JAN 20 2000
STA#4

(4)

ENGINEERING DATA TRANSMITTAL

1. EDT 622288

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) M. V. Shultz, Fluor Federal Services	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Spent Nuclear Fuel	6. Design Authority/ Design Agent/Cog. Engr.: L. A. Rodgers	7. Purchase Order No.: N/A
8. Originator Remarks:		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks: 11A. Design Baseline Document? [] Yes [X] No		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	SNF-5569	N/A	0	Probability of Potential Multicanister Overpack Loading Systems Drop of Proof Load in the K West Basin South Loadout Pit	S	1,2	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
		Design Authority	1	1	Risk Analyst M.V.Shultz B4-47 *milton V. Shultz* 1/18/00
		Design Agent			
1	1	Cog.Eng. L.A.Rodgers X3-85 *[signature]* 1/20/00			
1	1	Cog. Mgr. R.L.Garrett R3-26 *Ralph Crown for RLG* 1/20/00			
		QA N/A			
1	1	Safety B.S.Lew X3-79 *[signature]* 1/20/00			

18. *milton V. Shultz* M.V.Shultz Signature of EDT Originator Date 1/18/00	19. *Ralph C for RLG* R.L.Garrett Authorized Representative for Receiving Organization Date 1/20/00	20. *[signature]* 1/20/00 R.L.Garrett Design Authority/ Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

BD-7400-172-1

Probability of Potential Multi-Canister Overpack Loading System Drop of Proof Load in the K West Basin South Loadout Pit

M. V. Shultz
Fluor Federal Services, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 622288
Org Code: 403
B&R Code: EW31300000
UC: 620
Charge Code: 105350/CB80
Total Pages: 43

Key Words: Spent nuclear fuel, crane drop, multi-canister overpack (MCO), load drop, K Basin, probability

Abstract: This document presents the results of a probabilistic analysis of the potential for load drop during the load test of the K West Basin South Loadout Pit Gantry. The calculations are in support of the cask loading system (CLS) subproject load test of the gantry.

1/20/00

Release Approval Date

JAN 20 2000
DATE
STA: 4
HANFORD RELEASE
ID: 4

Release Stamp

Approved for Public Release

PROBABILITY OF POTENTIAL MULTI-CANISTER OVERPACK LOADING SYSTEM DROP OF PROOF LOAD IN THE K WEST BASIN SOUTH LOADOUT PIT

M. V. Shultz, Jr.
Fluor Federal Service, Inc.
Richland, Washington

January 2000

This page intentionally left blank.

CONTENTS

LIST OF FIGURES

APPENDICES

This page intentionally left blank.

LIST OF TERMS

BHEP	basic human error probability
MCO	multi-canister overpack
MLS	MCO Loading System
PLC	Programmable Logic Controller
FRS	Fuel Recovery System
SAR	safety analysis report

This page intentionally left blank.

PROBABILITY OF POTENTIAL MULTI-CANISTER OVERPACK LOADING SYSTEM PROOF LOAD DROP IN THE K WEST BASIN SOUTH LOADOUT PIT

1.0 PURPOSE AND OBJECTIVES

The purpose of this calculation note is to document the probabilistic calculation of the per lift potential for drop of a test load by the Multi-Canister Overpack (MCO) Loading System (MLS) during load testing at the K West Basin south loadout pit. The MLS subproject needs to load test the MLS in the K West Basin south loadout pit. To perform this test, a basket mockup weighing approximately 4,500 lb (125% of a fully loaded MCO basket accounting for water displacement) needs to be used for one or more load tests. The test load will comprise a standard basket lifting attachment with several ring-shaped steel segments to provide the required weight. The test load will exceed the *K Basin Safety Analysis Report* (WHC-SD-WM-SAR-062) (SAR) allowances for load drop in the K West Basin south loadout pit. This probabilistic calculation will be used as part of the basis for seeking U.S. Department of Energy approval to use an MLS test weight that exceeds SAR allowances.

2.0 SUMMARY OF FINAL RESULTS AND CONCLUSIONS

The point estimate value calculated for the probability of potential MLS test load drop in the south loadout pit is 1.1×10^{-6} per load test. A load test is defined as the lift by the MLS of the test load from the Fuel Recovery System (FRS) shuttle, movement of the test load to the MCO loading position, lowering of the test load into the MCO, and reversal of this process with return of the test load to the FRS shuttle. The probability of 1.1×10^{-6} per lift is approximately a factor of 25 smaller than the midpoint of the crane load drop failure data provided in NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants*.

The dominant contributors to the load drop probability are the potential random failure of the MLS support structure, the MLS structure, and the grapple structure. The failure of the load locking rod lift cylinder air valve coupled with the failure of the locking rod locking pawl also has a similar probability of failure to the random structural failures.

The potential for external influences causing a load drop is also present. Basin crane impacts with the MLS and cask transport vehicle impacts with the MLS support structure during the load test need to be prevented. This can be accomplished with appropriate procedural controls and planning.

3.0 METHODOLOGY

Fault tree analysis is used to calculate the probability of a potential MLS test load drop in the K West Basin south loadout pit. The fault tree logic represents the failures required before a potential drop by the MLS could occur in the K West Basin south loadout pit. The fault tree model is based on the physical layout detailed in NAC International, Inc. drawings 101 (sheets 1, 2, and 3), 201, 210, and 211. This information is also shown on Hanford drawing H-1-84031, *Grapple Support Stand South Load-out Pit Plan and Details.*

4.0 ASSUMPTIONS

The following assumptions were used in the development of the fault tree logic and failure probabilities used in this calculation note.

1. The basic human error probability (BHEP) used in the fault tree to represent an operator error is 0.03. This value is documented in NUREG/CR-4772, *Accident Sequence Evaluation Program Human Reliability Analysis Procedure* (step 6 in Table 4-1, page 4-3).

2. The Programmable Logic Controller (PLC) that manages the operation of the MLS can fail in ways that would cause a load drop.

3. A single failure of the MLS support structure, MLS structure, lifting screw, or lifting grapple will result in a drop of the test load.

4. The test load will not spuriously disassemble based on the interlocking ring configuration of the steel weight segments.

5. The probability of test load hangup in the MCO during testing is negligible based on the fact that the test load is 2 in. smaller in diameter than a standard MCO fuel basket. However, test load hangup is assumed to be credible if the MLS is moved while the test load is being lifted from the MCO.

6. MLS structure failure probability due to material defect and/or fatigue is assumed to be 1.0×10^{-7} per lift. Navy crane failure data from NUREG-0612 indicate a low-end failure probability per lift of 2.5×10^{-5} (NUREG-0612, page 4-3). NUREG-0612 also indicates that, for non-inspected components with design factors of two, the probability of failure can be reduced by a factor of 0.1. If the design factor is four (not atypical for load carrying equipment), then the probability of failure could be reduced by a factor of 0.01. This would yield a failure probability of 2.5×10^{-7} per lift. Since the equipment is newly manufactured and tested, the value was reduced to 1.0×10^{-7} per lift.

7. MLS support structure (structure permanently located in the south loadout pit area) failure probability due to material defect and/or fatigue is 1.0×10^{-7} per lift. This assumption is based on the reasons listed in assumption 6.

8. MLS grapple structure failure probability due to material defect and/or fatigue is 1.0×10^{-7} per lift. This assumption is based on the reasons listed in assumption 6.

9. Loss of electrical power is not considered a significant initiator because the control system and design of the MLS are fail-safe under loss of power.

10. The MLS mast servo motor resolver, limit switches, and brake are tested just before the start of the load testing.

11. The MLS and grapple assembly have been tested to 150% of design capacity by the company that constructed the equipment before installation at the K West Basin. This testing provides assurance that the system is capable of performing the 125% load test, which would leave only random structural and operational failures as initiators of a test load drop.

12. "Free wheeling" of the MLS mast screw ball nut, when the test load is latched to the MLS grapple, can produce drop velocities sufficient to cause significant damage to the south loadout pit.

13. "Free wheeling" of the MLS mast screw ball nut is not credible unless the drive motor is decoupled from the mast screw ball nut.

14. The MLS grapple will not disengage from the test load unless air pressure is applied to the grapple air cylinder, the manual unlatching bail is actuated, or the grapple suffers a catastrophic structural failure.

15. Partial grapple lock ball engagement that would allow lifting the test load and creating the potential for a subsequent load drop has such a low probability that it does not have to be considered. Visual evidence is available through a slot in the grapple structure where the lock rod can be observed to verify that the lock rod has slid into the fully engaged position before a load is lifted.

16. A single load test will take 2 h to perform. A load test is defined as the lift by the MLS of the test load from the FRS shuttle, movement of the test load to the MCO loading position, lowering of the test load into the MCO, and reversal of this process with return of the test load to the FRS shuttle.

17. Correct calibration of the horizontal motion hard stops has occurred before this test takes place. This validates the assumption that the positioning of the MLS for load pickup from the shuttle and lowering into the MCO is sufficiently accurate to prevent inadvertent hooking of the grapple manual unlatching bail unless other failures occur.

5.0 INPUT DATA

This section describes the failure data used in the fault tree logic, that is described in Section 6.0, "Calculations," and presented graphically in Figure 1.

Event AIRVLVF is a failure of a solenoid air valve to operate on demand. The failure probability for the ball nut brake air release valve (brake is designed to be engaged when air pressure is removed) is assumed to be represented by the failure probability of a solenoid valve to open on demand, which is 3.0×10^{-3} per demand (DP-1633, page 38).

Event AIRVALVF is a spurious failure of the locking pin air cylinder air valve that causes the lift side of the air cylinder to become pressurized. This results in the withdrawal of the locking rod if it is not restrained and a subsequent drop of the test load. The failure rate of a solenoid valve to spuriously operate is given as 5.0×10^{-7}/h (WSRC-TR-93-262, page 20). The test duration is assumed to be 2 h.

Event BAILHOOK is the probability of the grapple manual unlocking bail hanging up on a projection in the south loadout pit when the test load is lowered in a location other than over the FRS shuttle or the MCO. The conditional probability is set to 1.0. This event is modeled to allow evaluation of the fact that unintentional operation of the manual load release may not be a certainty for every mispositioned load condition.

Event BELTFAIL is the failure of the ball nut drive belt. The Reliability Analysis Center of the U.S. Department of Defense in publication NPRD-95, *Nonelectronic Parts Reliability Data 1990*, indicates that drive belt failures occur at a rate of 3.88×10^{-6}/h. The test duration is assumed to be 2 h.

