

## ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 654633

Proj.  
ECN

ECN Category (mark one)	3 Originator's Name, Organization, MSIN, and Telephone No		4 USQ Required	5 Date
Supplemental <input type="checkbox"/>	GA Chaffee, NS, X3-79, 372-1411		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	10/10/0
Direct Revision <input type="checkbox"/>	6 Project Title/No /Work Order No		7 Bldg /Sys /Fac No	8 Approval Designator
Change ECN <input type="checkbox"/>	Spent Nuclear Fuel Project/K Basin		100K	S(n)
Temporary <input type="checkbox"/>	9 Document Numbers Changed by this ECN (includes sheet no and rev)		10 Related ECN No(s)	11 Related PO No
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Supersedure <input type="checkbox"/>	2a. Modification Work		12d. Restored to Original Condition (Temp. or Standby ECNs only)	
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4a. Justification (mark one)		14b. Justification Details		
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Design Improvement <input type="checkbox"/>				
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ENGINEERING CHANGE NOTICE				Page 2 of <u>2</u>	1 ECN (use no from pg 1)  654633
6 Design Verification Required	17 Cost Impact <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p style="text-align: center; font-weight: bold;">ENGINEERING</p> <p>Additional <input type="checkbox"/> \$ _____</p> <p>Savings <input type="checkbox"/> \$ _____</p> </div> <div style="width: 45%;"> <p style="text-align: center; font-weight: bold;">CONSTRUCTION</p> <p>Additional <input type="checkbox"/> 5 _____</p> <p>Savings <input type="checkbox"/> \$ _____</p> </div> </div>			18 Schedule Impact (days)	
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0. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number/Revision
HNF-SD-WM-SAR-062. Rev 4A		

1. Approvals

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# Potential Multi-Canister Overpack Cask Drop in the K West Basin South Loadout Pit

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management  
Project Hanford Management Contractor for the  
U.S. Department of Energy under Contract DE-AC06-96RL13200



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Department of Energy**  
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# Potential Multi-Canister Overpack Cask Drop in the K West Basin South Loadout Pit

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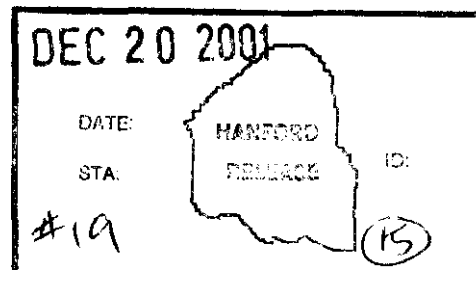
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*Anis Braden*  
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## 1.0 PURPOSE AND OBJECTIVES

The purpose of this calculation note is to document the probabilistic calculation of a potential drop of a multi-canister overpack (MCO) cask or MCO cask and immersion pail on a per lift basis at the K West Basin south loadout pit. This calculation note supports both initial cask loading system alignment activities and normal operations. To perform normal operations in the basin, an MCO cask needs to be lifted four different times. A probabilistic calculation of the potential for a drop will be used for the MCO lifts required during operations.

## 2.0 SUMMARY OF FINAL RESULTS AND CONCLUSIONS

The point estimate value calculated for the probability of a potential drop in the south loadout pit is  $1.5 \times 10^{-5}$  per lift. The probability of  $1.5 \times 10^{-5}$  per lift is approximately a factor of two smaller than the midpoint of the crane load drop failure data provided in NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants*. The point estimate value for the frequency of potential drops in the south loadout pit is  $6.0 \times 10^{-5}$  per MCO, based on four lifts per MCO. With an MCO-drop accident frequency limit of 0.01 per year, the number of MCOs that can be handled in the south loadout pit must be limited to 165 MCOs per year.

## 3.0 METHODOLOGY

Fault tree analysis is used to calculate the probability of a potential MCO cask drop in the K West Basin south loadout pit. The fault tree logic represents the failures required before a potential drop by the transfer bay crane could occur in the K West Basin south loadout pit. Drops that are induced by a seismic event are not included in the fault tree analysis; however, they are included when considering the number of MCOs that can be handled per year.

## 4.0 ASSUMPTIONS

The following assumptions are represented by the fault tree logic and failure probabilities developed for 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-4722, *Accident Sequence Evaluation Program Human Reliability Analysis Procedure* (page 4-3, Table 4-1, step 6).
2. It is assumed that the controller that manages the load cell signals for overhead protection can fail such that no overload signal is sent to the 110% overload alarm or no overload signal is sent to shut off power to hoisting at 125% of normal load.

3. It is assumed that a single failure of an MCO cask lifting attachment, a crane hood, or a crane cable will result in a drop of the MCO cask.
4. It is assumed that three of the four rigging lines (each equipped with an upper hook, sling, and lower hook) on the immersion pail would have to fail to allow an immersion pail to drop.
5. For the crane bridge to fail, the probability of material defect, damage, and/or fatigue is assumed to be  $1.0 \times 10^{-7}$ .
6. For the crane trolley to fail, the probability of material defect, damage, and/or fatigue is assumed to be  $1.0 \times 10^{-7}$ .
7. Loss of electrical power failure is based on Hanford Site-specific, loss-of-power data of 1.22 per year (WHC-EP-0811, *Analysis of Power Loss Data for the 200 Area Tank Farms in Support of K Basin SAR Work*).

## 5.0 EVENTS THAT LEAD TO LOAD DROP

The various failures that could lead to a load drop are divided into the following four categories: (1) load support failure, (2) bridge failure, (3) trolley failure, and (4) hoist drum failure. Load support failure is divided into the following three accidents: two-blocking, load hangup, and load line structural failure. The bridge and trolley failures are separate accidents. Hoist drum failure is divided into the following four accidents: hoist gear failure, shaft reducer failure, loss of power, and electric drive failure. Each of these accidents is described in the following subsections. Figure I is an eight-page figure showing the relationship between all of the identified failures that could result in an MCO drop. Each of the failures is identified by its name and a designated number. Sheet 8 of Figure I provides an index to the events; the page number identifies the sheet of Figure I on which the event appears, and the zone number identifies the horizontal position of the event on the identified sheet.

### 5.1 LOAD SUPPORT FAILURE

If the load support fails, the load drops as a result of one of the following: a two-blocking event, a load hangup event, or load line structure failure. Each of these events is discussed in further detail in this section.

