running
PERACCUMIIIC#	1	1N 1.00E-32N	1.00E-32N	30,000 lbs of organic accumulates in 8.7	
PERBETEM[illegible]	1	1N 2.00E-02N	2.00E-02N	Temperature sensor calibrated just before this batch	Calibrated every 6 months & 1 batches a year
PERFBLININC#	1	1N 1.00E-32N	1.00E-32N	Excess TBP is Received in 8.7 From 9.7	Incredible Event
PERSAML[illegible]	1	1N 2.00E-01N	2.00E-01N	Lab does not request additional sample	Eng estimate
PERSR175010A#	1	1N 1.00E-01N	1.00E-01N	Sample is Not Representative of Tank Contents	No credit is taken for sampling involving < 10,000 TBP
PERSR7.8010A#	1	1N 1.00E-01N	1.00E-01N	Sample is not representative of tank contents	Sampling poor 10%
PERTK175.20A#	1	1N 2.00E-03N	2.00E-03N	Sufficient TBP present in tank 17.5	a: 1 in 5 years (1/500 Batches)
PERTR175002A#	1	1N 2.00E-02N	2.00E-02N	Material Is Being Received From 17.5	Pu Recovery, Assume 1 out of 50 batches
RLPPUMP-NREG#	1	1N 1.0E-3N	1.00E-03N	Pump switch fails to open	Per Demand, Generic Data
SAM-7.8-FAIA#	5	6D 1.00E-05 H	7.20E-04	Sampler malfunctions such that a sample can not be pulled (tank 7.8)	6 days to Correct: FR 1E-5/hr Sampler, Failure
SAM_17.5FAIA#	5	6D 1.00E-05 H	7.20E-04	Sampler malfunctions such that a sample can not be pulled (tank 17.5)	6 Days to restore: FR 1E-5/hr
SPGBEVAPPLGG#	3	1D 2.0D	8.65E-01	Plugging of instrumentation causes a low spg reading	A: 1 day to detect and restore (easy to correct), detected with next feed tank
TBP17.5-INCG#		1.0E-32N	1.00E-32	Several batches containing excess TBP are received from 17.5 (30,000 lbs total)	a: Incredible - it would take 3 consecutive transfers from 17.5 during a batch
TBPDENS1PREA#		1.0E-32N	1.00E-32	Process upsets causes dilute 2AW or high density in 11.7S	incredible, phase inversion of > 10,000 lbs

Basic Event Data for 7.6E & 7.7E Evaporators (CONT.)

Event	C	Input	Calc.	Description	Source
TBPDENS2PREA#		1.0E-32H	8.76E-29Y	Process upsets causes dilute 2W or high density in 11.7S	incredible, phase inversion of > 10,000 lbs
TBPTK---PREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess organic in feed	Estimated as 1/10years - Not detected for 12 hours
TBPTK2BPPREA#	3	12H 0.1Y	1.37E-04	Process upset causes excess TBP in canyon product	a: process upset exists for 12 hours: FR 1/10yr
TSTBETE-FAIG#	5	4D 1.00E-06 H	4.80E-05	Batch Evaporator Temperature Sensor Fails	Temp Sensor, Discovered within 4 days: FR1E-6/hr
TUBBEAIRLEGG#	3	40D 3.00E-07 H	2.88E-04	Air leak cause false sp g reading (batch evaporator)	10ft Long*4 days to restore, (next feed tank filling)

Data Type Codes for 7.6E & 7.7E Evaporators

Type Code	Rate	Description	Source	EF	D
AGI BLA	5.0E-7H	Agitor blades fall off	a: fails at 1/10 frequency of agitator failure		
AGI FAC	5.0E-6H	Agitator failure	WSRC-TR-93-262, AGI-FA-C		
ALR COM	3.00E-06H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I multiplied by 0.1 beta for common cause		
ALR NRI	3.00E-05H	Alarm/Annunciator, Fails to alarm (Instr. & Control)	WSRC-TR-93-262, ALR-NR-I	10	L
ANA FAI	5.00E-06 H	Analyzer, Failure (Instr. & Control)	WSRC-TR-93-262, ANA-FA-I	10	L
CAV FOG	3.00E-06 H	Valve (Control), Air-Operated, Fails open (Compressed Gas)	WSRC-TR-93-262, CAV-FO-G	10	L
DPS FAI	3.00E-06 H	Sensor/Transmit., Transdu./Proc. Sw., Differ. Pres., Failure (Instr. & Control)	WSRC-TR-93-262, DPS-FA-I	10	L
LMS NRE	1.00E-06 H	Switch, Limit, Fails to open/close (Electric Power)	WSRC-TR-93-262, LMS-NR-E	10	L
LST FAI	5.00E-07 H	Sensor/Transmitter/, Transducer/Proc. Switch, Level, Failure (Instr. & Control)	WSRC-TR-93-262, LST-FA-I	3	L
MOV OOC	3.00E-03 N	Valve (Standby or Safety), Motor-Operated, Fails to open/close (Chemical)	WSRC-TR-93-262, MOV-OO-C	10	L
MOV OOG	1.00E-02 N	Valve (Standby or Safety), Motor Operated, Fails to open/close (Compressed Gas)	WSRC-TR-93-262, MOV-OO-G	10	L
OPR ACH	5.0E-2 N	Failure of Administrative Control (High)	WSRC-TR-93-581, Table 4, Item 1, High	5	L
OPR ACN	5.0E-3 N	Failure of Administrative Control (Nominal)	WSRC-TR-93-581, Table 4, Item 1, Nominal	10	L
OPR CSN	1.0E-2 N	Failure to respond to compelling signal (Nominal)	WSRC-TR-93-581, Table 4, Item 2, Nominal	[illegible]	L
OPR CVL	1.0E-2 N	Checker verification error	WSRC-TR-93-581, Table 4, Item 3, Low	[illegible]	L
OPR DEN	1.0E-2 N	Diagnosis error (Nominal)	WSRC-TR-93-581, Table 4, Item 30, Nominal	5	L
OPR ILN	5.0E-3 N	Incorrect labeling or tagging (Nominal)	WSRC-TR-93-581, Table 4, Item 10, Nominal	10	L
OPR IRN	1.0E-2 N	Incorrect reading or recording of data (Nominal)	WSRC-TR-93-581, Table 4, Item 11, Nominal	5	L
OPR LAN	3.0E-4 N	Laboratory analysis error (Nominal)	WSRC-TR-93-581, Table 4, Item 19, Nominal	10	L
OPR MCN	5.0E-3 N	Miscalibration (Nominal)	WSRC-TR-93-581, Table 4, Item 12, Nominal	10	L
OPR VRH	.05N	Failure to verify within control room (High)	WSRC-TR-93-581, Table 4, Item 3, High		
PER .20	2.00E-03N	0.2% chance			
PER 002	2.00E-02N	2% chance			
PER 010	1.00E-01N	10% Chance			
PER 020	2.00E-01N	20% chance			
PER 035	3.50E-01N	35% chance			
PER INC	1.00E-32N	Incredible Event			
RLP NRE	1.0E-3N	Relay fails to open	WSRC-TR-93-262m RLP-NRE		
SAM FAI	1.00E-05 H	Sampler, Failure (Instr. & Control)	WSRC-TR-93-262, SAM-FA-I	10	L
SPG PLG	2.0D	TUBE PLUGS	Estimate by facility sep. tech (Chostner) - Plugs frequently		
TBP PRE	0.1Y	Process upset causes excess organic in feed	Never Seen, Estimated as Once in Ten Years		

Data Type Codes for 7.6E & 7.7E Evaporators (CONT.)