Event BRAKCFAL is a failure of the mechanical ball nut brake to operate on demand. Brake failure data from the Savannah River failure data compilation (DP-1633, page 11) range from 4.0×10^{-6}/h to 1.0×10^{-5}/h. Conservatively assuming 10,000 h/yr, the brake would fail with an upper probability of $(1.0 \times 10^{-5}/h)\ (10{,}000\ h) = 1.0 \times 10^{-1}$. Assuming the brakes were applied 100 times per year, the demand failure would be 1.0×10^{-1} per 100 demands, or 1.0×10^{-3} per demand. This value compares well with the solenoid brake failure probability on demand (DP-1633, page 38), so 1.0×10^{-3} is used to represent the failure probability of the mechanical ball nut brake per demand.

Event BRSENFAL is the failure of the ball nut drive belt tensioning transducer given that a drive belt failure has occurred. The failure rate for the drive belt tensioning transducer is assumed to be represented by the failure rate of position sensors. NPRD-95 indicates that position transducer failure occurs at a rate of 1.54×10^{-5}/h. The test duration is assumed to be 2 h.

Events GANTSTRU, GRAPSTRU, and SUPSTRUC are failures of the MLS structure, grapple structure, and MLS support structure, respectively. These are mechanical component failures. Navy crane failure data from NUREG-0612 indicate a low-end failure probability per lift of 2.5×10^{-5} per lift (NUREG-0612, page 4-3). NUREG-0612 also indicates that, for non-inspected components with design factors of two, the probability of failure can be reduced by a factor of 0.1. If the design factor is four (not atypical for load carrying equipment), then the probability of failure could be reduced by a factor of 0.01. This would yield a failure probability of 2.5×10^{-7} per lift. Since the equipment is newly manufactured and tested, the value was reduced to 1.0×10^{-7} per lift. The load test will consist of several lifting and lowering actions, but the MLS will not be unloaded until the test weight is returned to the FRS shuttle. Therefore, one lift per load test is defined as having occurred.

Events LCFAIL1, LCFAIL2, and LCFAIL3 are the random failure of the MLS load cells given a load hang-up has occurred. A failure of any one of the load cells is assumed to prevent the PLC from shutting down the ball nut drive motor from an overload condition. NPRD-95 indicates that strain gauge load transducer failure occurs at a rate of 1.2×10^{-5}/h. The test duration is assumed to be 2 h.

Event LOADHANG is a random PLC error that leads to hang-up of the test load while being lifted out of the MCO. The PLC is postulated to spuriously initiate horizontal movement of the MLS at the same time that the test load is being lifted out of the MCO. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of $\sim 1.0 \times 10^{-8}$/h. The test duration is assumed to be 2 h.

Event LSCOMMON is included in the fault tree model to account for common cause (or mode) failures of the mast full-up limit switches. The approach used is the beta factor method (NUREG CR-2300, page 3-90). In this method, the beta factor is multiplied by the failure rate of the redundant component to provide an estimate of the common cause failure rate. Beta factors normally range between 0.01 and 0.1. A beta factor of 0.1 was chosen as a conservative screening value. The probability of a limit switch failing to open or close on demand is 3.0×10^{-5} per demand based on EGG-SSRE-8875, *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs* (page 22). The failure rate for event LSCOMMON is therefore 3.0×10^{-6} per demand.

Events LS1FAIL and LS2FAIL are the independent random failures of the MLS mast limit switches to stop upward movement of the mast before the grapple attachment structure "hard stops." This is assumed to result in failure of the screw attachment to the grapple and a subsequent drop of the test load. Since the limit switches are assumed to be tested before the load test, the failure of these limit switches over time will be detected before the test lift is performed. Thus the dominant failure mode of the limit switch is a failure to open or close on demand. The probability of a limit switch failing to open or close on demand is 3.0×10^{-5} per demand based on EGG-SSRE-8875, *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs* (page 22).

Event MSHUTOFF is an operator error that leads to failure to recognize mispositioning of crane and actuate manual shutdown when PLC failure causes the test load to be lowered in an incorrect location. As indicated in Section 4.0, "Assumptions," the BHEP used for operator error is 0.03.

Event OPFAIL is the failure of the operator to recognize that the MLS has stopped at a position that does not line up with the MCO or the FRS shuttle and manually requests the PLC to lower the test load. As indicated in Section 4.0, "Assumptions," the BHEP used for operator error is 0.03.

Event PLCFAIL0 is the random failure of the PLC to respond to an overload signal from a load transducer given that an overload condition exists. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of $\sim 1.0 \times 10^{-8}$/h. The test duration is assumed to be 2 h.

Event PLCFAIL2 is the random failure of the PLC that causes the controller to actuate the locking rod air piston to withdraw the locking rod, resulting in unlatching and dropping the test load. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of about 1.0×10^{-8}/h. The test duration is assumed to be 2 h.

Event PLCFAIL3 is the random failure of the PLC that causes the MLS mast to be driven to the up position "hard stop" point, resulting in a lift screw failure and subsequent load drop. Included in this event is failure to correctly calculate the position from the resolver input and failure to shut down the drive motor when the position is correctly calculated. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of $\sim 1.0 \times 10^{-8}$/h. The test duration is assumed to be 2 h.

Event PLCFAIL4 is the random failure of the PLC that results in the horizontal positioning of the MLS in an incorrect position to lower a basket to the FRS shuttle or MCO. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of $\sim 1.0 \times 10^{-8}$/h. The test duration is assumed to be 2 h.

Event PLCFAIL5 is the random failure of the PLC that results in the PLC spuriously lowering the test load before it is in position over the FRS shuttle or MCO. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of $\sim 1.0 \times 10^{-8}$/h. The test duration is assumed to be 2 h.

Event PLCFAIL8 is the random failure of the PLC to respond to a ball nut drive belt failure signal from the belt tensioning transducer given that a drive belt failure has occurred. A PLC failure is assumed to be equivalent to microcircuit failure (INSPEC 1981, page 92), which has a failure rate of $\sim 1.0 \times 10^{-8}$/h. The test duration is assumed to be 2 h.

Event RESOFAIL is the failure of the servo motor resolver to provide accurate position information to the PLC, which results in the MLS mast "hard stopping" as it is moved to the up position. This is assumed to result in failure of the screw attachment to the grapple and the subsequent drop of the test load. NPRD-95 indicates that resolver failure occurs at a rate of 1.14×10^{-7}/h. The test duration is assumed to be 2 h.

Event RODLOCKF is the failure of the load locking pin locking pawls to prevent the withdrawal of the locking pin when the locking pin air cylinder or manual unlocking bail are inadvertently actuated. The capability of the locking pawls to prevent the air cylinder from lifting the load locking pin has been verified by factory testing. "Estimating the Exponential Failure Rate from Data with No Failure Events" (Welker and Lipow 1974) provides a basis for estimating a failure rate based on data showing no failures. Using this technique, a failure rate of 0.1 could be obtained with as little as four tests with no failures. A failure rate of 0.1 per demand is applied to this event based on the assumption that several pawl tests have been performed successfully.

Event SCRWMATF is the failure of the MLS mast lift screw due to material defect or design error. NPRD-95 indicates that automotive axle failure occurs at a rate of 1.6×10^{-8}/h. Although the lift screw is not identical to an automotive axle, the characteristics of an automotive axle operating under conditions of shock loading and varying stresses make it a good candidate to represent the failure characteristics of the lift screw. The test duration is assumed to be 2 h.

Event SETPOINT is the failure of the operator to set the overload setpoint to the correct value, which allows an overload condition to cause a test load drop. As indicated in the Section 4.0, "Assumptions," the BHEP used for operator error is 0.03. The BHEP is multiplied by an additional 0.01 to take credit for procedural steps that require a work package be developed to reset the load cell setpoints and a requirement to get a key from the shift manager for access to the controller to execute the work package. Thus the probability of event SETPOINT is 3.0×10^{-4}.

Events XPERROR1, XPERROR2, XPERROR3, AND XPERROR4 are included in the model to account for external events that may result in test load drop. These events are important because appropriate procedural controls need to be implemented to ensure that they do not dominate the drop probability.

- XPERROR1 is the movement of the basin crane to a position that interferes with the MLS during the load test. This event is assumed to be composed of an error in planning that allows the basin crane to be operated and a failure in the planning review process to identify the fact that the crane should not be operated in the south loadout pit area during the MLS load test. A probability of 0.03 is assigned to the planning error, and a probability of 1×10^{-2} is assigned to the failure of the review process to identify the error resulting a composite probability of 3×10^{-4}.

- XPERROR2 is the failure of personnel operating the basin crane to observe the potential for impact with the MLS and abort the operation. A probability of 1×10^{-3} is assigned to this failure. These probabilities are consistent with human error probabilities used for scoping purposes.

- XPERROR3 is the unplanned movement of a parked cask truck during the load test due to human error and is assigned a probability of 0.03.

- XPERROR4 is the probability that the truck strikes the MLS while load testing is being performed and causes a load drop. A probability of 1×10^{-5} is assigned based on the considerations of size of the vehicle, impediments preventing the vehicle from striking the MLS, and the velocity needed to overcome the impediments in order to strike the MLS.

To reiterate, these events are included in the model to highlight the need for appropriate controls to prevent external influences from being a major factor in causing a test load drop.

Many of the assumptions in this fault tree model are very conservative. The following list details some of the conservative assumptions along with a statement of the more likely condition for each situation addressed.

- A test load drop event that can occur due to failure of the ball nut drive belt would require the ball nut to reach a very high rate of rotation. Actually, the ball nut would limit the velocity of the drop to a much lower value than what occurs from free fall.
- A "hard stop" condition would result in failure of the lift screw and a subsequent drop of the test load. Actually, the most likely result of a hard stop would be a burned out servo motor or a slipping belt that would be noticed by the operator.
- The operator would neglect recovery actions. Actually, the operator monitors the operation very closely. In addition, the MLS load test will be monitored by several other individuals who can provide input to the operator should failures occur.

6.0 CALCULATIONS

The logic to calculate the probability of a drop per lift is modeled as a fault tree in Figure 1. The solution of the fault tree in Figure 1 yields a list of minimal cutsets based on Boolean logic. A minimal cutset is the minimum number of failure events that will result in the top event. The failure probabilities discussed in Section 5.0, "Input Data," were used to quantify the solution of the fault tree in Figure 1. The computer software code CAFTA, version 2.1, was used to yield the minimal cutsets and quantify the top event of the fault tree in Figure 1. CAFTA, version 2.1, has been validated as reported in WHC-SD-MP-SWD-0004, *CAFTA Computer Program Testing and Acceptance Report*, and the results generated for this calculation note have been randomly spot checked by the technical reviewer to ensure the calculations were performed correctly. Appendix A is a listing of the minimal cutsets and their quantification for logic in Figure 1 using the input data discussed above. Appendix B shows the failure probability data base.