#### 5.1.1 Two-Blocking Event (KW210)

The "Two-Blocking Event" is the load drop due to an operator error in raising the load too high and failure of both limit switches. The Two-Blocking Event is identified by name and by designator KW210 in Figure I, sheet 1. Before using the transfer bay crane, the lower limit switch is tested on both the main hoist and the auxiliary hoist per Spent Nuclear Fuel Operations Technical Procedure OP-14-003W Rev 0/R, dated May 27, 1998, *Perform Pre-Use Test on*

*105KW Transfer Bay Crane.* The test simply raises the hoist until the first limit switch stops it. The upper limit switch is tested annually and whenever the lower limit switch fails.

- Event KWOP1 is the operator error that leads to “two-blocking” the transfer bay crane with a load attached. As mentioned in the assumptions above, the BHEP used for this operator error is 0.03, as shown for Event KWOP1 in Figure 1, sheet 1.
- Event KWLSW1 is the failure of the first limit switch to stop transfer bay crane hoisting to prevent two-blocking. Because the upper limit switch is tested before each lift, the failure of this limit switch over time will be detected before a lift is performed. The dominant failure mode of the limit switch is a failure to open or close on demand. The probability of the limit switch failing is  $3.0 \times 10^{-5}$  per demand based on EGG-SSRE-8875, *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs*, page 22, and shown for Event KWLSW1 in Figure 1, sheet 1.
- Event KWLSW2 is the failure of the second or “high” limit switch to stop transfer bay crane hoisting to prevent two-blocking. This limit switch is tested once per year. Thus, the failure of these limit switches over time will dominate the failure to open or close on demand. The probability of a limit switch failing over time is  $1.0 \times 10^{-6}$  per hour (EGG-SSRE-8875, page 22). Conservatively assuming operations of 10,000 hours per year means the failure probability of the upper limit switch is  $(1.0 \times 10^{-6} \text{ per hour})(10,000 \text{ hours}) = 0.01$ , as shown for Event KWLSW2 in Figure 1, sheet 1. The time-based value is used rather than the demand-based value because the upper limit switch is rarely used.

The probability of a load drop due to a Two-Blocking Event is the product of the individual failure mode probabilities because all three failures must occur simultaneously. The product of the three failure mode probabilities is  $(0.03)(3 \times 10^{-5})(0.01) = 9.0 \times 10^{-9}$  as shown for Event KW210 in Figure 1, sheet 1.

### 5.1.2 Load Hangup Event (KW220)

The “Load Hangup Event” is the load drop that begins with an operator error that hangs up the load and activates the overload protection features of the transfer bay crane. The overload protection fails, and the load drops. This accident is identified by name and by designator KW220 in Figure 1, sheet 1.

- Event KWOP2 is the operator error that leads to “load hangup” of the transfer bay crane with a load attached. As mentioned in the assumptions given in Section 4.0, the BHEP used for this operator error is 0.03, as shown for Event KWOP2 on Figure 1, sheet 1.
- Event KW310 is the overload protection system failure detailed in Figure 1, sheet 2. This failure may come about in two ways: (1) the overload trip setpoint is incorrectly set too high to be effective (Event KWOP4MIS); or (2) the overload alarm fails to stop hoisting (Event KW410), which may take place because the 110% overload alarm is not given (or is ignored) and the 125% alarm is not given.

1. Event KWOP4MIS is the operator error of incorrectly resetting both load cell setpoints so that the setpoints trip at higher loads than desired for the 110% and 125% overload protection. This operator error has the effect of bypassing both trip points. **As** mentioned in the assumptions given in Section 4.0, the BHEP used for this operator error is 0.03. The BHEP is multiplied by a factor of 0.01 to take credit for procedural steps that require a work package be developed whenever the load cell setpoints are reset. In addition, the key must be obtained from the shift manager to access the controller. Thus, the probability of having incorrect trip points is  $(0.01)(0.03) = 3.0 \times 10^{-4}$ , as shown for Event KWOP4MIS in Figure 1, sheet 2.
2. Event KW410 is the failure of the overload protection system to stop hoisting. The two events that may result in the occurrence of Event KW410 are (a) Event KW510 in which the 110% overload protection alarm is not given (or is ignored), and (b) Event KWLCPOW in which the 125% overload alarm is not given.
  - a. Event KW510 is failure of the 110% overload protection alarm to be given or for the alarm to be ignored. Event KW510 results from either random failure of the 110% overload alarm (Event KWLCA) or from operator error of continuing to hoist after the 110% overload alarm has sounded (Event KWOP3). The following paragraphs describe each of these two events.
    - (1) Event KWLCA is the random failure of the 110% overload alarm given a load hangup has occurred. Alarms randomly fail about  $1.0 \times 10^{-6}$  per hour (EGG-SSRE-8875, page 21). It is assumed that the 110% overload circuit and alarm are tested once a year to verify the alarm works as desired. Conservatively assuming operations of 10,000 hours per year, the probability that the alarm will not function in the event that a load hangup produces 110% overload is  $(1.0 \times 10^{-6} \text{ per hour})(10,000 \text{ hours}) = 0.01$ , as shown for Event KWLCA in Figure 1, sheet 2.
    - (2) Event KWOP3 is the operator error of continuing to hoist after the 110% alarm has sounded because of a load hangup. **As** mentioned in the assumptions given in Section 4.0, the BHEP used for this operator error is 0.03, as shown for Event KWOP3 in Figure 1, sheet 2.

Either Event KWLCA or Event KWOP3 may lead to continued hoisting after a load hangup. Thus, the two probabilities (0.01 and 0.03) are added to give the total probability of 0.04 for the failure to stop hoisting, as shown for Event KW510 in Figure 1, sheet 2. The additional event that must occur to result in failure to stop hoisting is that the 125% overload protection controller must fail (KWLCPOW).

- b. Event KWLCPOW is the random failure of the overload protection controller to send a signal to stop hoisting given a 125% overload. To assign probabilities to a controller failure, the controller failure is assumed to be equivalent to a microcircuit failure (*Guide to Selected Components* [INSPEC 1981], page 92), which has a failure rate of  $1.0 \times 10^{-8}$  per hour. It is assumed that the 125% overload circuit in the controller is tested once a year to verify the alarm works as desired. Conservatively

assuming operations of 10,000 hours per year, the probability that the controller will not function in the event that a load hangup produces 125% overload is  $(1.0 \times 10^{-8} \text{ per hour})(10,000 \text{ hour}) = 1.0 \times 10^{-4}$ , as shown for Event KWLCPOW in Figure 1, sheet 2.