Type Code	Rate	Description	Source	EF	D
TST FAI	1.00E-06 H	Sensor/Transmitter/, Transducer/Proc. Switch, Temp., Failure (Instr. & Control)	WSRC-TR-93-262, TST-FA-I	3	L
TUB LEG	3.00E-07 H	Tube, Leakage (external) (per ft.) (Compressed Gas)	WSRC-TR-93-262, TUB-LE-G	10	L

APPENDIX D HUMAN ERROR ANALYSIS FOR "RED OIL"

EPD-SIM-940098

DATE: October 5, 1994

TO: C. R. Lux
E.V. Browne
L.W. Christiansen

FROM: R.E. Vail

RE: Human Factors Review of the "Red Oil" Explosion Fault Trees for the F Canyon Evaporators

CC: D.A. Sharp
J.H. Starling
D.J. Baker
H.C. Benhardt

Introduction

A Human Factors review of the F Canyon Evaporators (7.6E, 8.5E, 9.3E, and 17.7E) fault trees for "red oil" (Tomsk-like) explosions was performed over the past two weeks. The review included: (1) documentation of the supporting information required to justify the evaluation of the assigned human error codes, per WSRC-TR-93-581(presented in Attachments 1 through 4); (2) suggested events to be recoded (as noted in "ERROR CODE" column of Attachments 1 through 4); (3) a review of dependencies between multiple human error events in a single minimal cut set (Attachment 5); (4) identification of human error events that require procedure modification before full credit can be given to the event (as noted in the "HEP" column of Attachments 1 through 4); and (5) identification of human error events that need further logic development by the analysts, in conjunction with the facility technical representatives.

Review Methodology

A qualitative task analysis to support the human error modeling and quantification selections made by the fault tree analysts did not exist. Because of this lack of documentation, the available information was compiled before an evaluation of each human error was possible. The types information included actions involved, who performed the action, equipment, feedback and indication, and the event probability and error factor. All human error events in the batch evaporator (7.6E) tree (BATCH.CAF) were reviewed. For the additional four trees (8.5E, 9.3E-C, 9.3E-B and 17.7E), I had each tree's analyst mark the branches that were not directly "pruned" from the BATCH tree and *only* these tree-specific branches/ human error events were reviewed. The CONT93C.CAF tree was not reviewed in-depth because its logic duplicated the CONT93.CAF tree, minus the sampling branches.

Any reference to a reviewed procedure should not be misconstrued as an in-depth procedure (or programmatic) review. The only steps reviewed were those that directly pertained to the modeled operator actions. Glaring inadequacies were noted.

EPD-SIM-940098

Summary of Findings Based on Items (1) through (5) in Introduction

(1) Human error documentation (that meets the intent of both DOE STD-93-3009 and NUREG/CR-1278) was provided in this memo by the Human Reliability Analyst for four of the five red oil explosion fault trees (the fifth tree was an exact duplicate of the CONT93.CAF tree) for 88 different human error events.

(2) Twenty-four of the above 88 human errors should be re-coded. The changes and the effect on the probability value are as follows (the suggested changes are denoted under the "ERROR CODE" column in Attachments 1 through 4):

one event (OPRLV906ACNA#) is a major rework and logic change;
11 human errors changed from lower to higher values w/o changing type code;
four changed type code and decreased failure probability value;
six changed type code and increased failure probability value;
two changed type code with no change in probability value.

Note: Values in WSRC-TR-93-581 are mean values (on a log scale).

(3) **Dependence** - The assumption of independence (zero dependence) between operator actions had been assumed by the fault tree analysts for most human error events in the trees. A more conservative general guideline is to first assume some level of dependence between human activities during the logic model development and early quantifications, unless a diligent search reveals no significant interaction between activities. This includes both inter- and intra- operator actions.

The assessment of dependence was performed in accordance with NUREG/CR-1278 guidelines. The nominal conditional human error probabilities reported in Table 20-21 (items 2a through 5a) were used to quantify low (LD, p=0.05), moderate (MD, p=0.15), high (HD, p=0.5) and complete (CD, p=1.0) dependence levels. The following general guidelines of dependence level determination from Chapter 10 of NUREG/CR-1278 were applied:

- CD is unusual between two people working on a job.
- CD between two actions performed by the same person is more common.
- CD when two (or more) switches/components are treated as a pair (manipulated at the same time per a procedure).
- HD usually for two operators in a CR for tasks in which they are supposed to interact.
- HD for two <u>controls</u> at a panel if the operator doesn't have to change his position.
- HD if two (or more) parameters indications are read on the same recorder/ display, and are treated as a functional unit.
- MD if two operators assigned to the same panel and split 50-50 between them the CR display scanning/ monitoring duties.
- If a decision cannot be made between two levels of dependence, then the higher level is chosen.

Several of the F Canyon control room operator duty positions may be performed by a single operator. The operators have been cross-trained on several positions and in some cases may perform two duties during one shift. (These two duty stations are within close proximity of each other). There is also the possibility that an operator may report for the following shift "day" and perform a different duty position than the previous day. Several of the duty combinations are as follows (based on conversations with R. Eubanks, Shift Technical Engineer, F Canyon):

Solvent Recovery operator & Low Activity Waste operator
Lab Waste operator & 2nd U Cycle (17.7E) operator
Lab Waste operator and LAW operator

(2nd Pu cycle position precludes it from being in combination with others)

It is suggested that the failure probabilities for one of each of these pairs (or triplets) of human error events should retain its "original" value. The other events should be adjusted to account for dependencies when these two (or more) events appear in the same minimal cut set. The recommended failure probability of "p=?" for the second (third, fourth, ...) human error event in the minimal cut set, is given after the events. (The order of the events (i.e., the one(s) receiving the conditional probability) should be determined by the time sequence of the events. To facilitate making the changes, an extension to the coding scheme might be developed. Where "L", "M" or "H" are used in the third position of the OPR type code, the characters "C" (for CD), "M" ("much" for HD), "S" ("some" for MD), and "V" ("very little" for LD) and then the associated values of 1.0, 0.5, 0.15 and 0.05, respectively.

The suggested dependence levels are listed by tree in Appendix 5.

(4) Procedure addition or changes required (for "old" existing operator errors):

a. **OPRPUMPAVRNA#**, SOP 221-F-40825, Att 7.1 should have "lower limits" for Items #9 and #10, 8.5E spg and 8.5 True Level (p=0.5)

b. **OPRRA147ACNA#**, "operator fails to respond to low level in Tank 14.7" - no ARP exists (there may be operator aids on panel boards for when pump prime is lost on 14.7) (p=1.0 now, would go to p=0.001) (in 9.3E & 17.7E trees)

c. **OPRRA904ACNA#**, "Operator fails to respond to low level alarm in Tank 904", SOP 211-F-1221, Steps 5.5.1 & 5.6.1 NOTES are mispositioned and contain typos for setpoint information (p=1.0 until fixed, then p=0.01)

d. **OPRQ73--ACLA#**, "Operator fails to settle tank contents prior to transferring out", SOP 221-F-40790, implies agitator "OFF". Need to add step to "ENSURE agitator is off".