As an example, the quantification calculation for the following set of failures (cutset) that lead to a load drop involves the multiplication of the probabilities. If the events are defined as EVENT1, EVENT 2, and EVENT3 and their probabilities are 1.0×10^{-2}, 1.0×10^{-4}, and 3.0×10^{-2}, respectively:

$$(1.0 \times 10^{-2} \text{ [EVENT1]})\ (1.0 \times 10^{-4} \text{ [EVENT2]})\ (0.03 \text{ [EVENT3]}) = 3.0 \times 10^{-8}.$$

7.0 RESULTS

Solving the logic in the fault tree in Figure 1 results in a listing of 39 minimal cutsets, as listed in Appendix A. The quantification of the minimal cutsets resulting from solving the logic in the fault tree in Figure 1 is also represented by the numbers on the far right hand side of Appendix A for each minimal cutset. The total probability of a potential load drop per lift is 1.1×10^{-6}, which is shown in the upper right hand corner of Appendix A under the column heading "MOD./CS. PROB." This number represents a point estimate value for the probability of potential drop per load test in the south loadout pit (1.1×10^{-6} per load test).

8.0 CONCLUSIONS

The probability of 1.1×10^{-6} per load test is a factor of approximately 25 times smaller than the value used in WHC-SD-WM-SAR-062 (page 3A-3) for cask–MCO drops (2.7×10^{-5} per lift). The value of 2.7×10^{-5} per lift is the midpoint of the frequency range for crane load drops described in NUREG-0612. The upper end of the frequency range for crane load drops described in NUREG-0612 is 3.0×10^{-4} per lift.

The fault tree model shows the importance of certain components and situations. Since the PLC controls all of the MLS functions, PLC failures are very important. The assumption that the system will be thoroughly tested before the load test occurs reduces the probability of programming errors causing load drops. It is not possible to assign a programming fault-caused probability of load drop without an inordinate amount of analysis, and generic programming error rates do not give any significant insights.

The major contributors to the load drop probability are the random structural failures of the MLS support, the MLS, and the grapple. The failure of the locking pin air cylinder air supply valve coupled with the failure of the locking pin locking pawls is also a major contributor. However, this failure cutset may have an artificially high probability due to the lack of information concerning the reliability of the locking pin locking pawls.

External conditions such as natural phenomena, fires, and floods are not considered in this evaluation. Evaluation of operational conditions in the K West Basin south loadout pit area gives important insights. Stringent procedural control of the basin crane and cask vehicle movement should be considered to ensure that these types of events do not dominate the probability of a load drop.

9.0 REFERENCES

DP-1633, 1982, *Component Failure-Rate Data with Potential Applicability to a Nuclear Fuel Reprocessing Plant,* E.I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, South Carolina.

EGG-SSRE-8875, 1990, *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs*, EG&G Idaho, Incorporated, Idaho Falls, Idaho.

H-1-84031, 1999, *Grapple Support Stand South Load-out Pit Plan and Details*, Fluor Daniel Hanford, Incorporated, Richland, Washington.

INSPEC (Institution of Electrical Engineers), 1981, *Electronic Reliability Data, a Guide to Selected Components*, Unwin Brothers Limited, The Gresham Press, Old Woking, Surrey, England.

NAC International, Inc., drawings 101 (Sheets 1, 2, and 3), 201, 210, and 211, NAC International, Inc., Norcross, Georgia.

NPRD-95, 1995, *Nonelectronic Parts Reliability Data 1995,* Reliability Analysis Center, Rome, New York.

NUREG-0612, 1980, *Control of Heavy Loads at Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, Washington, D.C.

NUREG/CR-2300, 1982, *PRA Procedures Guide,* U.S. Nuclear Regulatory Commission, Washington, D.C.

NUREG/CR-4772, 1987, *Accident Sequence Evaluation Program Human Reliability Analysis Procedure*, Sandia National Laboratories, Albuquerque, New Mexico.

Welker, E. L., and M. Lipow, 1974, "Estimating the Exponential Failure Rate from Data with No Failure Events, from the *Proceedings of the 1974 Annual Reliability and Maintainability Symposium*, Los Angeles, California.

WHC-EP-0811, 1994, *Analysis of Power Loss Data for the 200 Area Tank Farms in Support of K Basin SAR Work*, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-MP-SWD-0004, 1993, *CAFTA Computer Program Testing and Acceptance Report*, Rev. 0-D, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SAR-062, 1999, *K Basins Safety Analysis Report*, Rev. 3L, Westinghouse Hanford Company, Richland, Washington.

WSRC-TR-93-262, 1993, *Savannah River Site Generic Data Base Development,* Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 1 of 12)

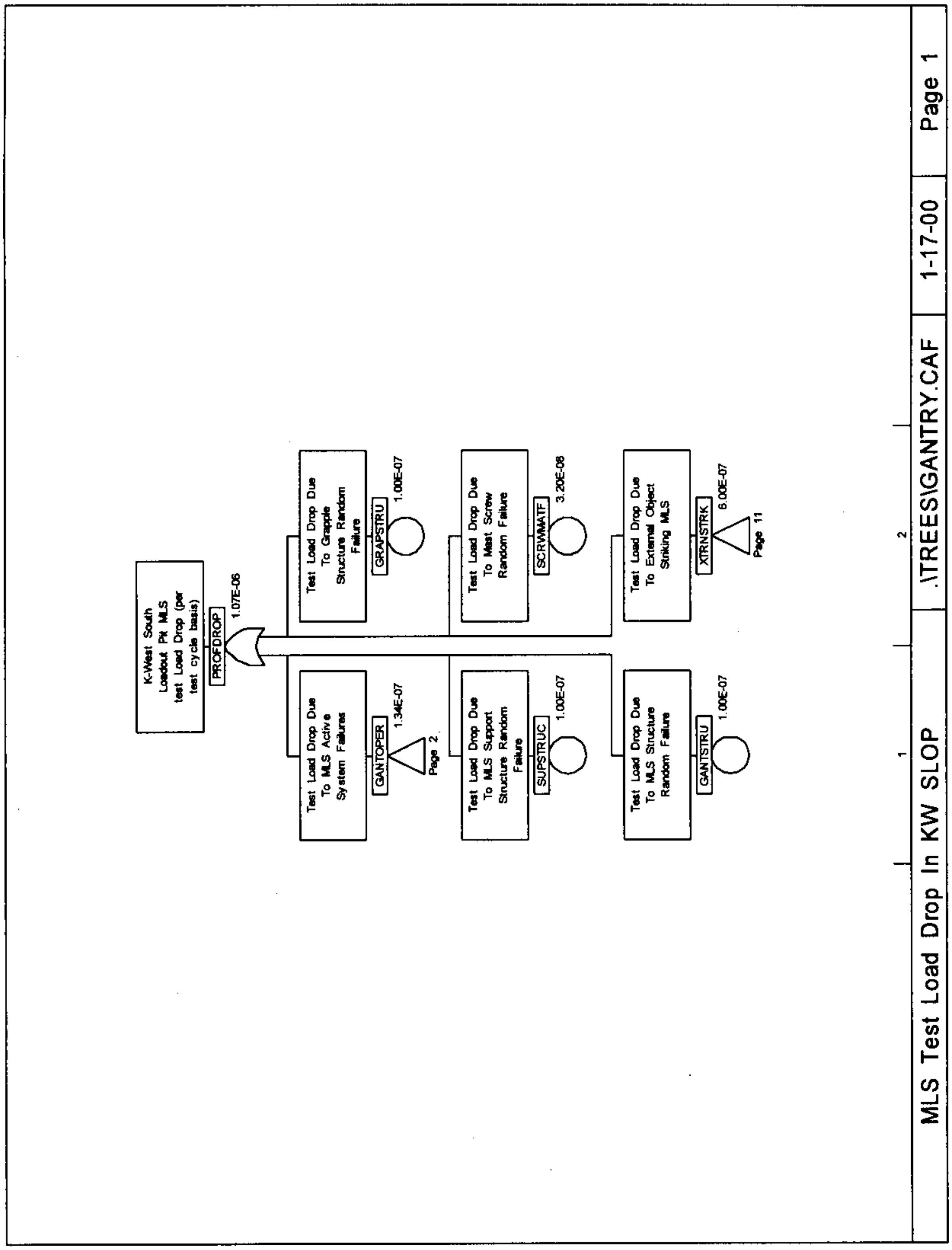

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 2 of 12)