Because both the 125% controller must fail and the 110% alarm must fail or be ignored, the total probability that the overload protection fails to stop hoisting is the product of the two,  $(0.04)(1 \times 10^{-4}) = 4.0 \times 10^{-6}$ . This probability is shown for Event KW410 in Figure 1, sheet 2.

Either the use of incorrect trip points or the occurrence of various alarm failures may result in the overload protection failure identified as KW310 in Figure 1, sheet 2. This probability is  $3.04 \times 10^{-4}$ , which is the sum of the probabilities for KW410 and KWOP4MIS.

For Event KW220, the Load Hangup Event, to occur, both the operator error that results in a load hangup must occur along with the various failures to prevent further hoisting. Therefore, the load hangup event probability is  $(0.03)(3.04 \times 10^{-4}) = 9.12 \times 10^{-6}$ , as shown for Event KW220 in Figure 1, sheet 1.

### 5.1.3 Load Line Structural Failure (KW230)

The "Load Line Structural Failure" event leads to a load drop by failure of the transfer crane lifting components or the immersion pail lifting system. This accident is identified by name and by designator KW230 in Figure 1, sheet 1. Details are given in Figure I, sheets 3, 4, and 5.

Event KWCASK is the probability of crane failure due to component failures. KWCASK comprises four components that could fail: KWCLA, KWCRH, KWCCA, and KWCDR. Events KWCLA, KWCRH, KWCCA, and KWCDR are failures of the cask lifting attachment, crane hook, crane cable, and crane drum, respectively. These are mechanical component failures. Navy crane failure data from NUREG-0612 indicate a low-end failure probability of  $2.5 \times 10^{-5}$  per lift (NUREG-0612, page 4-3). NUREG-0612 also indicates that approximately 17% of the drops are related to crane component failures based on the Navy data (NUREG-0612, page 4-4). Thus, the crane component failure probability is  $(0.17)(2.5 \times 10^{-5} \text{ per lift}) = 4.3 \times 10^{-6}$  per lift. Given that there are four components whose failure could lead to the drop, the probability of each one failing can be taken to be one-fourth of  $4.3 \times 10^{-6}$  per lift, or about  $1.08 \times 10^{-6}$  per lift.

Event KWCASK, the probability of crane failure due to component failures, is the sum of the component failure probabilities. Because each of these four components is assumed to be one-fourth of the total, the total is just the original probability,  $4.3 \times 10^{-6}$  per lift. This probability is shown for Event KWCASK in Figure 1, sheet 3.

The immersion pail lifting system fails by failure of the lift beam (KWLB) or any three of the four lifting rigging lines (KWLSC). Event KWLB is the probability of crane failure due to failure of the lift beam. The failure probability assigned this component is conservatively assumed to be  $1.0 \times 10^{-6}$  per lift as derived for the transfer crane component failures.

Event KWLS is the probability of failure of three of four load paths for the immersion pail lifting system. Each of the four lifting rigging lines has three components: the upper hook (KWLSxUH), the lifting sling (KWLSxS), and the lower hook (KWLSxLH). The “x” refers to the rigging lines,  $x = 1, 2, 3, \text{ or } 4$ . The failure probability for each of these components is conservatively assumed to be  $1.0 \times 10^{-6}$  per lift as was derived for the transfer crane component failures. Because there are more than four components, the failure probability per component would be less than this amount. Thus, the probability of any lifting rigging line failing is the sum of the three component failure probabilities, or  $3.0 \times 10^{-6}$  per lift as shown as Events as KWLS1, KWLS2, KWLS3, and KWLS4 in Figure 1, sheets 4 and 5.

To drop the load, three of the four lifting rigging lines must fail simultaneously. The probability of this occurring is  $(3.0 \times 10^{-6})^3 = 2.7 \times 10^{-17}$ . Because there are four ways for this to occur, the result is multiplied by 4 to give  $1.08 \times 10^{-16}$  as shown for Event KWLS in Figure 1, sheet 3.

The failure of the immersion pail lifting system (Event KWIP) requires either a failure of the lift beam or a failure of the lifting rigging lines. These two probabilities are added to give the immersion pail lifting system failure probability of  $1.0 \times 10^{-6}$  shown as Event KWIP in Figure 1, sheet 3.

Finally, the load line structural failure drops the load either by failure of the transfer crane lifting components or by failure of the immersion pail lifting system. The probability of this event is the sum of the two probabilities,  $5.3 \times 10^{-6}$ , as shown for Event KW230 in Figure 1, sheet 1.

## **5.2 CRANE BRIDGE FAILURE (KW120)**

If the crane bridge fails, the load drops due to **loss** of an essential support element. The probability of such a failure is assumed to be  $1.0 \times 10^{-7}$ . This accident could happen because of material defect, damage, and/or fatigue. The event is shown in Figure 1, sheet 1, as Event KW 120.

## **5.3 CRANE TROLLEY FAILURE (KW130)**

If the crane trolley fails, the load drops due to the loss of an essential support element. The probability of such a failure is assumed to be  $1.0 \times 10^{-7}$ . This event could happen because of material defect, damage, and/or fatigue. The event is shown in Figure 1, sheet 1 as KW130.

## **5.4 HOIST DRUM FAILURE**

If the hoist drum fails, the load drops as a result of one of the following: hoist gear failure, shaft reducer failure, loss of power, or electric drive failure. These failures lead to a “free spool” condition in which the hoist spool does not maintain tension in the cables that support the load. Each of these events is discussed in further detail in this section.

#### 5.4.1 Hoist Gears Fail (KW240)

The “Hoist Gears Fail” event leads to a load drop by failure of the hoist spool to maintain tension in the supporting cables due to failure of the hoist gears combined with an inadequate response to the failure. This accident is identified by name and by designator KW240 in Figure 1, sheet 6.

Event KWHG is a failure of the drum hoist gear. Failure data on gear failures in a Savannah River failure data compilation (DP-1633, *Component Failure-Rate Data with Potential Applicability to a Nuclear Fuel Reprocessing Plant*, page 17) range from  $5.0 \times 10^{-8}$  per hour to  $1.0 \times 10^{-5}$  per hour. For conservatism,  $1.0 \times 10^{-5}$  per hour is chosen as the failure rate for drum hoist gears. Assuming a 1-hour lift, the failure probability is  $1.0 \times 10^{-5}$ , as shown in Figure 1, sheet 6, for Event KWHG.