e. **OPRTK147ACNA#**, "Operator fills tank 14.7 (level procedurally controlled) There are numerous procedures that addresses the chronic (or known accidental diversion) loss of solvent, daily solvent inventory control, and compensating for low solvent inventories. But these do not address the control of an acute, gross solvent loss. Perhaps an Abnormal Operating Procedure (AOP) is needed to handle this scenario. (p=1.0 now, then p=0.005 with AOP)

f. **OPRG175-ACLA#**, "Operator fails to settle tank contents prior to transferring out" (to 8.7) No procedure currently exists (p=1.0 now, to p=0.005 when procedure added). (7.6E Batch tree)

g. **OPRGS175ACNA#**, "Procedural violation results in sample not being taken", no procedure exists for this infrequent route from sump handling (might be similar to procedure SOP 221-F-40780) (p=1.0 now, to p=0.005 when procedure added).(7.6E)

h. **OPRG175VDEHA#**, "Operator fails to correct excessive TBP sent to 8.7", Rerun operator does not have procedure for decanting from 17.5 to 8.7; (p=1.0 now, to p=0.005 when procedure added).(7.6E)

i. **OPRG175TACLA#,** "Operator transfers too much TBP to 8.7", procedure not written; special procedure should direct Rerun operator to look for the "sharp break" in spg.

j. **OPRG-9.7CVNA#,** "Operator fails to visually check sample for solvent", event type code changed to -VIH- because it's a visual inspection task that is NOT procedure-driven. p=0.5 now, could be changed to p=0.01 if proceduralized, used every time and sample aisle operators expectations trained on looking for TBP in sample.

k. **OPR8.7AGACNA#,** "Operator fails to agitate tank 8.7 prior to sampling" SOP 221-F-40825 does not state to have/ or turn the agitator ON prior to sampling. (p=1.0 now, p=0.005 then) (in 7.6E) (treated as "new" sensitivity event in 8.5E tree)

l. **OPRTK128DENA#,** "Operator fails to diagnose cause of change in spg, level interface"; was not able to verify if a procedure existed that gave guidance on the diagnostic criteria for the Solvent Recovery operator for Tank 12.8. (p=1.0 until "proven" then p=0.01)

m. **OPRGS137ACNA#,** "Procedural violation results in no sample being taken for 13.7, although procedures exist for sampling 13.7, they do not cover this scenario for 7.6E tree.

(5) Logic changes - A change in the logic (or clarification) is suggested for the following operator action. OPRLV906ACNA#, "Operator fills tank 906 (level procedurally controlled)". The action implies inventory control at regular intervals and communication of inventory amounts among the F Canyon and Outside Facilities operators. A first response to this event may be that the 2nd Pu Cycle operator shuts down his cycle. The Low Activity Waste operator might shut down the evaporator. The Solvent Recovery operator may perform troubleshooting if solvent recovery cycle is involved at that time. Consider adding the following events (or some combination), as appropriate:
- 2nd Pu operator fails to shutdown cycle (CS? or AC?)
- LAW operator fails to shutdown evaporator (CS? or AC?)
- SR operator fails to diagnose loss of solvent inventory (DE?)

Fault Tree Recommendations

1. In general, the trees are strongly influenced by the contributions of operator, E&I technician, and laboratory error. Administrative controls, both those currently in place and ones promised, are needed to properly credit these human actions. In instances where the facility commits to providing the new administrative controls (e.g., alarm response procedures, decanting SOPs, etc.), then full credit should be assigned, as noted in the "HEP" column of Attachments 1 through 4. Additionally, if no commitment is forthcoming, then no credit (p=1.0) should be assigned for that particular operator action.

2. Overall, modeling of operator error was fairly accurate. The majority of proposed changes are to operator error events that reflected a lack of knowledge of the procedural/ administrative controls in place for the facility. The fault tree analysts should acquire the procedural documentation earlier in the development phase. (These changes became evident with a review of the procedure index for F Canyon and the procedures). Most of

these were changes from the "administrative controls" (AC) type code to the "compelling signal" (CS) type code, or the reverse. Several changes reflected changes to and from the "diagnosis error" (DE).

3. It is suggested that the fault tree analysts document their selection rationale (and the underlying task analysis) for operator errors earlier in the tree development cycle. Because the error sensitivity and assumptions rely on this task analysis documentation, it is counterproductive to wait until the review phase to construct it.

4. Calibrations involving "evaporator temperature sensor" (e.g., OPRGCETEMCNA# in the 8.5E tree) for Molytek equipment may be better modeled as a programming error ("incorrect reading or recording of data", -IR-, p=0.01). Our technical (STE) contact says that Molytek is an uncalibratable IPI.

5. The following two gates (page 29) of the Batch Evaporator tree, do not contain descriptions of the branch: GE_12.8_XFER_G and GE_12.8_XFER1_G

The following are presented to clarify suggested changes:

6. Sample aisle operator has high expectancy for "no TBP present" condition, and would not be looking for the presence of TBP/solvent in the sample. This would increase the probability of his failing to detect it, therefor the higher failure value should be used.

7. Shift Technical Engineer (STE) does not expect TBP to be present in the continuous evaporator. (First the operator would have to clue-in the STE to the low density readings.) When there is a low spg (density) reading, the STE would first expect and investigate instrument malfunction (increasing the amount of time until the TBP is diagnosed/detected). (e.g., OPRCESPGDEHA#, p=0.1 in the 8.5E tree)

8. Alarms exist for low levels on Tanks 14.7, 906, and 904. The "administrative control failure" events (OPRRA147ACNA#, OPRA904ACNA3 and OPRA906ACNA#) should be changed to "failure to respond to a compelling signal" (-CSN-). (The failure probability increases from p=0.005 to p=0.01).

Procedural Recommendations

1. Although not affecting the "taking of spg readings" (e.g., OPRCESPGACNA#), the SOP 221-F-40825, Att 7.1 Data Sheet should have the minimum limits value for "sp gr" in the table (item #10) and for 8.5 True Level (Item #9)

2. SOP 211-F-1221 "Operation of Segregated Solvent Systems Round Sheets (U)", has incorrectly positioned and misleading NOTES for Alarm Setpoints of Low and Low-Low. The NOTE for Tanks 904 and 906 Low-level alarms should be moved from above the "Low Low-Level " alarm substep (5.6.1) to above the "Low-level" substep (5.5.1). The NOTE for "Low Low-level" alarm is currently missing the needed descriptor "Low" (i.e., only has one "LOW"). It should be moved up to just above substep 5.6.1. (Also, in Appendix 7.9, change "Level 96" to read "Level %").

3. Alarm Response Procedure, SOP 221-F-ARP-WX-10-1 (Rev. 0) "OSR 7.6E HI POT TEMP" has incorrect documents listed in the "References" section of the ARP. Both

references incorrectly refer to the 8.5E Continuous Evaporator, instead of the batch evaporator. Additionally, the second reference refers to the starting up, when the Corrective Actions 3.3 directs a "shutdown". This type of error may not be limited to this one ARP and should be verified for similar ARPs.

Facility Recommendations

1. The PRoVOX low D/P alarm for PI-8259 (17.7E , point #24) erroneously displays the word "HIGH" in red on the "17.7 Evaporator" display to indicate an alarmed LOW condition.. This alarm is used in the "CONT177.CAF" tree operator event "OPRRBLOCCSNA#, Operator fails to respond to 17.7E temp., level, or dp alarms (close block valve)". Until the required (PRoVOX) alarm setpoints and descriptions are verified/ validated for the 17.7 Evaporator (and other vessels where the PRoVOX may be relied on instead of panel information), no credit (p=1.0) should be given for these operator alarm response events.

2. Alarm Response Procedures (ARPs) do not exist currently for all OSR-related annunciator/alarms in the Canyon Control Room. Specifically, an ARP is not in the Control Room ARP manual for Panel WV-1A alarm *"OSR 14.8 Cooling Water HIGH Temp"*.