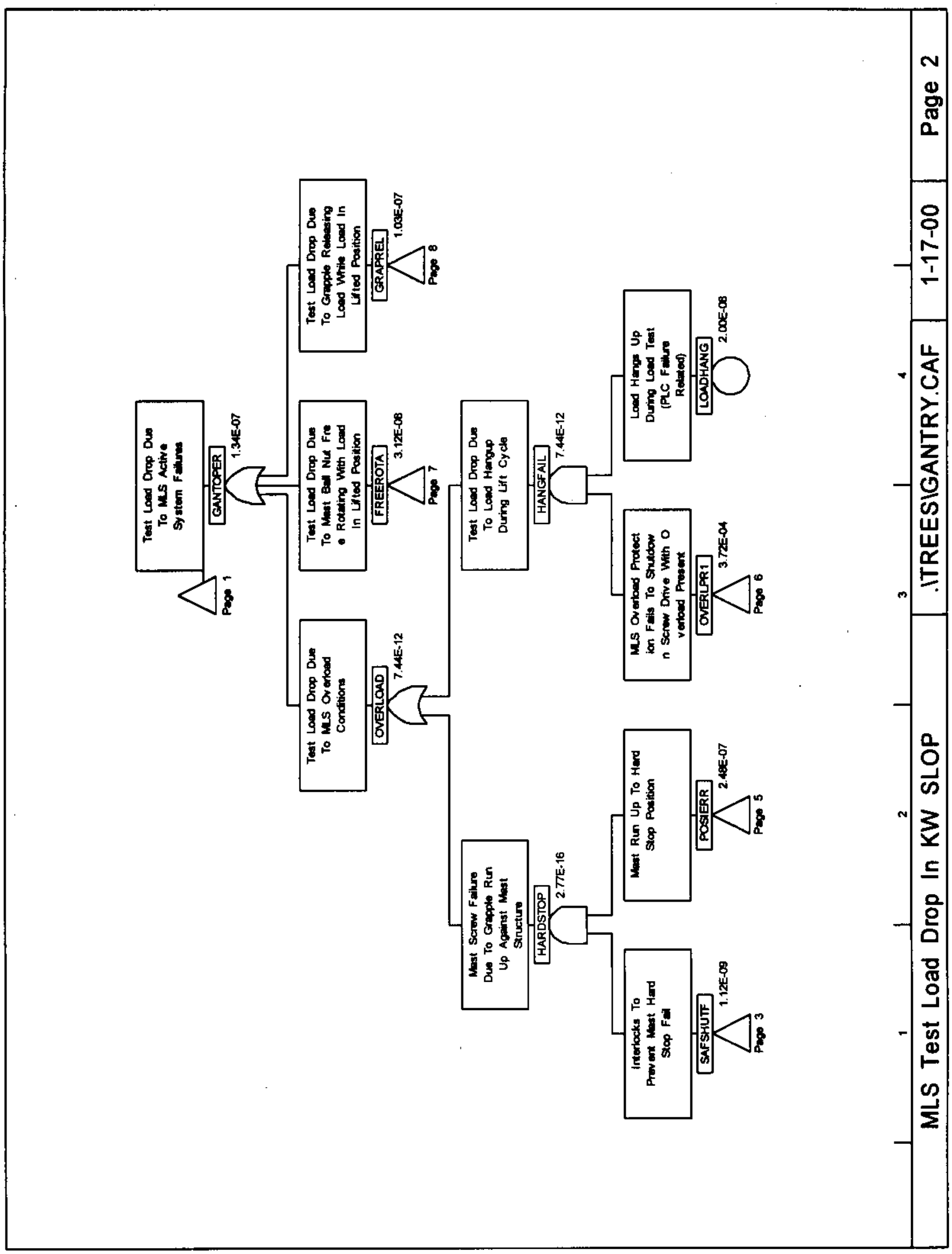

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 3 of 12)

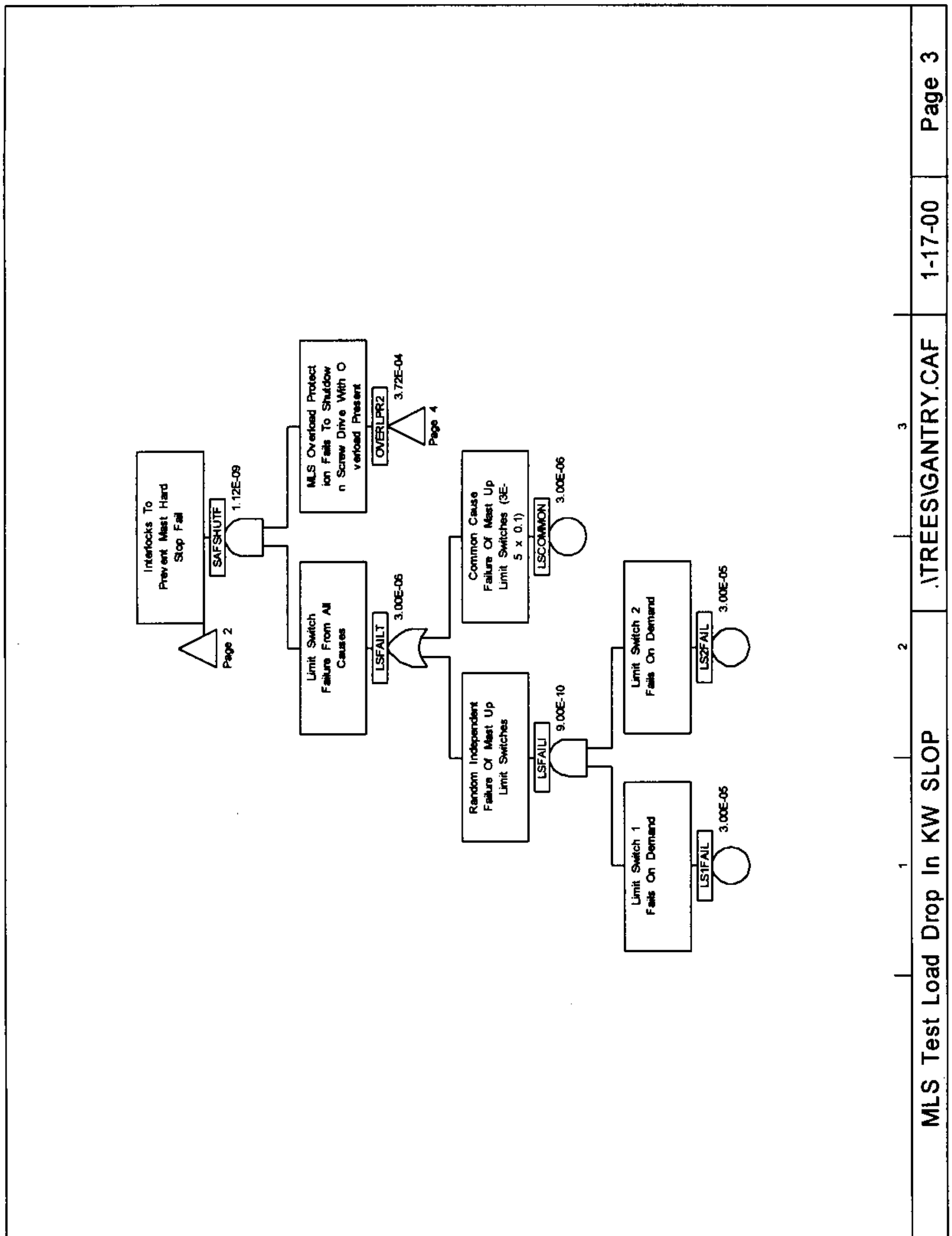

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 4 of 12)

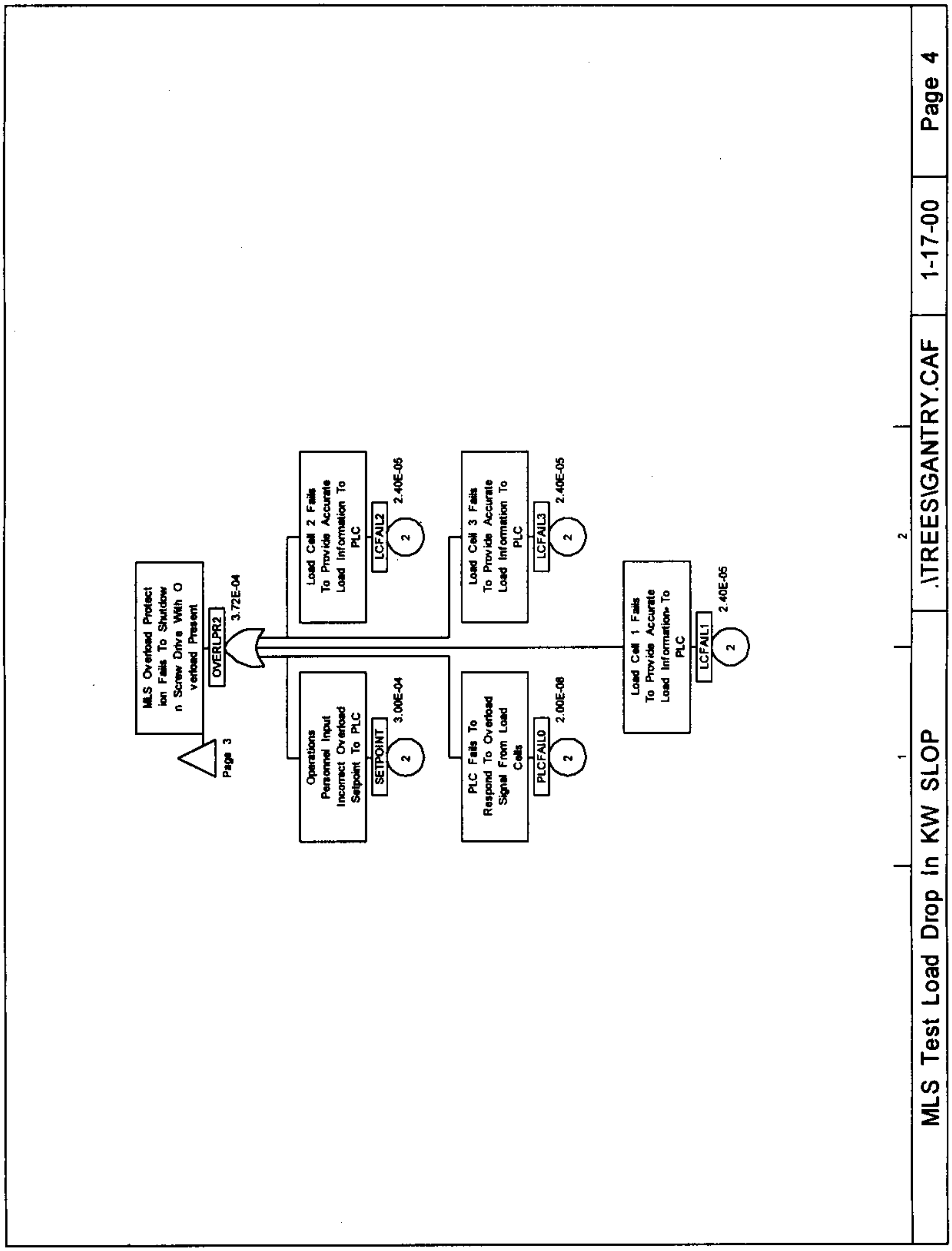

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 5 of 12)