If the hoist gears fail, a sensor sends a signal to actuate the hoist drum brake. If either fails, the load will fall.

Event KWDISEN is a failure of a discontinuity sensor associated with the hoist drum gears such that a signal is not sent to the programmable logic controller and then on to the drum brake to apply the drum brake. Failure data for sensors indicate  $1.0 \times 10^{-6}$  failures per hour (EGG-SSRE-8875, page 25). It is assumed that the discontinuity sensor is tested once a year to verify that the sensor works as desired. Conservatively assuming operations of 10,000 hours per year, the probability that the sensor will not function in the event that the hoist gear fails is  $(1.0 \times 10^{-6} \text{ per hour})(10,000 \text{ hours}) = 0.01$ , as shown for Event KWDISEN in Figure 1, sheet 6.

Event KWSHB is a failure of a solenoid hoist brake to operate on demand. The failure probability for a solenoid hoist brake is assumed to be represented by the failure probability of a solenoid valve to open on demand, which is 0.001 per demand (DP-1633, page 38), as shown for Event KWSHB in Figure 1, sheet 6.

The probability that the automatic response to a gear failure also fails is the sum of the probabilities that the sensor fails and the solenoid brake fails. This probability, 0.011, is shown in Figure 1, sheet 6, for Event KW320.

The probability that both the hoist gear fails and the automatic response fails at the same time is the product of the probabilities of the two events. This probability is  $1.1 \times 10^{-7}$  as shown in Figure 1, sheet 6, for Event KW240.

#### 5.4.2 Shaft Reducer Fails (KW250)

The “Shaft Reducer Fails” event leads to a load drop by failure of the hoist spool to maintain tension in the supporting cables due to failure of the shaft reducer combined with a failure of the mechanical load brake. This accident is identified by name and by designator Event KW250 in Figure 1, sheet 6.

Event KWRG is a failure of a reducer gear. Failure data on gears in a Savannah River failure data compilation (DP-1633, page 17) range from  $5.0 \times 10^{-8}$  per hour to  $1.0 \times 10^{-5}$  per hour. For

conservatism,  $1.0 \times 10^{-5}$  per hour is chosen as the failure rate for reducer gear. Assuming a 1-hour lift, the failure probability is  $1.0 \times 10^{-5}$ , as shown as Event KWRG in Figure 1, sheet 6.

Event KWMLB is a failure of a mechanical load brake to operate on demand. Brake failure data from the Savannah River compilation (DP-1633, page 11) range from  $4.0 \times 10^{-6}$  per hour to  $1.0 \times 10^{-5}$  per hour. For conservatism,  $1.0 \times 10^{-5}$  per hour is chosen as the failure rate for reducer gear failures. It is assumed that the mechanical load brake is tested once a year to verify that the brake works as desired. Conservatively assuming operations of 10,000 hours per year, the probability that the brake will not function in the event that the reducer gear fails is  $(1.0 \times 10^{-5} \text{ per hour})(10,000 \text{ hours}) = 0.1$ . Assuming the brakes are applied 100 times per year, the demand failure would be 0.1 per 100 demands = 0.001 per demand. This value compares well with the solenoid brake failure probability on demand; therefore, 0.001 is used to represent the failure probability of the mechanical load brake per demand, as shown for Event KWMLB in Figure 1, sheet 6.

The probability that the reducer gear and mechanical load brake fail at the same time is the product of the two probabilities. This probability is  $1.0 \times 10^{-8}$ , as shown for Event KW250 in Figure 1, sheet 6.

#### 5.4.3 Loss of Power (KW260)

The "Loss of Power" event leads to a load drop by failure of the hoist spool to maintain tension in the supporting cables due to electrical failure combined with a failure of the solenoid hoist brake and mechanical load brake. This accident is identified by name and by designator KW260 in Figure 1, sheet 7.

Event LOEP is a **loss** of electrical power as represented by losses of power in the 200 Areas over a 20-year period. Based on WHC-EP-0811, a loss of electrical power in the 200 Areas occurs approximately 1.22 times per year. This probability can be judged to be representative of power losses in the 100K Area because the Hanford Site grid supplies all areas on the Hanford Site. The yearly average power loss probability can be represented as an hourly power loss of  $1.4 \times 10^{-4}$  per hour. Thus for a 1-hour operation period per lift, the probability of loss of power per lift is  $1.4 \times 10^{-4}$ , as shown for Event LOEP in Figure 1, sheet 7.

Event KWSHB is the failure of the solenoid hoist brake. The probability of the failure of the solenoid hoist brake is 0.001, as shown for Event KWSHB in Figure 1, sheet 7. Event KWMLB is failure of the mechanical load brake. The probability of failure of the mechanical load brake is 0.001, as shown for Event KWMLB in Figure 1, sheet 7.

Because all three failures must occur at the same time for the load to drop, the probabilities for electrical failure, solenoid hoist brake failure, and mechanical load brake failure are multiplied to determine the probability of failure resulting from loss of power. Therefore, the probability of load drop resulting from loss of power is  $(1.4 \times 10^{-4})(0.001)(0.001) = 1.4 \times 10^{-10}$ , as shown for Event KW260 in Figure 1, sheet 7.



#### 5.4.4 Electric Drive Fails (KW270)

The “Electric Drive Fails” event leads to a load drop by failure of the hoist spool to maintain tension in the supporting cables due to failure of the electric hoist motor combined with a failure of the mechanical load brake. This accident is identified by name and by designator KW270 in Figure 1, sheet 7.

Event KWEM is failure of the electric hoist motor. Based on failure data for motor-driven pumps failing to run (EGG-SSRE-8875), the failure rate applied to an electric motor failing to run is  $3.0 \times 10^{-5}$  per hour. Thus for a 1-hour operation period per lift, the probability of the electric hoist motor failing to run is  $3.0 \times 10^{-5}$  as shown for Event KWEM in figure 1, sheet 7.

Event KWMLB is the failure of the mechanical load brake. The probability of the mechanical load brake is 0.001, as shown in Figure 1, sheet 7.