References

[1] WSRC-TR-93-581, Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities (U), Benhardt, H. C., et al., February 1994.
[2] SOP 211-F-1221, Operation of Segregated Solvent Systems Round Sheets, Rev. 10
[3] SOP 221-F-40815, Processing LAW Concentrate, Rev. 3
[4] SOP 221-F-40825, 8.5E Continuous Evaporator Routine Operation, Rev. 5
[5] SOP 221-F-40790, Handling Hot Canyon Sump Solution in Vessel 7.3, Rev. 6
[6] SOP 221-F-40780, Handling Warm Canyon Sump Solution in Vessel 17.5, Rev. 4
[7] SOP 221-F-40506, Second Plutonium Cycle Solvent Extraction Round Sheet, Rev. 15
[8] SOP 221-F-40811, Shutting Down Batch Evaporators 7.6E, 7.7E, and 18.6E, Rev. 3
[10] SOP 221-F-41047, 12.8 Solvent Wash Change, Rev. 6
[11] SOP 221-F-41041, 14.5-2 Solvent Wash Change - First Cycle Down, Rev. 1
[12] SOP 221-F-41043, 14.8 Solvent Wash Change - First Cycle Down, Rev. 2
[13] SOP-221-F-41046, 14.5-1 Solvent Wash Change - First Cycle Down, Rev. 0
[14] SOP W-702002, Pressure Switch, United Electric, Calibration (U), Rev. 8
[15] SOP W-770005, Republic Pneumatic Transmitter, Calibration (U), Rev. 2
[16] SOP W-794001, Transmitter, Differential Pressure, Fischer & Porter/ Moore, Series 50 DP 3000; Calibration (Installed) (U), Rev. 5
[17] SOP W-794007, Ashcroft Series 4000, Pressure Transmitter, Calibration (U), Rev. 1
[18] SOP W-798003, Fischer-Porter Concept 45 Pneumatic Recorder, Calibration (U), Rev. 4
[19] SOP 221-F-40531(S), Transferring 2BP Solution from 9.8 to FB-Line, (Rev. 1)
[20] SOP 221-F-40415, Organic Level Depletion in 18.5 (U) (Rev. 1) (Inactive)
[21] SOP 221-F-40404, Routine Operation of 1CU Continuous Evaporator (Rev. 0) (Inactive)

Fault Trees Reviewed:

[1] BATCHEVI.CAF, 9/15/94, Runaway TBP Reaction in F Batch Evaporator
[2] CONTAQ3X.CAF, 9/14/94, Runaway TBP Reaction in F Continuous Evaporator
[3] CONT93.CAF, 9/16/94, no title
[4] CONT93C.CAF, 9/16/94, no title
[5] CONT177.CAF, 9/16/94, no title

ATTACHMENT 1

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
1 (52)	1	OPRGSPGCKACNA#	Operator fails to verify that 7.6E spg matches that of the feed	comparison of two spg readings at two steps in the procedure	LAW operator	3 spg recorders for: 8.5BT to 7.8 to 7.6E
2 (6)	2	OPRBBLOCCSNA# change to OPRBBLOCDENA#	Operator fails to respond to 7.6E temp. alarm (close block valve)	alarm acknowledgement; intiates "221-F-ARP- WX-10-1"; CRO asks Bldg Op to initiate SOP; (may not need to close this BV every time)	LAW operator & Bldg operator	alarm/ annunciator tile (WX-10-1); manual 3 inch valve in piping corridor; don't dress out
4	3	OPRGBETEMCNA#	Tank Temperature sensor is miscalibrated	whole temp loop cal; yields false low	single E&I tech; ops checks the functionality	sensor in 7.6 tank in Warm Canyon; transmitter on 2nd Level, recorder in CCR
5	4	OPRGPRESMCNA#	Calibration error- Pressure switch for steam gives a false signal		single E&I tech; Ops check;	detector - 2nd Level (on supply to coils); transmitter & recorder- 2nd Level; alarm in CCR
7 (37)	5	OPRG7.8-DEHA# change to OPRG7.8-ACHA#	Operator fails to recognize that too much TBP was transferred	reading spg at tank 7.8 during decanting procedure; he expects & looks for the "break"	LAW operator; SUPVPERM keylock to jet to transfer	CCR panel

TASK #	FEEDBACK/INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
1	none available to direct him to make the comparisons	fails to make comparison	1.0 until fixed; (then change to p=0.005)	10	SOP 221-F-40815; compare steps 5.2.1 & 5.2.3	procedure does not direct a comparison currently
2	alarm/ red light in CCR "OSR 7.6E HI POT TEMP"; in field - rising vlv stem & no position labels; "righty-tighty"; "DIAGNOSIS would include looking at steam flow indicator to see that steam has stopped"	Awareness of what needs to be done; fail to close all the way; CCR Op fails to call Bldg Op when he should have	change to p=0.01	5	SOP-221-F-40811 Step 4.4; then SOP 221-F-20050 Step 4.2.2;) ADD steam flow diagnosis criterion TO THESE PROCEDURES)	fails to shut off steam; Interlock has to have failed- he needs to diagnose this (should get "OSR 7.6E HI POT TEMP" alarm)
3			0.005	10	for Molytek	to check- look for "100C" boiling- can tell of cal is "off"
4			0.005	10	SOP W-794007	not discovered until next calibration; not "anded" w/ freq of cal b/c enabling branch
5	spg meter; graph recorder; conversion from % to sp gr required; equation below recorder	fails to recognize the break	1.0 until added, then p=0.05	5	NO procedure currently for this decanting	procedure to include info on "looking for the spg break"

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
7 (37)	6	OPRG7.8-ACNA#	Operator fails to settle tank contents prior to transferring out	turns off agitator and waits the specified amount of time	LAW operator; Supv may/may not look to see if "settled"	CCR panel
8	7	OPRG7.8-MCNA#	Calibration error- SPG instrument is calibrated to give a false reading		single E&I tech; OPs check	
9 (39)	8	OPR7.8AGACNA#	Operator fails to agitate tank 7.8 prior to sampling	only has "ON" and "OFF" positions; (records 7.8 lab results in the procedure step)	LAW operator	CCR panel
9 (39)	9	OPRGS7.8LANA#	Routine analysis gives false TBP result for tank 7.8		lab analyst; with low dependence supervisor check	772-F lab
9, (15, 24, 33, 39, 48)	10	OPRGOPCOACNA#	Operations violated procedure and continues without lab results	request sample; record results from lab in the procedure; SUPVPERM key switch required to make transfer, so operator won't act alone	LAW operator; Shift supervisor	CCR panel

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
6	spg recorder; conversion required; equation provided	omits procedure step	1.0 until added, then p=0.005	10	NO procedure yet	UNUSUAL CIRCUMSTANCES; "decanting" 7.8 has been done in the past, but it's not usually required (the other actions to prevent organics from reaching 7.8 appear successful)
7	in use operator notices the differences in the 2 tanks spg when none is expected		0.005	10	W-794001 (txm) W-798003 (rcrdr)	actual periodic sample "checks" for spg occur
8	"ON" or "OFF" pushbutton; agitator status indicating lights	fails to perform procedure step	1.0 until added, then p=0.005	10	new assumption to ALWAYS sample 7.8; NO procedure exists for ALWAYS sampling 7.8 (similar to 221-F-40815 Steps 5.5.4, 5.6.2 or 5.4.4)	Procedure exists for sampling 8.5BT sol'n in 7.8 but it doesn't spell out that "agitator must be ON"; procedure exists for "IF INDICATED ORGANIC IN TANK" but not for everytime it's sample
9			0.0003	10	assumptions made without procedure review	
10	transfer panel pushbuttons TEST, START, STOP; status lights & key switch	operator doesn't give complete info on the O/A results to supervisor; supv doesn't verify results w/i range to transfer	1.0 until fixed, then p=0.005	10	221-F-40815 Step 5.5.5; doesn't exist to require to sample 7.8 EVERY TIME	