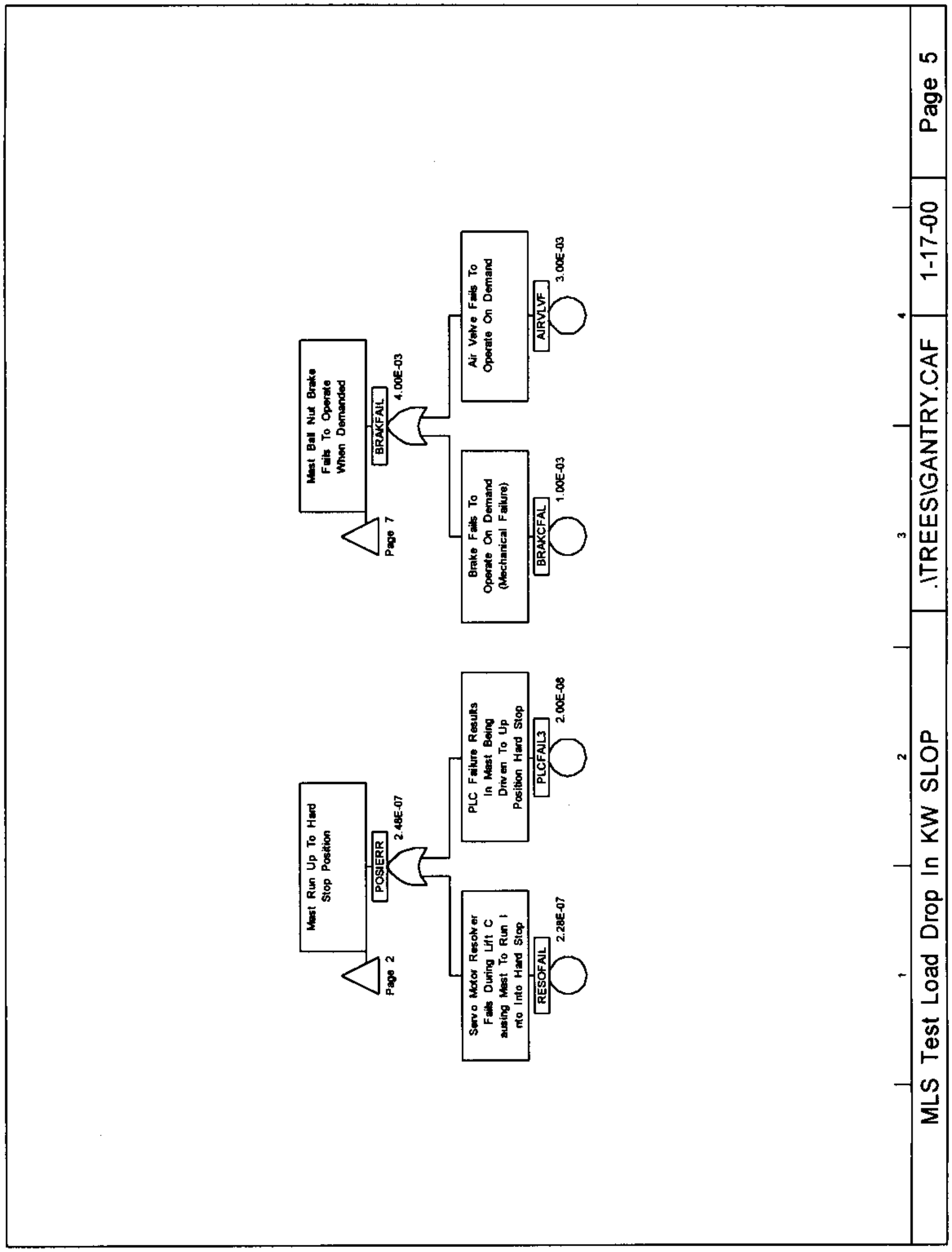

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 6 of 12)

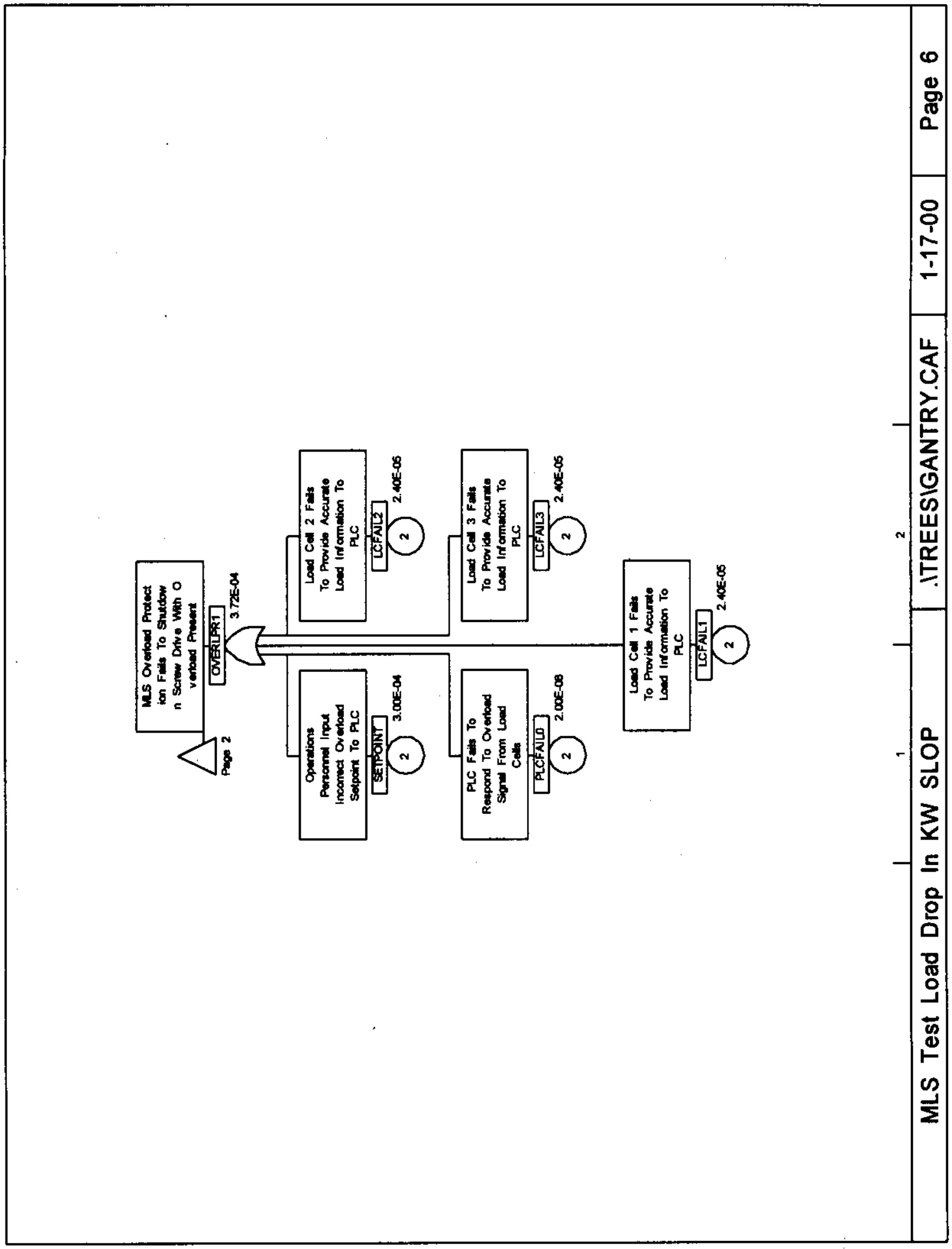

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 7 of 12)

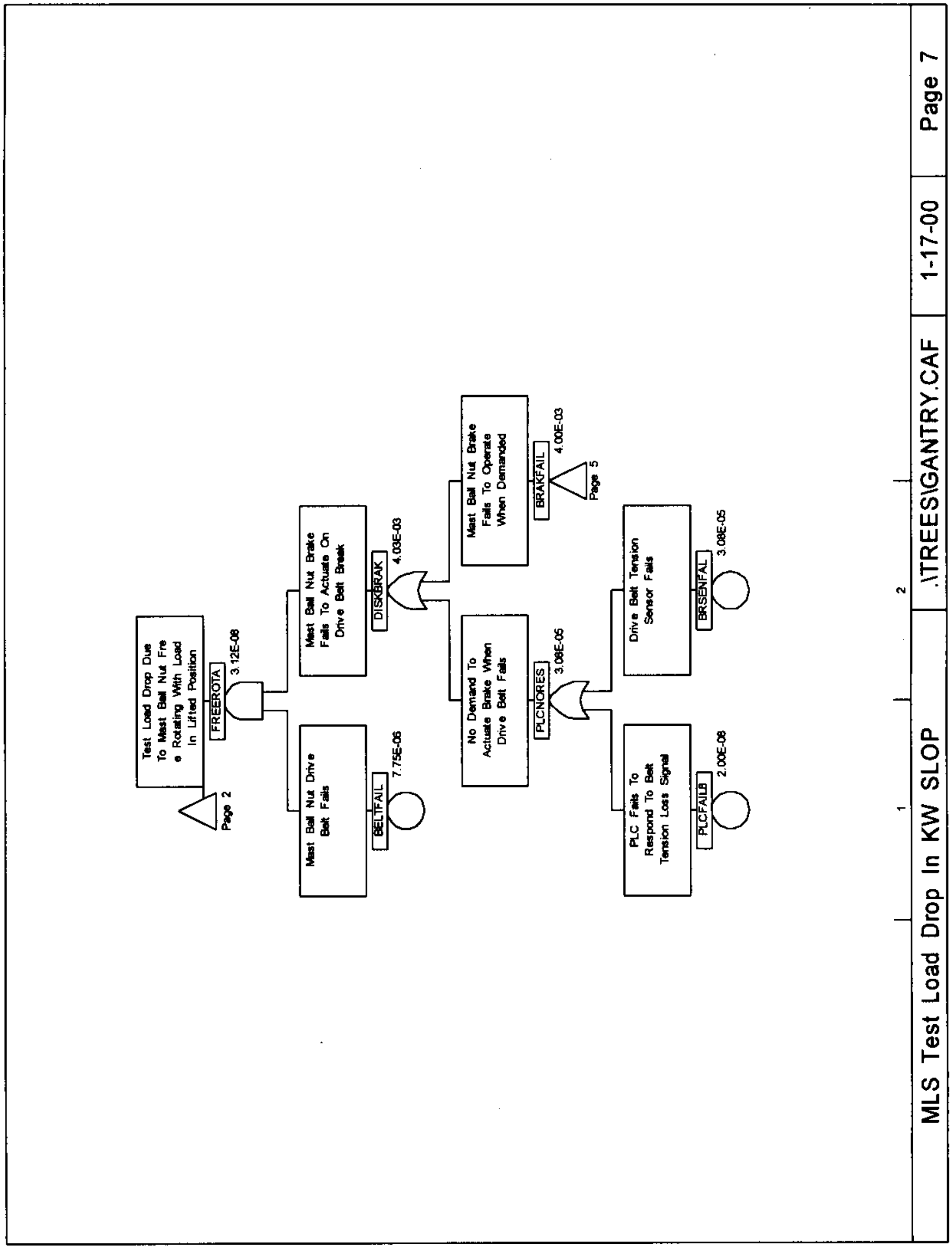

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 8 of 12)