Because both failures must occur at the same time for the load to drop, the probabilities for electric motor failure and mechanical load brake failure are multiplied to determine the probability of failure of the electric drive. Therefore, the probability of load drop resulting from loss of the electric drive is  $(3.0 \times 10^{-5})(0.001) = 3.0 \times 10^{-8}$ , as shown for Event KW270 in Figure 1, sheet 7.

## 6.0 RESULTS

Table 1 identifies the four broad categories of accidents that can lead to load dropping — Load Support Failure, Crane Bridge Failure, Crane Trolley Failure, and Hoist Drum Failure. As shown in the table, Load Support Failure can occur in three ways; therefore, the probability of Load Support Failure is the sum of the probabilities of these three events. Hoist Drum Failure can occur in four ways; therefore, the probability of Hoist Drum Failure is the sum of the probabilities of these four events. The probability of an event occurring that could result in load drop is the sum of the probabilities for **all** the four broad categories of events, or  $1.48 \times 10^{-5}$  per lift, as shown in Table 1.

Table I. Summary of Event Probabilities

Load Droo Event	Probabilitv Der Lift
Load Support Failure (KW110)*	1.44 E-05
“Two-Blocking” Event (KW210)	9.00 E-09
Load Hangup Event (KW220)	9.12 E-06
Load Line Structural Failure (KW230)	5.30 E-06
Crane Bridge Failure (KW120)*	1.00 E-07
Crane Trolley Failure (KW130)*	1.00 E-07
Hoist Drum Failure (KW140)*	1.50 E-07
Hoist Gears Fail (KW240)	1.10 E-07
Shaft Reducer Fails (KW250)	1.00 E-07
Loss of Power (KW260)	1.40 E-10
Electric Drive Fails (KW270)	3.00 E-08
Total for the Maior Categories of Events (DROP)	1.48 E-05

\*Major category of events

The CAFTA' software, Version 2.3, was used to calculate event probabilities using the assumed failure probabilities and logic described in Section 5.0. The CAFTA software, Version 2.1, has been acceptance tested as described in WHC-SD-MP-SWD-0004, *CAFTA Computer Program Testing and Acceptance Report*. The fault tree shown in Figure 1 is an output of CAFTA along with the table listing all 124 potential failure sequences (cutsets). Table 2 shows fourteen accident sequences with probabilities of occurrence that are at least  $1 \times 10^{-8}$  per lift. The CAFTA results were verified by hand calculations described earlier with the input data.

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<sup>1</sup> CAFTA is a trademark of Electric Power Research Institute, Palo Alto, California

Table 2. Most Likely Accident Sequences for Load Drops Over the South Loadout Pit.

Module Name		Event Description	Basic Event Probability	Accident Probability
DROP		Sum total of all cases	Not applicable	1.48 E-05
1	KWOP2	Operator Hangs Up Load	3.00 E-02	9.00 E-06
	KWOP4MIS	Operator Error of Setting Both Load Cell Trip Points Too High	3.00 E-04	
2	KWCCA	Crane Cable Fails	1.08 E-06	1.08 E-06
3	KWCLA	Cask Lifting Attachment Fails	1.08 E-06	1.08 E-06
4	KWCRH	Crane Hook Fails	1.08 E-06	1.08 E-06
5	KWCDR	Crane Drum Fails	1.08 E-06	1.08 E-06
6	KWLB	Immersion Pail Lift Beam Fails	1.00 E-06	1.00 E-06
7	KW130	Crane Trolley Failure: Material Defect, Damage, and/or Fatigue	1.00 E-07	1.00 E-07
8	KW120	Crane Bridge Failure: Material Damage, Defect, and/or Fatigue	1.00 E-07	1.00 E-07
9	KWDISEN	Discontinuity Sensor Fails to Send Signal to Programmable Logic Controller to Apply Drum Brakes	1.00 E-02	1.00 E-07
	KWHG	Drum Hoist Gear Fails	1.00 E-05	
10	KWLCPOW	125% Overload Signal Not Sent So Hoisting Continues	1.00 E-04	9.00 E-06
	KWOP2	Operator Hangs Up Load	3.00 E-02	
	KWOP3	Operator Keeps Hoisting After 110% Overload Alarm Sounds	3.00 E-02	
11	KWEM	Electric Hoist Motor Fails	3.00 E-05	
	KWMLB	Mechanical Load Brake Fails	1.00 E-03	
12	KWLCA	110% Overload Alarm Fails to Function When Demanded	1.00 E-02	3.00 E-06
	KWLCPOW	125% Overload Signal Not Sent So Hoisting Continues	1.00 E-04	
	KWOP2	Operator Hangs Up Load	3.00 E-02	
13	KWHG	Drum Hoist Gear Fails	1.00 E-05	1.00 E-08
	KWSHB	Solenoid Hoist Brake Fails	1.00 E-03	
14	KWMLB	Mechanical Load Brake Fails	1.00 E-03	1.00 E-06
	KWRG	Reducer Gear Fails	1.00 E-05	

NOTE: The above list of fourteen accident sequences (cutsets) was generated by CAFTA Version 2.3. Accidents with probabilities less than 1 E-06 are not shown in this table. The complete list of accident sequences is given in Figure 2 of this document.

Seismic events should be included as a potential initiator of load drop accidents. The frequency of a design basis seismic event is  $4.0 \times 10^{-4}$  per year at the K Basins (HNF-SD-WM-SAR-062, *K Basins Final Safety Analysis Report*). The probability of a seismic event while an MCO is being lifted is lower because most of the time MCOs are not being lifted. If it is conservatively assumed that the MCOs are being lifted 1,000 hours per year, then the seismic-induced drop frequency is  $4.6 \times 10^{-5}$  per year as shown in the calculation below.

$$(4.0 \times 10^{-4} \text{ /yr}) \left( \frac{1,000 \text{ h/yr}}{8,766 \text{ h/yr}} \right) = 4.6 \times 10^{-5} \text{ /yr}$$

If the MCO-drop accident frequency must be limited to 0.01 per year, the non-seismic accident frequency limit should be reduced to  $0.01 - 0.000046 = 0.00995$  per year. Evidently, the seismic-induced accidents are a minor portion of the total. If four lifts are required when handling each MCO in the south loadout pit, then the point estimate value for the frequency of potential drops in the south loadout pit is  $6.0 \times 10^{-5}$  per MCO. Thus, the south loadout pit must be limited to handling 165 MCOs per year as shown in the calculation below.

$$\frac{0.00995 \text{ /yr}}{6.0 \times 10^{-5} \text{ /MCO}} = 165 \text{ MCO/yr}$$

## 7.0 CONCLUSION

The probability for cask-MCO drops of  $1.5 \times 10^{-5}$  per lift is approximately a factor of two smaller than the value used in WHC-SD-WM-SAR-062, (page 3A-3 ( $2.7 \times 10^{-5}$  per lift)). The value of  $2.7 \times 10^{-5}$  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 in NUREG-0612 is  $3.0 \times 10^{-4}$  per lift.