PAGE #	TASK #	ERRORCODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
10 (40)	11	OPRGS7.8ACNA#	Procedure violation results in no sample being taken for tank 7.8		LAW operator	
10 (16, 25, 34, 40, 49)	12	OPRGNROMCVLA#	Operations fails to recognize/correct omission of sample	verify that vial has liquid sample in it; ensure pressure guages on the sampler are working	sample aisle operator (dressed out, with respirator)	sample aisle
11 (15, 24, 35, 41, 50)	13	OPRGNOTRACNA# change to OPRGNOTRACHA#	Sample not transported to Lab on a timely basis	collects sample bottles in tray; transports them over to Labs	sample aisle operator (dressed out, with respirator)	sample aisle of 221F out to 772-F Labs
11 (15, 24, 35, 41, 50)	14	OPRGLOSEILNA#	Sample accountability error in lab causes loss of sample	proper labeling of sample vial; recording the sample identification in logbooks/ forms	lab tech specialist	in 772-F labs
11 (17, 26, 35, 41, 50)	15	OPRGINSUACHA#	Insufficient sample pulled	Ops has no real way of knowing if insuff. unless Lab alerts/ communicates back to them; then CCR Ops would request an addn'l sample pulled & analyzed	sample aisle operator (dressed out, with respirator)	sample aisle ; would be almost self-correcting by the CCR Op wanting to have the results before proceeding in his SOP

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
11			1.0 until fixed, then p=0.005	10	NO procedural requirement yet to sample 7.8 every time	
12	sampler pressure guage operating; presence of liquid in sample vial	sample aisle op does not notice indication of sampler malfunction	0.005	10	Troubleshooting a Sampler, SOP-38100; Sample Aisle Training Manual (U) SOP-53815 (unapproved)	cannot see vials within all tanks/samplers (only with Warm side Thief Samplers)
13		will wait until collects several different samples before taking all to Lab	0.05	5	assumptions made without procedure review	
14	logbooks or sample request, unique identifier # on "trailer" (chain -of-custody)		0.005	10	assumptions of data and sample accountability made without procedure review	No barcode scanning of labels
15	(As modeled, Lab does not call CCR to say too little sample); BUT if results don't come back from Lab the CCR Op would call Lab looking for them & would repeat request	sample aisle operator doesn't notice that the amount pulled is too little; CRO doesn't notice omission of results & continues	0.05	5	assumptions of data and sample accountability made without procedure review	Lab usually calls to alert CR of problems with sample... here it is assumed that they will not (20% of time)

PAGE #	TASK #	ERRORCODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
12 (42)	16	OPRG7.8IRNA#	Operator incorrectly reads spg display	reads recorder display in %; adds +70; then divides by 100; records on roundsheet	LAW operator	CCR panel
12 (42)	17	OPRG7.8TACHA#	Operator transfers too much organic to the batch evaporator	observes the "Break" in the spg trend	LAW operator	CCR panel
14	18	OPRG175-ACLA# change to OPRG175-ACNA#	Operator fails to settle tank contents prior to transferring out (to 8.7)	event similar to Task #6 above	Rerun operator	CCR panel
14	19	OPRGS175LANA#	Routine analysis gives false TBP results for tank 17.5	similar to #9 above	lab tech	772-F Lab
14	20	OPRG175-MCNA#	Calibration Error- SPG instrumentation is calibrated to give a false reading	event similar to Task #7 above	E&I tech	
15	21	OPRGS175ACNA# change to OPRGS175ACHA#	Procedural violation results in sample not being taken for tank 17.5	very infrequent route (from sump handling)	Rerun operator	CCR
18	22	OPRG175VDEHA# change to OPRG175VACHA#	Operator fails to correct excessive TBP sent to 8.7	similar to event #5 above	Rerun operator	CCR
18	23	OPRG175-IRLA# change to OPRG175-IRNA#	Operator incorrectly reads spg display	similar to event #16 above	Rerun operator	CCR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
16	has to make conversion; formula provided on the display label		0.01	5		more likely to make error in readings than conversions; the different spg meters may have different scales and conversions
17	monitoring for sharp drop in the spg trend	doesn't notice the break (within several minutes it may roll by on the recorder)	1.0 until added, then p=0.005	10	NO procedure exists for 7.8 to 7.6E	
18	spg recorder		1.0 until added, then p=0.005	10	NO procedure exists (but may be similar to SOP-40780)	
19	not a special request		0.0003	10	assumptions made without procedure review	not routine transfer; 17.5 is on sample schedule for O/A
20			0.005	10	x-mitter W-794001, recorder W-798003	not a routine transfer
21			1.0 until added, then p=0.05	5	NO procedure exists; special procedure would have to be written	
28			1.0 until fixed; then p=0.05	5	NO procedure exists for decanting from 17.5 to 8.7	
29			0.01	5		

PAGE #	TASK #	ERRORCODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
18	24	OPRG175TACLA# change to OPRG175TACHA#	Operator transfers too much TBP to 8.7	similar to event #17 above, but here "high" value used because infrequent route	Rerun operator	CCR
19 (44)	25	OPRG11.7CSLA# change to OPRG11.7CSNA#	Operator fails to shut down process (compelling signal)	acknowledge "organic level" alarm; shutdown process	2nd Pu cycle operator	CCR
20 (45)	26	OPRTK906ACNA# change to OPRTK906CSNA#	Operator fails to respond to low level alarm in tank 906	acknowledge alarm; shutdown process	OF-CR operator; 2nd Pu cycle operator	Outside facilities; CCR
20 (45)	27	OPR906LEMCNA#	Calibration error - level instrument is calibrated to give a false reading		single E&I tech ; Op check	Outside facilities
21	28	OPRG-9.8SONA# change to OPRG-9.8ACNA#	Operator fails to turn agitator off after sampling	tank is always unagitated, except during sampling	LAW operator	CCR
21	29	OPRG-9.7CVNA# change to OPRG-9.7VIHA#	Operator fails to visually check sample for solvent	look at sample to see if it appears to have the "solvent" in it; not expected	sample aisle operator (Lab may notice)	sample aisle

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
24	spg requires conversion from % scale to spg	does not notice "break"	1.0 til added, then p=0.01	5		"High" value used because infrequentlu used route
25	few alarms competing for Op's attention	decant process automated	0.01	5	NO ARP; 221-F-40506, App 8.7 Step "11.7 Organics"	infer that it directs to shutdown process if organic can't be transferred out; SOP requires transferring organic elsewhere before it contaminates aqueous stream
26	OF-CR occupied at all times	NOTES containing setpoints need to be fixed for both LOW-LEVEL and LOW LOW-LEVEL alarms	0.5 until fixed (then p=0.01)	5	SOP 211-F-1221 Steps 5.5.1 (LOW), 5.6.1 (LOW LOW-LVL)	(Pump cavitation stops transfer) If no response from Canyon Supervisor, OF will shutdown process within 15 min. (avoid pump cavitation). Credit (0.5) given because of training & alert for pump cavitation
27	at tank 906		0.005	10	W-?????	This could/would be a relative amount instead of an absolute
28	No credit given to sampling; no credit given to detecting large loss of organic	assuming that procedure states "turn off agitator/settle"	0.01	5	SOP 221-F-40531, Step 5.0.6; DCS 9.8 sample procedure	inconsequential B-Line scenario modeled for illustration not contribution
29	separation in "layers" of sample liquid & beading		0.5	2	not told specifically to look for it	Not procedurally controlled and don't expect it/ Lab may or may not report it