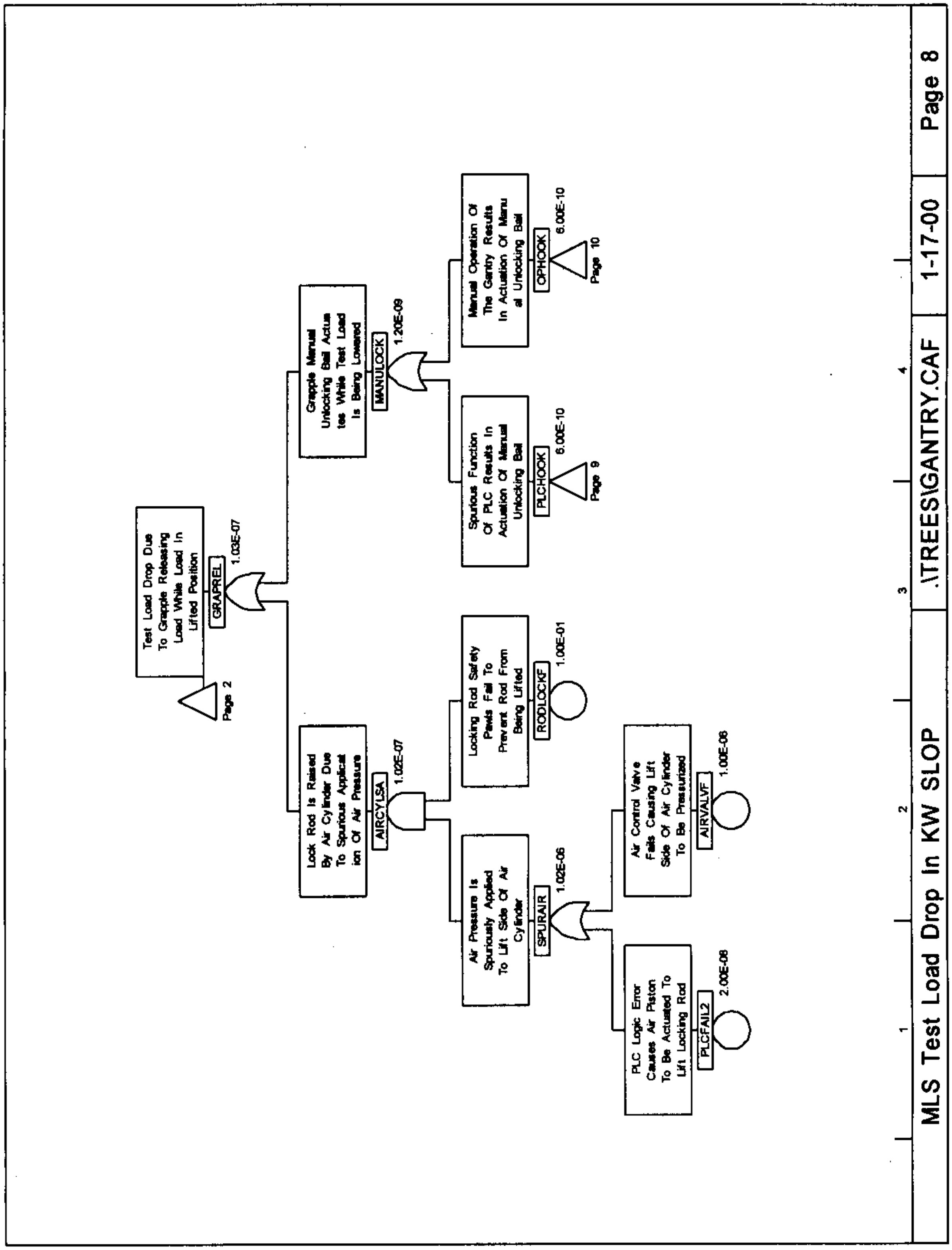

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 9 of 12)

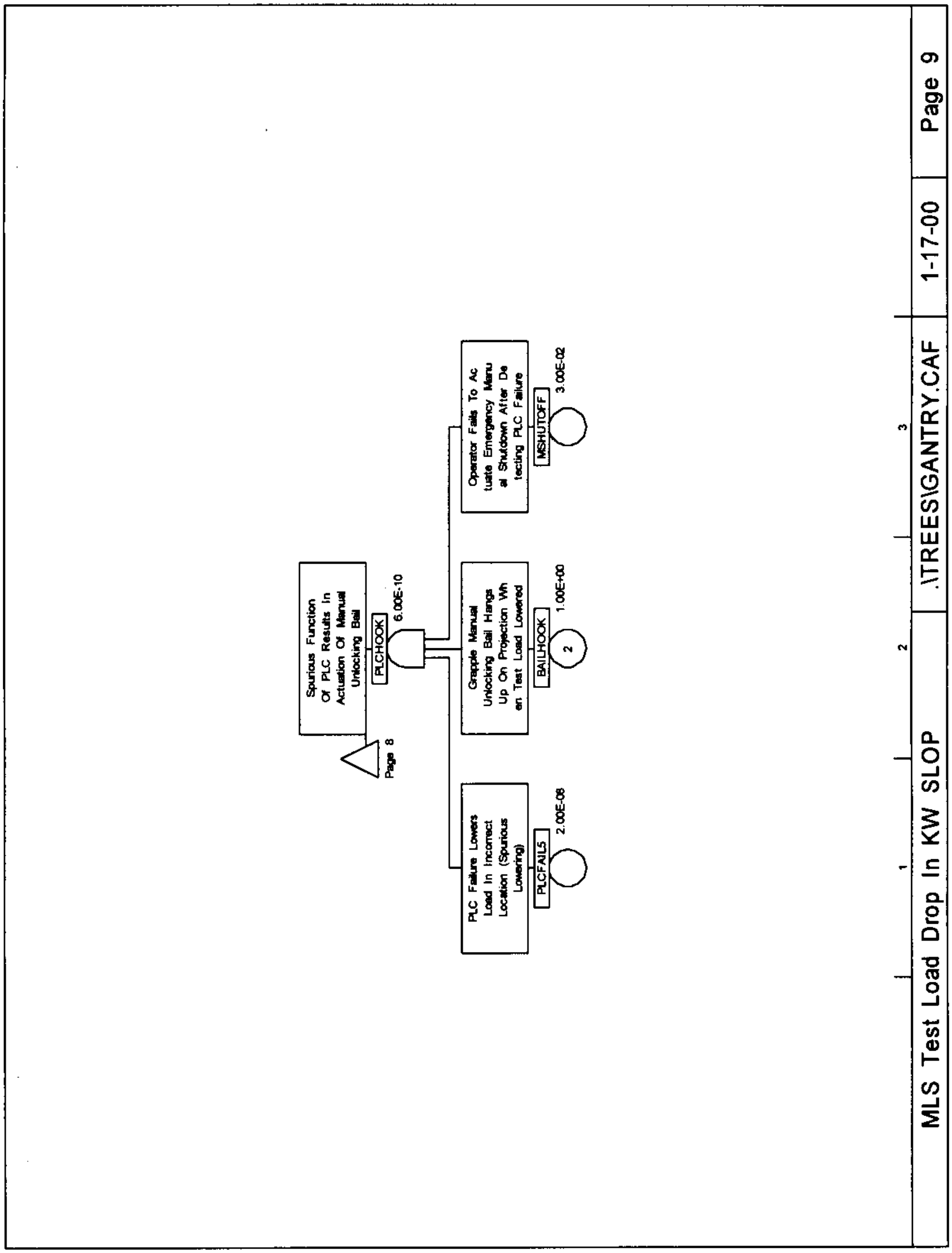

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 10 of 12)

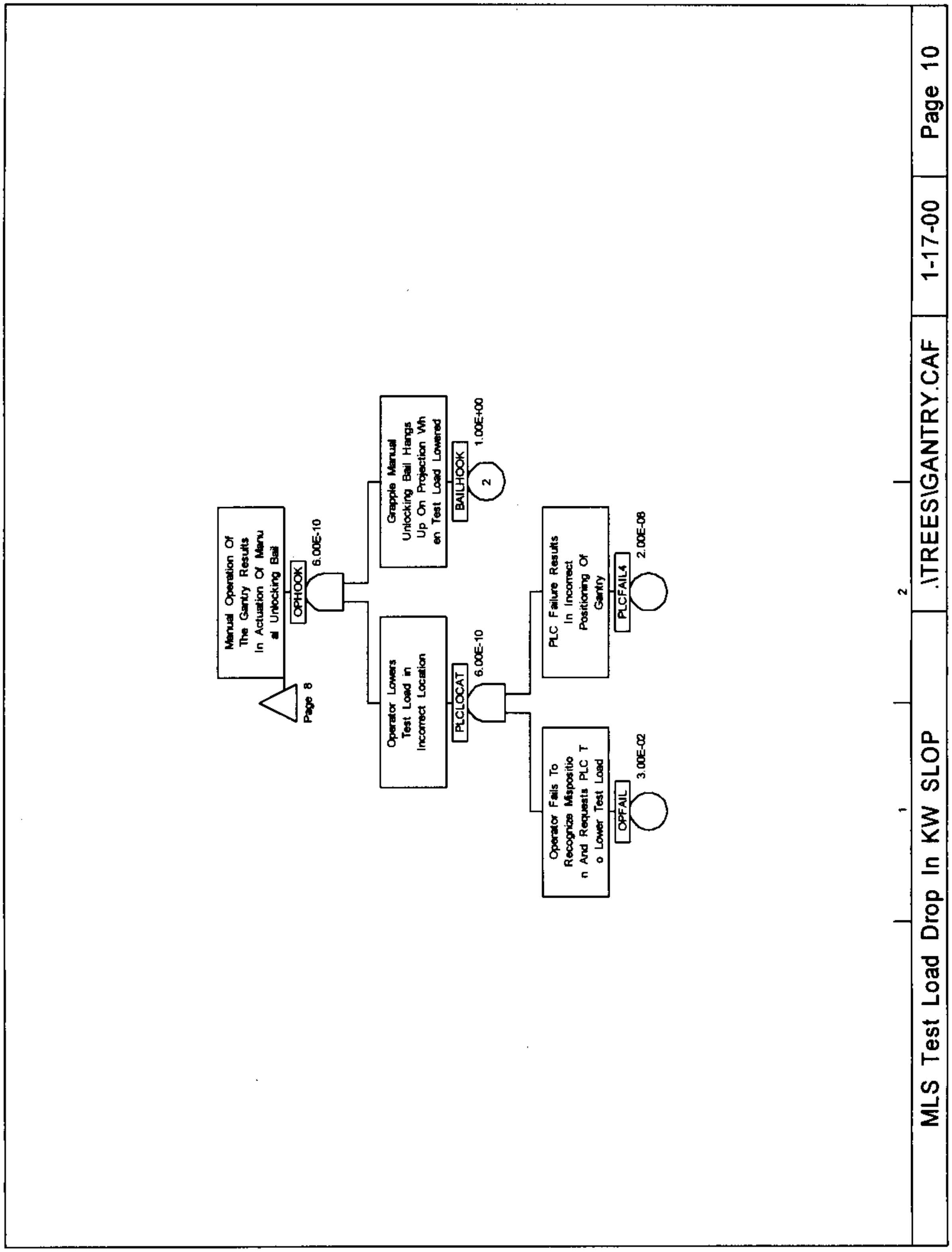

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 11 of 12)