## 8.0 REFERENCES

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Figure 1. Multi-Canister Overpack Cask Drop in K West South Loadout Pit. (Sheet 1 of 8)

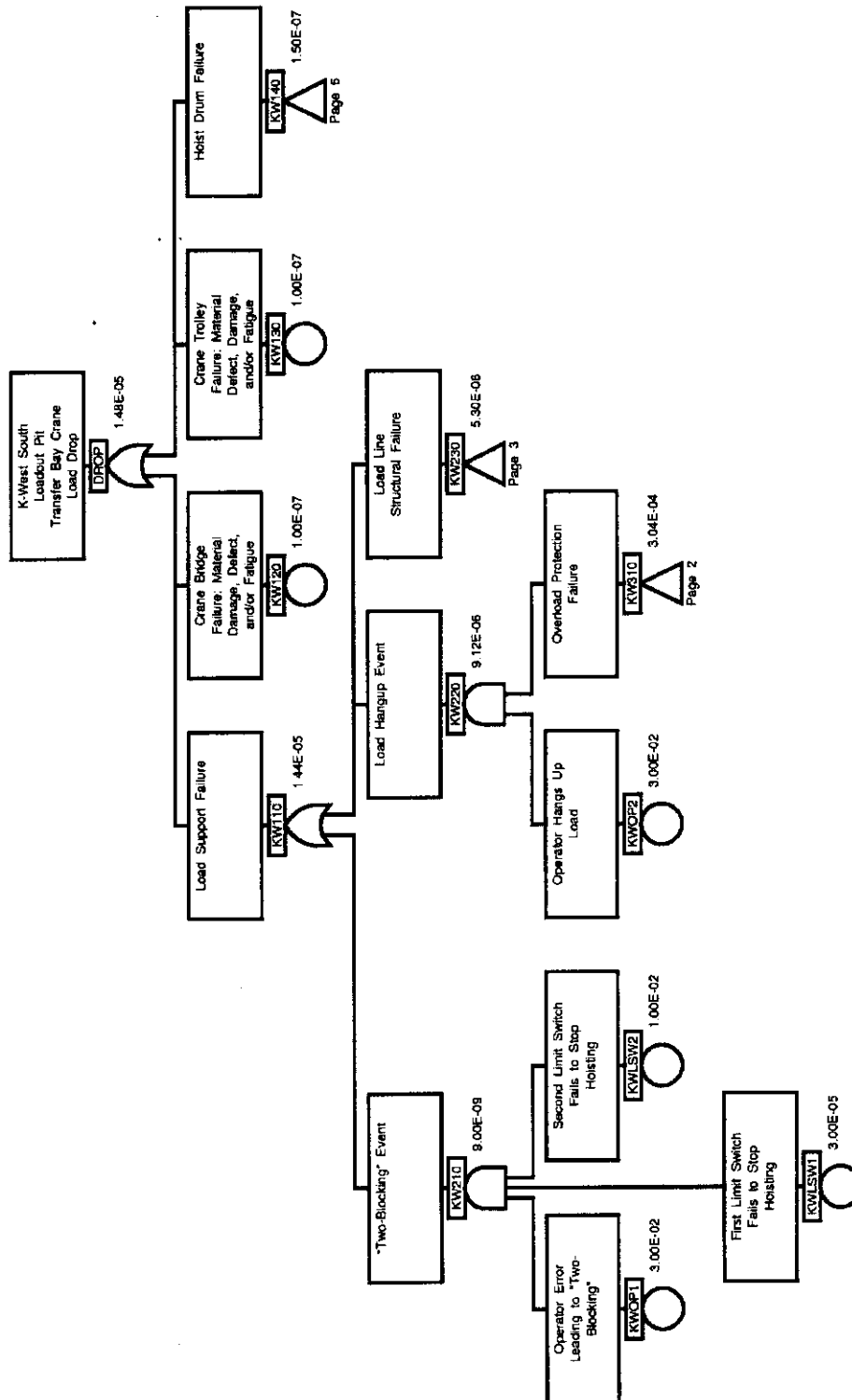


Figure 1. Multi-Canister Overpack Cask Drop in K West South Loadout Pit. (Sheet 2 of 8)