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
22 (46)	30	OPRG10.8CSLA# change to OPRG10.8ACNA#	Operator fails to shutdown process (compelling signal)	could not confirm an alarm (ARP) for "organic level"	2nd Pu cycle operator	CCR
23 (43)	31	OPRGTK87ACNA#	Operator fails to empty tank 8.7	typically not emptied	LAW operator	CCR
23 (47)	32	OPRG8.7-MCNA#	Calibration error- spg instrument is calibrated to give a false reading	similar to Tasks #7 & #14 above	E&I tech	
23 (48)	33	OPRGS8.7LANA#	Routine analysis gives false TBP results for tank 8.7	similar to Tasks #9 &18	lab tech & supervisor low dependence check	772-F lab
23 (48)	34	OPR8.7AGACNA#	Operator fails to agitate tank 8.7 prior to sampling		LAW operator	CCR
24 (49)	35	OPRGS8.7ACNA#	Procedural violation results in (NO) sample being taken for tank 8.7	similar to Task #21 above	LAW operator asks sample aisle operator to pull sample	sample aisle
27 (51)	36	OPRG8.7-ACNA#	Operator fails to settle tank contents prior to transferring out (a:proc.)		LAW operator	CCR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
30			0.005	10	NO ARPs exist; SOP 221-F-40506, App 8.10, Nuclear Safety Control "10.8 Organic"	data recorded every hour (or every transfer); INFERS shutdown or x-fer solvent elsewhere.
31	spg getting low on 8.7 to receipt tank	step ommitted in the special procedure or Ops omits doing step	1.0 til fixed (the p=0.005)	10	NO procedure exists; SPECIAL procedure would be written for this scenario	if organic gets in 8.7, it'd be sent on somewhere else to handle the organic
32			0.005	10		
33			0.0003	10		Rountine
34			1.0 til added (then p=0.005)	10	SOP 221-F-40825	Procedure does NOT state to have the agitator ON
35			0.005	10	SOP-40825 , Step 5.4.3.2.1	
36			1.0 til added (then p=0.005)	10	NO procedure exists; 8.7 to 8.5E decanting procedure to be written	

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
27 (51)	37	OPRG8.7TACNA#	Operator transfers too much TBP to continuous evaporator (a: proc.)		LAW operator	CCR
27 (51)	38	OPRG8.7-IRNA#	Operator incorrectly reads spg display	similar to Task #16 above	LAW operator	CCR
28	39	OPRG137-ACLA#	Operator fails to settle tank contents prior to transferring out		Solvent Recovery operator	CCR
28	40	OPRG137-DEHA# change to OPRG137-IRNA#	Operator fails to recognize that too much TBP was transferred	verified by spg "break"; similar to #16 & #38 above	Solvent Recovery operator	CCR
29	41	OPRS12.8ACLA#	Operator fails to settle tank prior to transfer		Solvent Recovery operator	CCR
30	42	OPR12.8-ACHA#	Operator transfers too much organic		Solvent Recovery operator	CCR
31	43	OPRTK128DENA#	Operator fails to diagnose cause of change in spg, level, interface	verify spg; verify interface; verify level	Solvent Recovery operator	CCR
32	44	OPRG138-ACHA#	Operator fails to settle tank contents prior to transferring out	**13.8 to 13.6-1S** transfer;	Solvent Recovery operator	CCR
32	45	OPRG138-ACNA#	Operator fails to check temperature (on 13.6-1S) - transfers too much	only organic & increased temp because only steam jetting?	Solvent Recovery operator	CCR
32	46	OPRG13.8VRHA#	Operator fails to verify temperature reading (on 13.6-1S)	scanning effort to verify temp; not procedurally controlled	Solvent Recovery operator	CCR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
37			1.0 til added (then p=0.005)	10	procedure for decanting does not exist	
38			0.01	5		
39			0.005	10	SOP 221-F-40815, Step 5.4.2	Settle 2 hours
40			0.01	5		
41			0.005	10	SOP 221-F-41047, Step 5.1	done rountinely
42			0.005	10	SOP 221-F-41047, Step 5.12.a	
43	Level on 12.8 (interface, LL, spg) & 13.8 (spg, LL)		Maybe 1.0 until proven; then 0.01	5	Uncertain if Procedure available?	Please VERIFY.....There should be procedural guidance (& training) on how to make this diagnosis
44			0.005	10	SOP 221-F-41047, Step 27; also -41041, Step 4.11; -41043, Step 4.11; -41046, Step 4.9.1	settle 1 hour
45			0.005	10	SOP 221-F-41046, Step 4.9.2	57 degree C
46			0.05	5		"High" because not procedure-driven

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
32	47	OPRG138-MCNA#	Calibration Error - Temp. instrument is calibrated to give a false reading		single E&I tech; with Ops check	
33	48	OPRGS137LANA#	Routine analysis gives false TBP result for tank 13.7		Solvent Recovery operator	CCR
33	49	OPRG137GACNA#	Operator fails to agitate tank 13.7 prior to sampling		Solvent Recovery operator	CCR
34	50	OPRGS137ACNA#	Procedural violation results in no sample being taken for 13.7		Solvent Recovery operator	CCR
36	51	OPRG137-MCNA#	Calibration Error- SPG instrument is calibrated to give a false reading			
36	52	OPRG137-IRNA#	Operator incorrectly reads the spg display		Solvent Recovery operator	CCR
36	53	OPRG137TACHA#	Operator transfers too much organic to 7.8 (proc. violation)		Solvent Recovery operator	CCR
43 (46)	54	OPRLV906AONA#	Operator fills tank 906 (Level procedurally controlled)	Implies an inventory control at regular intervals at various points in the cycle	2nd Pu cycle operator and OF Operator	CCR and Outside Facil. CR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
47			0.005	10		
48			0.0003	10		
49			0.005	10	SOP 221-F-41046, Step 4.11; -41043, Step 4.13; -41047, Step 5.33; - 41041, Step 4.14	
50			0.005	10	same procedure steps as Task #50 above	
51			0.005	10		
52			0.01	5		
53			0.005	10	SOP 221-F-40815	
54			re-modeled with various HEPs		this event needs to be further developed & modified to include (events to the right):	the first response (2nd Pu cycle operator shuts down cycle); LAW operator shuts down evaporator; and maybe Solvent Recovery operator troubleshooting if Solvent recovery cycle is involved

PAGE #	TASK #	ERRORCODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
53	55	OPRBESPGACNA# change to OPRBESPGACHA#	Operator fails to take a spg reading in the evaporator prior to startup (heat)		LAW operator	CCR
53	56	OPRGSPG-MCHA#	Calibration error - spg instrumentation gives a false LOW reading		one E & I technician; with Ops check	Transmitter - 2nd Level; recorder -4th Level

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
55			0.05	5		Not called out in SOP that spg must be greater than 1.1 or 1.0; SOP 221-F-40815 may infer spg comparison
56			0.005	10		

ATTACHMENT 2

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
		NEW BRANCH EVENTS SPECIFIC TO THIS TREE				
3	1	OPR-VOL-IRNA#	Operator incorrectly reads flow or level indication	"flow" read on "8.5E HAT level; level on 8.5E	LAW CCR op	use recorders WZ-18 & WZ-19
3	2	OPR-PMP-DENA#	Operator incorrectly diagnoses pump speed	HAT level (=flow), 8.5E Level, and pump (s) RPM	LAW CCR op	WZ-30 (for one of the pumps)
3 (5, 7)	3	OPRCELE-MCNA	Calibration error- Level instrument is calibrated to give a high signal	(8.5E level? it can't be too far off because the evap overflows at a known level.)	E&I techn with Operations check	x-mitter & recorder (WZ-19)
3	4	OPRPUMPAVRNA#	Operator fails to verify spg level, and flow readings (self check**)	8.5E spg, 8.5E level, HAT "flow"/level	LAW operator, CCR	WZ-26 (8.5E level, 8.5E spg (WZ-19), HAT level/flow (WZ-18) or WZ-24 (controllers)
4	5	OPRGCSPGMCNA#	Calibration error- spg instrumentation gives false low reading		E&I techn with Operations check	x-mitter - 2nd Level; recorder (WZ-19)
6	6	OPRCEHATMCNG#	Calibration error- level instrument is set to give a high signal		E&I techn with Operations check	x-mitter - 2nd Level; recorder (WZ-19)
10	7	OPRGCETEMCNA# consider change to OPRGCETEIRNA#	Evaporator temperature sensor is out of calibration		E&I techn with Operations check	Molytek