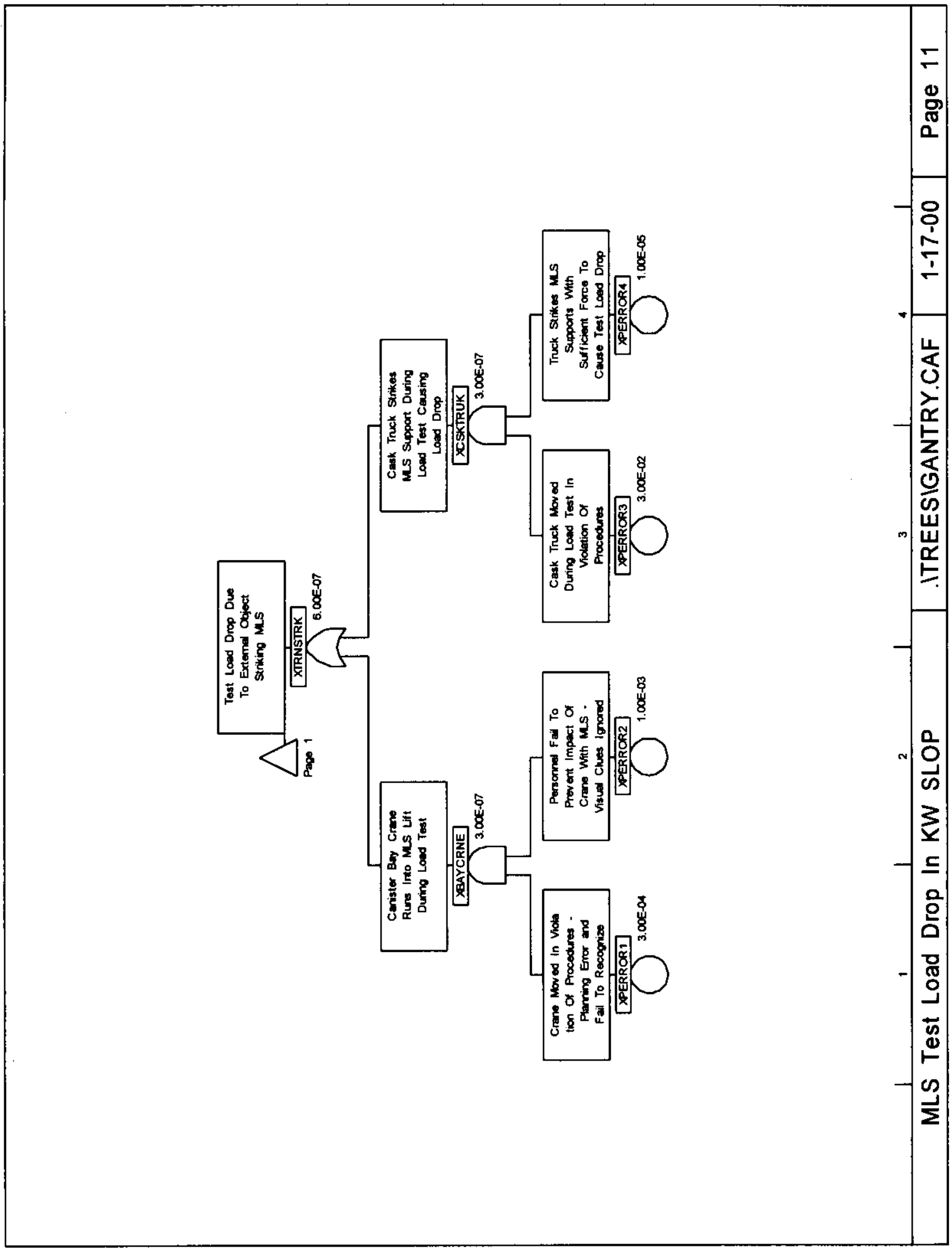

Figure 1. Multi-Canister Overpack Loading System Load Drop in K West South Loadout Pit During Load Test. (Sheet 12 of 12)

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AIRCYLSA	8	2	OVERLOAD	2	3						
AIRVALVF	8	2	OVERLPR1	2	3						
AIRVLVF	5	4	OVERLPR1	6	2						
BAILHOOK	9	2	OVERLPR2	3	3						
BAILHOOK	10	3	OVERLPR2	4	2						
BELTFAIL	7	1	PLCFAIL0	4	1						
BRAKCFAL	5	3	PLCFAIL0	6	1						
BRAKFAIL	5	4	PLCFAIL2	8	1						
BRAKFAIL	7	3	PLCFAIL3	5	2						
BRSENFAL	7	2	PLCFAIL4	10	2						
DISKBRAK	7	2	PLCFAIL5	9	1						
FREEROTA	2	4	PLCFAIL8	7	1						
FREEROTA	7	2	PLCHOOK	8	3						
GANTOPER	1	1	PLCHOOK	9	2						
GANTOPER	2	4	PLCLOCAT	10	2						
GANTSTRU	1	1	PLCNORES	7	2						
GRAPREL	2	4	POSIERR	2	2						
GRAPREL	8	3	POSIERR	5	2						
GRAPSTRU	1	2	PROFDROP	1	2						
HANGFAIL	2	4	RESOFAIL	5	1						
HARDSTOP	2	2	RODLOCKF	8	2						
LCFAIL1	4	2	SAFSHUTF	2	1						
LCFAIL1	6	2	SAFSHUTF	3	2						
LCFAIL2	4	2	SCRWMATF	1	2						
LCFAIL2	6	2	SETPOINT	4	1						
LCFAIL3	4	2	SETPOINT	6	1						
LCFAIL3	6	2	SPURAIR	8	1						
LOADHANG	2	4	SUPSTRUC	1	1						
LS1FAIL	3	1	XBAYCRNE	11	2						
LS2FAIL	3	2	XCSKTRUK	11	4						
LSCOMMON	3	2	XPERROR1	11	1						
LSFAILI	3	1	XPERROR2	11	2						
LSFAILT	3	2	XPERROR3	11	3						
MANULOCK	8	4	XPERROR4	11	4						
MSHUTOFF	9	3	XTRNSTRK	1	2						
OPFAIL	10	1	XTRNSTRK	11	2						
OPHOOK	8	4									
OPHOOK	10	2									

MLS Test Load Drop In KW SLOP	.\TREES\GANTRY.CAF	1-17-00	Page 12

APPENDIX A

CUTSET REPORT

This page intentionally left blank.

.\TREES\MLS.CUT CUTSET REPORT 12-27-99 Page 1

	MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1)	PROFDROP					*1.07E-06
1)	XPERROR1	Crane Moved In Violation Of Procedures - Planning Error and Fail To Reco		3E-4	3.00E-04	3.00E-07
	XPERROR2	Personnel Fail To Prevent Impact Of Crane With MLS - Visual Clues Ign		1E-3	1.00E-03	
2)	XPERROR3	Cask Truck Moved During Load Test In Violation Of Procedures		3E-2	3.00E-02	3.00E-07
	XPERROR4	Truck Strikes MLS Supports With Sufficient Force To Cause Test Load D		1E-5	1.00E-05	
3)	GANTSTRU	Test Load Drop Due To MLS Structure Random Failure		1.0E-7	1.00E-07	1.00E-07
4)	GRAPSTRU	Test Load Drop Due To Grapple Structure Random Failure		1.0E-7	1.00E-07	1.00E-07
5)	AIRVALVF	Air Control Valve Fails Causing Lift Side Of Air Cylinder To Be Pressuri		1E-6	1.00E-06	1.00E-07
	RODLOCKF	Locking Rod Safety Pawls Fail To Prevent Rod From Being Lifted		1E-1	1.00E-01	
6)	SUPSTRUC	Test Load Drop Due To MLS Support Structure Random Failure		1.0E-7	1.00E-07	1.00E-07
7)	SCRWMATF	Test Load Drop Due To Mast Screw Random Failure		3.2E-8	3.20E-08	3.20E-08
8)	AIRVLVF	Air Valve Fails To Operate On Demand		3.0E-3	3.00E-03	2.32E-08
	BELTFAIL	Mast Ball Nut Drive Belt Fails		7.75E-6	7.75E-06	
9)	BELTFAIL	Mast Ball Nut Drive Belt Fails		7.75E-6	7.75E-06	7.75E-09
	BRAKCFAL	Brake Fails To Operate On Demand (Mechanical Failure)		1E-3	1.00E-03	
10)	PLCFAIL2	PLC Logic Error Causes Air Piston To Be Actuated To Lift Locking Rod		2E-8	2.00E-08	2.00E-09
	RODLOCKF	Locking Rod Safety Pawls Fail To Prevent Rod From Being Lifted		1E-1	1.00E-01	
11)	BAILHOOK	Grapple Manual Unlocking Bail Hangs Up On Projection When Test Load Lowe		1	1.00E+00	6.00E-10
	MSHUTOFF	Operator Fails To Actuate Emergency Manual Shutdown After Detecting PLC		3E-2	3.00E-02	
	PLCFAIL5	PLC Failure Lowers Load In Incorrect Location (Spurious Lowering)		2E-8	2.00E-08	
12)	BAILHOOK	Grapple Manual Unlocking Bail Hangs Up On Projection When Test Load Lowe		1	1.00E+00	6.00E-10
	OPFAIL	Operator Fails To Recognize Misposition And Requests PLC To Lower Test L		3E-2	3.00E-02	
	PLCFAIL4	PLC Failure Results In Incorrect Positioning Of MLS		2E-8	2.00E-08	
13)	BELTFAIL	Mast Ball Nut Drive Belt Fails		7.75E-6	7.75E-06	2.39E-10
	BRSENFAL	Drive Belt Tension Sensor Fails		3.08E-5	3.08E-05	
14)	LOADHANG	Load Hangs Up During Load Test (PLC Failure Related)		2E-8	2.00E-08	6.00E-12
	SETPOINT	Operations Personnel Input Incorrect Overload Setpoint To PLC		3.0E-4	3.00E-04	
15)	LCFAIL2	Load Cell 2 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.80E-13
	LOADHANG	Load Hangs Up During Load Test (PLC Failure Related)		2E-8	2.00E-08	
16)	LCFAIL3	Load Cell 3 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.80E-13
	LOADHANG	Load Hangs Up During Load Test (PLC Failure Related)		2E-8	2.00E-08	
17)	LCFAIL1	Load Cell 1 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.80E-13
	LOADHANG	Load Hangs Up During Load Test (PLC Failure Related)		2E-8	2.00E-08	