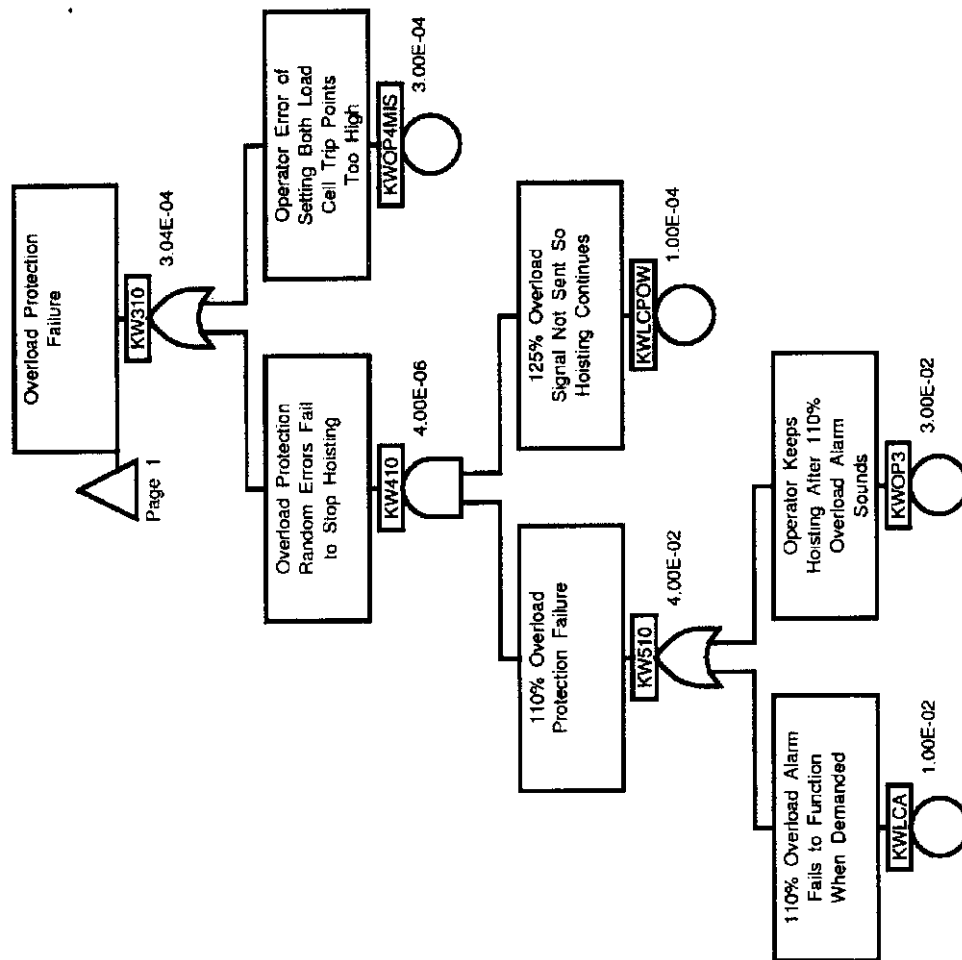




Figure 1. Multi-Canister Overpack Cask Drop in K West South Loadout Pit. (Sheet 3 of 8)

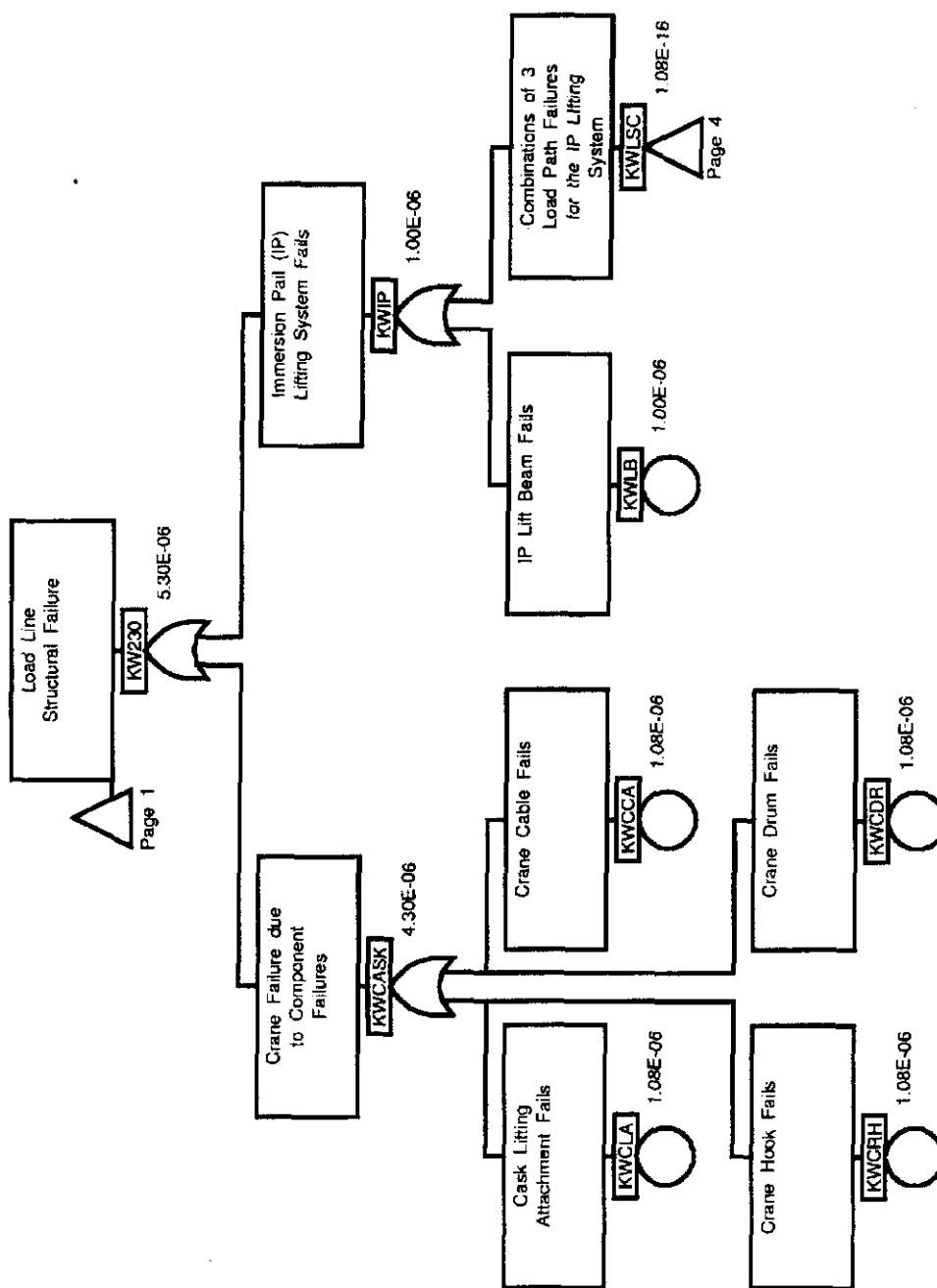


Figure 1. Multi-Canister Overpack Cask Drop in K West South Loadout Pit. (Sheet 4 of 8)