TASK #	FEEDBACK/INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
1		misreads recorder line	0.01	5	Roundsheet, SOP-221-F-40825	
2	HAT (WZ-18) uses square-root scale & paper chart is read directly; most others use scale marker at rgt side of recorder	may read wrong scale (other scale is still physically present & "SQR RT" is written in pen)	0.01	5	Roundsheet, SOP-221-F-40825	recorder scale unit (square root) should not be "temporarily" labeled on glass with pen
3			0.005	10	W-770005 (x-mitter); W-798003 (recorder)	
4	assumes good layout of instrumentation & procedure-driven	Omits step(s) in roundsheets	0.5 until fixed, then 0.01	5	SOP 221-F-40825 Att 7.1 (hourly readings)	SOP 221-F-40825 should have "lower limits" written in for 8.5E True Level & 8.5E sp gr, and others as appropriate
5			0.005	10	8.5E spg; transmitter W794001; recorder W798003	
6			0.005	10	transmitter W794001; recorder W798003	
7			consider p=0.01; else 0.005	10	Molytek	Molytek may be a non-calibratable IPI; event may need to be re-modeled (as a programming data entry error? p=0.01).

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
12, (13)	8	OPRGCPRSMCNA#	Calibration error- pressure switch for steam gives a false signal		E&I techn with Operations check	x-mitter - 2nd Level; recorder - CCR, switch-?
30	9	OPRCESPGIRNA#	Operator fails to realize that spg reading has dropped (continues to evaporate)	STE assumption: the spg "break" may not be present in the Continuous evaporator... but if running at normal densities, you'd get the "break".	LAW operator, CCR	8.5E sp g?; WZ-19 recorder
30	10	OPRCESPGDENA# change to OPRCESPGDEHA#	Shift technical engineer fails to diagnose cause of low reading	assume: reviews roundsheets once per shift (no signoff)	Shift Technical Engineer	
30	11	OPRCESPGACNA#	Operator fails to take continous evaporator spg readings	take 8.5E rounds hourly	LAW operator, CCR	8.5E sp gr (WZ-19), CCR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
8			0.005	10	recorder W798003; switch W702002; transmitter W794007	
9			0.01	5	NO procedure exists to direct Op to observe break	assumes good quality graphical display
10	not physically present in CCR at all times	look at other cycle problems; 906 losing level suddenly; 14.7 losing level suddenly; other indications of organic losses	0.1	3	no procedural sign-off	Typically would be flagged by Op; STE may first assume it to be an instrument problem (e.g. air leaks and TBP excess mimic each other)
11	"min. spg" limit not listed on Att 7.1	omits reading	0.005	10	SOP 221-F-40825, Att 7.1 Data Sheet	Data Sheet should have Min. Limit for item #9 "8.5E True Level" & #10 "8.5E Sp Gr"

ATTACHMENT 3

PAGE #	TASK #	NEW BRANCH	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
		EVENTS SPECIFIC TO THIS TREE				
14	1	OPR147LEMCNA#	Calibration error - Level instrument is calibrated to give a false reading -14.7		E&I technician	transmitter; recorder
14	2	OPRRA147ACNA# change to OPRRA147CSNA#	Operator fails to respond to low level in tank 14.7	same event as in 17.7E tree	solvent recovery operator, CCR	
15	3	OPR904LEMCNA#	Calibration error- 904 level instrument is calibrated to give a high signal		E&I technician	
15	4	OPRRA904ACNA# change to OPRRA904CSNA#	Operator fails to respond to low level alarm in tank 904		Outside Facilties operator	Outside Facilities CR
16	5	OPRQ73--ACLA# change to OPRQ73--ACNA#	Operator fails to settle tank contents prior to transferring out	(transfers 7.3 to 8.3)	HAW/Rerun operator	CCR
16	6	OPRQ73--MCNA#	Calibration error- spg instrument is calibrated to give a false reading		E&I technician	
16	7	OPRQS73-LANA#	Routine analysis gives false TBP results for tank 7.3		Lab tech specialist; low dependence Supv check	772-F Labs

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
1			0.005	10	SOP W-794001 (transmitter); W-798003 (recorder)	
2	annun tile and orange status light for "14.7 Lo Level" WS-23) (WT-1A)		1.0 until added; then 0.01	5	NO ARP exists (there were & may still be operator aids on the panel boards that indicate wgt ftr when pump loses prime)	
3			0.005	10		
4			0.5 until Notes fixed; then 0.005	10	SOP-211- F-1221, Steps 5.5.1 & 5.6.1	NOTES are mispositioned at these steps; typo left out critical piece of info & makes them unclear & inaccurate
5			0.005	10	SOP 221-F-40790, Step 5.4.1	currently IMPLIED Off; should add step to" ENSURE agitator is off" before settling
6			0.005	10	assumptions made without procedure review	
7			0.0003	10	assumptions made without procedure review	

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
16	8	OPR73-AGACNA#	Operator fails to agitate tank 7.3 prior to sampling		HAW/Rerun operator	
17 (22, 30)	9	OPRQOPOCOACNA#	Operations violates procedure and continues without lab results	similar to event in other tree	HAW	CCR
17	10	OPRQS73-ACNA#	Procedural violation results in no sample being taken for tank 7.3		HAW operator	CCR
17	11	OPRQNROMCVLA#	Operations fails to recognize/ correct omission of sample	similar to event in other tree	sample aisle operator (dressed out); HAW	sample aisle
18 (23, 31)	12	OPRQNOTRACHA#	Sample not transported to lab on a timely basis	similar to event in BATCH tree	sample aisle operator (dressed out/respirator)	sample aisle
18 (23, 31)	13	OPRQLOSEILNA#	Sample accountability error in lab causes loss of sample	similar to event in other tree	Lab specialist	772-F Labs
18 (23, 31)	14	OPRQINSUACHA#	Insufficient sample pulled	similar to event in other tree	sample aisle operator (dressed out/ respirator)	sample aisle
19	15	OPRQ73-VDENA# change to OPRQ73-VDEHA#	Operator fails to correct the excessive TBP sent to 8.3	DOESN'T REALLY CORRECT IT PER SE; FLAGS IT & INFORMS SUPERVISOR; SEPTECH WRITES SPECIAL PROCEDURE	HAW	CCR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
8			0.005	10	SOP 221-F-40790, Step 5.2.5	
9			0.005	10	SOP 221-F-40790, Steps 5.2.7, 5.2.8.b, 5.2.8.c, 5.2.8.d	
10			0.005	10	SOP 221-F-40790, Step 5.2.6	
11	sampler pressure guages; presence of liquid in vial	sample aisle operator doesn't notice indication of sampler malfunction	0.005	10	"Troubleshooting a Sampler", SOP-38100	
12		may wait until several samples collected because of IH and RC surveys	0.05	5	assumptions made without procedure review	
13	logbooks or sample request, unqiue identification # on chain-of-custody papers		0.005	10	assumptions made without procedure review	
14	Lab does not communicate insufficient sample, as modeled for this scenario)		0.05	5	assumptions of sample accountability made without procedure review	
15	spg recorder, agitation (or lack), gang valve failure		0.1	3	not proceduralized; must admit to error to avoid passing it downstream	"High" used because Op must admit to error; procedure exists for decanting 7.3 to 8.3