.\TREES\MLS.CUT CUTSET REPORT 12-27-99 Page 2

MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
18) BELTFAIL	Mast Ball Nut Drive Belt Fails		7.75E-6	7.75E-06	1.55E-13
PLCFAIL8	PLC Fails To Respond To Belt Tension Loss Signal		2E-8	2.00E-08	
19) LOADHANG	Load Hangs Up During Load Test (PLC Failure Related)		2E-8	2.00E-08	4.00E-16
PLCFAIL0	PLC Fails To Respond To Overload Signal From Load Cells		2E-8	2.00E-08	
20) LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	2.05E-16
RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
SETPOINT	Operations Personnel Input Incorrect Overload Setpoint To PLC		3.0E-4	3.00E-04	
21) LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	1.80E-17
PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
SETPOINT	Operations Personnel Input Incorrect Overload Setpoint To PLC		3.0E-4	3.00E-04	
22) LCFAIL2	Load Cell 2 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	1.64E-17
LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	
RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
23) LCFAIL1	Load Cell 1 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	1.64E-17
LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	
RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
24) LCFAIL3	Load Cell 3 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	1.64E-17
LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	
RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
25) LCFAIL1	Load Cell 1 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	1.44E-18
LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	
PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
26) LCFAIL2	Load Cell 2 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	1.44E-18
LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	
PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
27) LCFAIL3	Load Cell 3 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	1.44E-18
LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	
PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
28) LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	6.16E-20
LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
SETPOINT	Operations Personnel Input Incorrect Overload Setpoint To PLC		3.0E-4	3.00E-04	

.\TREES\MLS.CUT CUTSET REPORT 12-27-99 Page 3

MODULE/EVENT NAME		DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
29)	LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	1.37E-20
	PLCFAIL0	PLC Fails To Respond To Overload Signal From Load Cells		2E-8	2.00E-08	
	RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
30)	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	5.40E-21
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
	SETPOINT	Operations Personnel Input Incorrect Overload Setpoint To PLC		3.0E-4	3.00E-04	
31)	LCFAIL2	Load Cell 2 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.92E-21
	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
32)	LCFAIL1	Load Cell 1 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.92E-21
	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
33)	LCFAIL3	Load Cell 3 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.92E-21
	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
34)	LSCOMMON	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)		3E-6	3.00E-06	1.20E-21
	PLCFAIL0	PLC Fails To Respond To Overload Signal From Load Cells		2E-8	2.00E-08	
	PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
35)	LCFAIL1	Load Cell 1 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.32E-22
	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
36)	LCFAIL2	Load Cell 2 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.32E-22
	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
37)	LCFAIL3	Load Cell 3 Fails To Provide Accurate Load Information To PLC		2.4E-5	2.40E-05	4.32E-22
	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	
38)	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	4.10E-24
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	PLCFAIL0	PLC Fails To Respond To Overload Signal From Load Cells		2E-8	2.00E-08	
	RESOFAIL	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Har		2.28E-7	2.28E-07	
39)	LS1FAIL	Limit Switch 1 Fails On Demand		3.0E-5	3.00E-05	3.60E-25
	LS2FAIL	Limit Switch 2 Fails On Demand		3.0E-5	3.00E-05	
	PLCFAIL0	PLC Fails To Respond To Overload Signal From Load Cells		2E-8	2.00E-08	
	PLCFAIL3	PLC Failure Results In Mast Being Driven To Up Position Hard Stop		2.0E-8	2.00E-08	

This page intentionally left blank.

APPENDIX B

BASIC EVENT DATA

This page intentionally left blank.

.\TREES\MLS.BE CAFTA Database Report 12-27-99
Page 1

	NAME	PROB	DESC
1	AIRVALVF	1.00E-06	Air Control Valve Fails Causing Lift Side Of Air Cylinder To Be Pressurized
2	AIRVLVF	3.00E-03	Air Valve Fails To Operate On Demand
3	BAILHOOK	1.00E+00	Grapple Manual Unlocking Bail Hangs Up On Projection When Test Load Lowered
4	BELTFAIL	7.75E-06	Mast Ball Nut Drive Belt Fails
5	BRAKCFAL	1.00E-03	Brake Fails To Operate On Demand (Mechanical Failure)
6	BRSENFAL	3.08E-05	Drive Belt Tension Sensor Fails
7	GANTSTRU	1.00E-07	Test Load Drop Due To MLS Structure Random Failure
8	GRAPSTRU	1.00E-07	Test Load Drop Due To Grapple Structure Random Failure
9	LCFAIL1	2.40E-05	Load Cell 1 Fails To Provide Accurate Load Information To PLC
10	LCFAIL2	2.40E-05	Load Cell 2 Fails To Provide Accurate Load Information To PLC
11	LCFAIL3	2.40E-05	Load Cell 3 Fails To Provide Accurate Load Information To PLC
12	LOADHANG	2.00E-08	Load Hangs Up During Load Test (PLC Failure Related)
13	LS1FAIL	3.00E-05	Limit Switch 1 Fails On Demand
14	LS2FAIL	3.00E-05	Limit Switch 2 Fails On Demand
15	LSCOMMON	3.00E-06	Common Cause Failure Of Mast Up Limit Switches (3E-5 x 0.1)
16	MSHUTOFF	3.00E-02	Operator Fails To Actuate Emergency Manual Shutdown After Detecting PLC Failure
17	OPFAIL	3.00E-02	Operator Fails To Recognize Misposition And Requests PLC To Lower Test Load
18	PLCFAIL0	2.00E-08	PLC Fails To Respond To Overload Signal From Load Cells
19	PLCFAIL2	2.00E-08	PLC Logic Error Causes Air Piston To Be Actuated To Lift Locking Rod
20	PLCFAIL3	2.00E-08	PLC Failure Results In Mast Being Driven To Up Position Hard Stop
21	PLCFAIL4	2.00E-08	PLC Failure Results In Incorrect Positioning Of MLS
22	PLCFAIL5	2.00E-08	PLC Failure Lowers Load In Incorrect Location (Spurious Lowering)
23	PLCFAIL8	2.00E-08	PLC Fails To Respond To Belt Tension Loss Signal
24	RESOFAIL	2.28E-07	Servo Motor Resolver Fails During Lift Causing Mast To Run Into Into Hard Stop
25	RODLOCKF	1.00E-01	Locking Rod Safety Pawls Fail To Prevent Rod From Being Lifted
26	SCRWMATF	3.20E-08	Test Load Drop Due To Mast Screw Random Failure
27	SETPOINT	3.00E-04	Operations Personnel Input Incorrect Overload Setpoint To PLC
28	SUPSTRUC	1.00E-07	Test Load Drop Due To MLS Support Structure Random Failure
29	XPERROR1	3.00E-04	Crane Moved In Violation Of Procedures - Planning Error and Fail To Recognize
30	XPERROR2	1.00E-03	Personnel Fail To Prevent Impact Of Crane With MLS - Visual Clues Ignored
31	XPERROR3	3.00E-02	Cask Truck Moved During Load Test In Violation Of Procedures
32	XPERROR4	1.00E-05	Truck Strikes MLS Supports With Sufficient Force To Cause Test Load Drop

This page intentionally left blank.

APPENDIX C

PEER REVIEW CHECKLISTS

This page intentionally left blank.

PEER REVIEW CHECKLIST

Document Title: SNF-5569, *Probability of Potential Multi-Canister Overpack Loading System Drop of Proof Load in the K West Basin South Loadout Pit*
Document Author: Milt Shultz
Document Date: December 1999
Scope of Review: Entire document

Yes	No	NA	
[ ]	[ ]	[X]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[ ]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[X]	[ ]	[ ]	Software input correct and consistent with document reviewed.
[X]	[ ]	[ ]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[X]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]	[ ]	[X]	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]	**Document approved.**

THOMAS B. POWERS [signature] 1/10/2000
Reviewer (Printed Name and Signature) Date

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: Probability of Potential Multi-Canister Overpack Loading
Title: System Drop of Proof Load in the K West Basin South Loadout
Author: Milton V. Shultz
Date: December 29 1999
Scope of Review:

Yes	No*	NA	
[✓]	[ ]	[ ]**	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[✓]	[ ]	[ ]	Problem completely defined.
[✓]	[ ]	[ ]	Accident scenarios developed in a clear and logical manner.
[✓]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[✓]	[ ]	[ ]	Computer codes and data files documented.
[✓]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[✓]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[✓]	Mathematical derivations checked including dimensional consistency of results.
[✓]	[ ]	[ ]	Models appropriate and used within range of validity, or use outside range of established validity justified.
[ ]	[ ]	[✓]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[✓]	[ ]	[ ]	Software input correct and consistent with document reviewed.
[✓]	[ ]	[ ]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[✓]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[✓]	Safety margins consistent with good engineering practices.
[✓]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[✓]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[✓]	[ ]	[ ]	Format consistent with applicable guides or other standards.
[ ]		[✓]**	Review calculations, comments, and/or notes are attached.
[✓]	[ ]	[ ]	Document approved (for example, the reviewer affirms the technical accuracy of the document).

David J. Braun [signature] — Dec 29, 1999

Reviewer (printed name and signature) — Date

* All "no" responses must be explained below or on an additional sheet.

** Any calculations, comments, or notes generated as part of this review should be signed, dated, and attached to this checklist. The material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

DISTRIBUTION SHEET

To Distribution	From Fluor Federal Services	Page 1 of 1
		Date January 10, 2000
Project Title/Work Order SNF-5569, Rev. 0 Probability of Potential Multicanister Overpack Loading Systems Drop of Proof Load in the K West Basin South Loadout Pit		EDT No. 622288
		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
C. J. Alderman	R3-11	X			
K. E. Ardes	X3-85	X			
R. L. Boylestonn	R3-26	X			
J. R. Ellis (5)	R3-26	X			
R. L. Garrett	R3-26	X			
K. D. Gibson	R3-26	X			
B. S. Lew	X3-79	X			
T. B. Powers	R3-26	X			
L. A. Rodgers	X3-85	X			
M. V. Shultz	B4-47	X			
J. L. Weamer	X3-85	X			
R. H. Webb	R3-85	X			
SNF Project Files	R3-11	X			
Central Files (2)	B1-07	X			