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
19	16	OPRQ73--IRNA#	Operator incorrectly reads spg display		HAW	CCR
19	17	OPRQ73-TACLA#	OPR transfers too much TBP to 8.3 - doesn't watch transfer		HAW	CCR

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
16	spg recorder		0.001	5		
17	"break" in spg trend		0.005	10	SOP 221-F-40790, NOTE before Step 5.4.6	

ATTACHMENT 4

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
		ONLY EVENTS IN BRANCH (GE-CE-SOLV-R) ARE DIFFERENT FROM OTHER TREES:				
12	1	OPRRCLN-ACNA#	Failure to clean (empty) 18.5 at specified interval	emptied every 4 months to remove organics; divert away from 17.7 evap	2nd U Cycle operator	receives Operations "Tickler # 22"
13	2	OPRRESPGIRNA#	Operator fails to realize that spg reading has dropped (continues to evaporate)	look for spg "break"	2nd U Cycle operator	spg recorder
13	3	OPRRESPGACNA#	Operator fails to take continuous evaporator spg readings	perform rounds	2nd U Cycle operator	spg recorder
13	4	OPRRESPGDENA# change to OPRRESPGDEHA#	Shift technical engineer fails to diagnose ("correct") cause of low reading		STE	
14	5	OPRRCSPGMCNA#	Calibration error- spg instrumentaion gives a false low reading		E&I technician	
15	6	OPRRA147ACNA# change to OPRRA147CSNA#	Operator fails to respond to low level alarm in tank 14.7	same event as in 9.3E tree	Solvent Recovery CCR operator	

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
1	admin control "tickler"	omits doing procedure (or tickler omission)	0.005	10	SOP 221-F-40415, Step 4.6	
2	"break" or drop in spg		0.01	5	No procedure exists	
3	hourly	omits reading	0.005	10	SOP 221-F-40404, Attachment 5.1, "SP Gr" Column	
4	might be told of suspicious reading by CRO or review of Op's logs	doesn't ask Op; considers equipment malfun. as only cause; "cognitive tunnelvision"	0.1	3	No formalized (proceduralized) review of logbooks	Use "high" value because STE not present in CCR at all times; must rely on communications from CRO & own training & knowledge of the plant
5			0.005	10		
6	on WT panel, annun tile and orange status light, "14.7 Lo Level WS-23" (WT-1A)	There were/ are? signs on the panelboard that indicated when the 14.7 pump lost prime	1.0 until added; then p=0.0.1	5	Although Solv. Recov. operator has an alarm to repond to there is NO ARP, SOP or AOP to direct his action for grosss solvent loss	Training is not set up to look for GROSS LOSS OF SOLVENT scenario

PAGE #	TASK #	ERROR CODE	ERROR DESCRIPTION	ACTION INVOLVED	OPERATOR (ACTOR)	EQUIPMENT
15	7	OPR147LEMCNA#	Calibration error - level instrument is claibrated to give a false reading-14.7		E&I technician	
1 5	8	OPRTK147ACNA#	Operator fills tank 14.7 (Level procedurally controlled)		Solvent Recov. operator; Engineering can specify quantity of solvent to add if inventory appears low	

TASK #	FEEDBACK/ INDICATION	ERRORS	HEP	EF	PROCEDURE	NOTES
7			0.005	10	W-794001 (trxm) W-798003 (recorder)	
8			1.0 until added; then p=0.005	10	several procedures exist to address daily solvent inventory control & perhaps chronic loss of solvent; NO procedures exist for acute and gross loss of solvent... need AOP-type control	SEPTECH may actually specify the wrong amount to the CRO; IMPLIES inventory control accountability process needed (to avoid GROSS SOLVENT LOSS)

ATTACHMENT 5

Dependence Between Operator Events by Trees

BATCH (7.6E) tree

The primary operations duties in the BATCH tree are performed by the LAW operator and the Solvent Recovery operator. On occasion, these two duties may be performed by a single operator. All events below

OPR event couplings	Level	p=?	Operator
OPRTK128DENA#, OPRG138-ACNA#, OPR12.8-ACHA# &OPRG137TACHA# (may transfer too much to 13.8 & on to 13.7 - inattention)	HD	0.5	Solvent Rec.
OPR12.8-ACHA# and OPRTK128DENA# (may transfer too much b/c inattentive & misses diagnosis too)	HD	0.5	Solvent Rec.
OPRS12.8ACLA# and OPRG138-ACHA# (not settle first tank, may increase prob. of not settle second)	CD	1.0	Solvent Rec.

CONTAQ3X.CAF (8.5E) tree

The primary operations duties in the 8.5E tree are performed by the LAW operator and the 2nd Pu cycle operator. Because of the attention demands on the 2nd Pu cycle operator when the cycle is up and running, the two positions are not usually shared by a single operator.

OPR event couplings	Level	p=?	Operator
ORG11.7CSLA# & OPRLV906ACNA#	MD	0.15	2nd Pu
OPR8.7AGACNA# & OPRPUMPAVRNA#	HD	0.5	LAW
OPRG8.7-ACNA# & OPRPUMPAVRNA#	HD	0.5	LAW
OPR175AGACNA# & OPRPUMPAVRNA#	MD	0.15	HAW(Rerun)/LAW

ATTACHMENT 5, (Cont.)

Dependence Between Operator Events by Trees

CONT9.3.CAF tree

The primary operations duties in the 9.3E tree(s) are performed by the HAW and Solvent Recovery operators. Additional human error events involve lab technicians, sample aisle, and Outside Facilities operators.

OPR event couplings	Level	p=?	Operator
OPRTK147ACNA# & OPRQESPGACNA# (HAW expects SR to do inventory control correctly)	HD	0.5	HAW/SR
OPRTK147ACNA# & OPRQESPGIRNA# (HAW expects no excess solvent, so overshoots "break")	HD	0.5	SR/HAW
OPRTK904ACNA# & OPRQESPGACNA#	MD	0.15	OF/HAW
OPRQ8.3-IRNA# & OPRQBLOCCSNA# (if incorrectly reads spg, won't expect alarms)	HD	0.5	HAW
OPRQLOSEILNA# & OPRQOPCOACNA#	MD	0.15	SR/Lab
OPRTK904ACNA# & OPRQESPGIRNA# (HAW expects no excess solvent, so overshoots "break")	HD	0.5	OF/HAW

CONT17.7.CAF tree

The primary operations duties in the 17.7E tree are performed by the 2nd U Cycle and Solvent Recovery(SR) operators. An additional human error event involves the Shift Technical Engineer (STE).

OPR event couplings	Level	p=?	Operator
OPRRESPGDENA# & OPRTK147ACNA#	HD	0.5	STE/SR
OPRTK147ACNA# & OPRRESPGACNA# (2nd U operator expects SR to control inventory correctly)	HD	0.5	SR/2nd U
OPRTK147ACNA# & OPRRESPGIRNA# (HAW expects no excess solvent, so overshoots "break")	HD	0.5	SR/2nd U
OPRCLN--ACNA# & OPRBLOCCSNA# (thinks 18.5 is clean & doesn't expect TBP & investigates instrumentation failure)	MD	0.15	2nd U
OPRTK147ACNA# & OPRRA147ACNA#	MD	0.15	SR

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