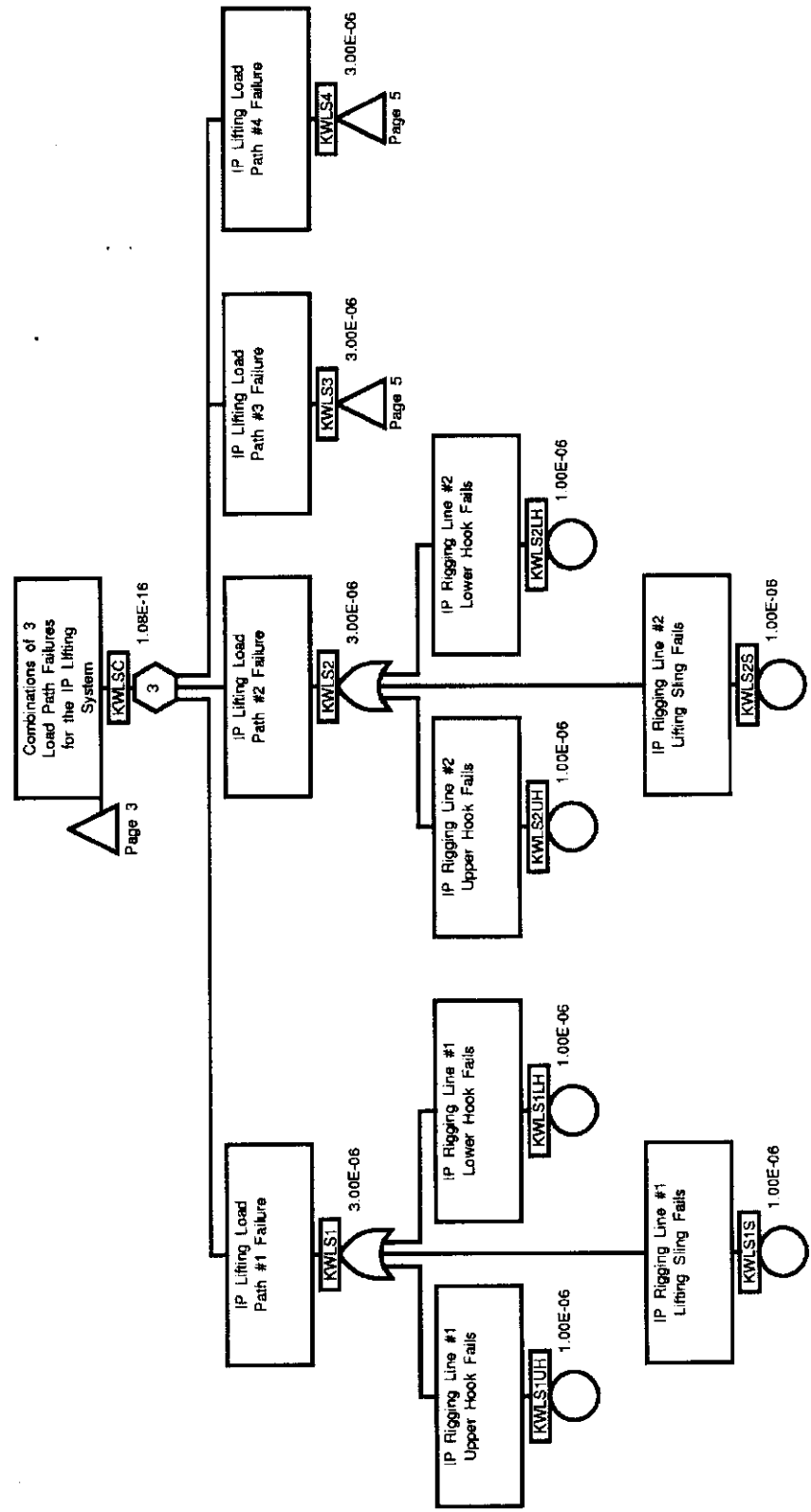


Figure 1. Multi-Canister Overpack Cask Drop in K West South Loadout Pit. (Sheet 5 of 8)

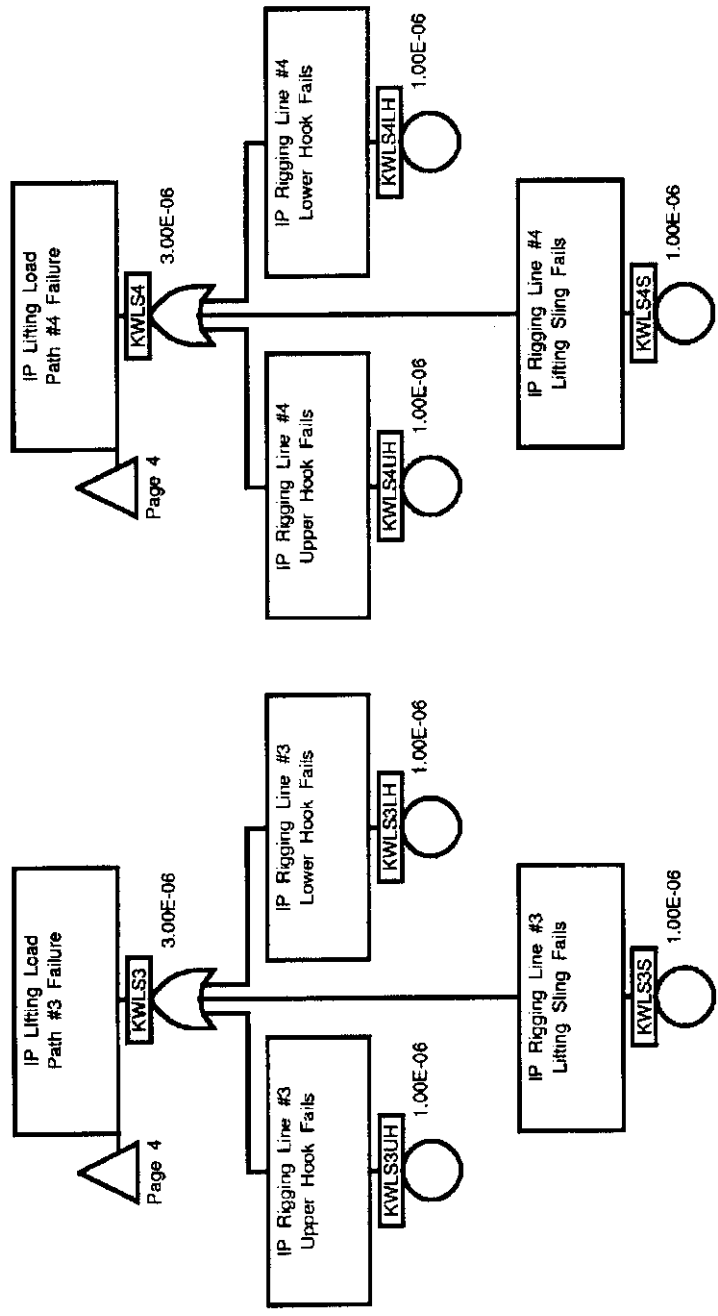


Figure 1. Multi-Canister Overpack Cask Drop in K West South Loadout Pit. (Sheet 6 of 8)

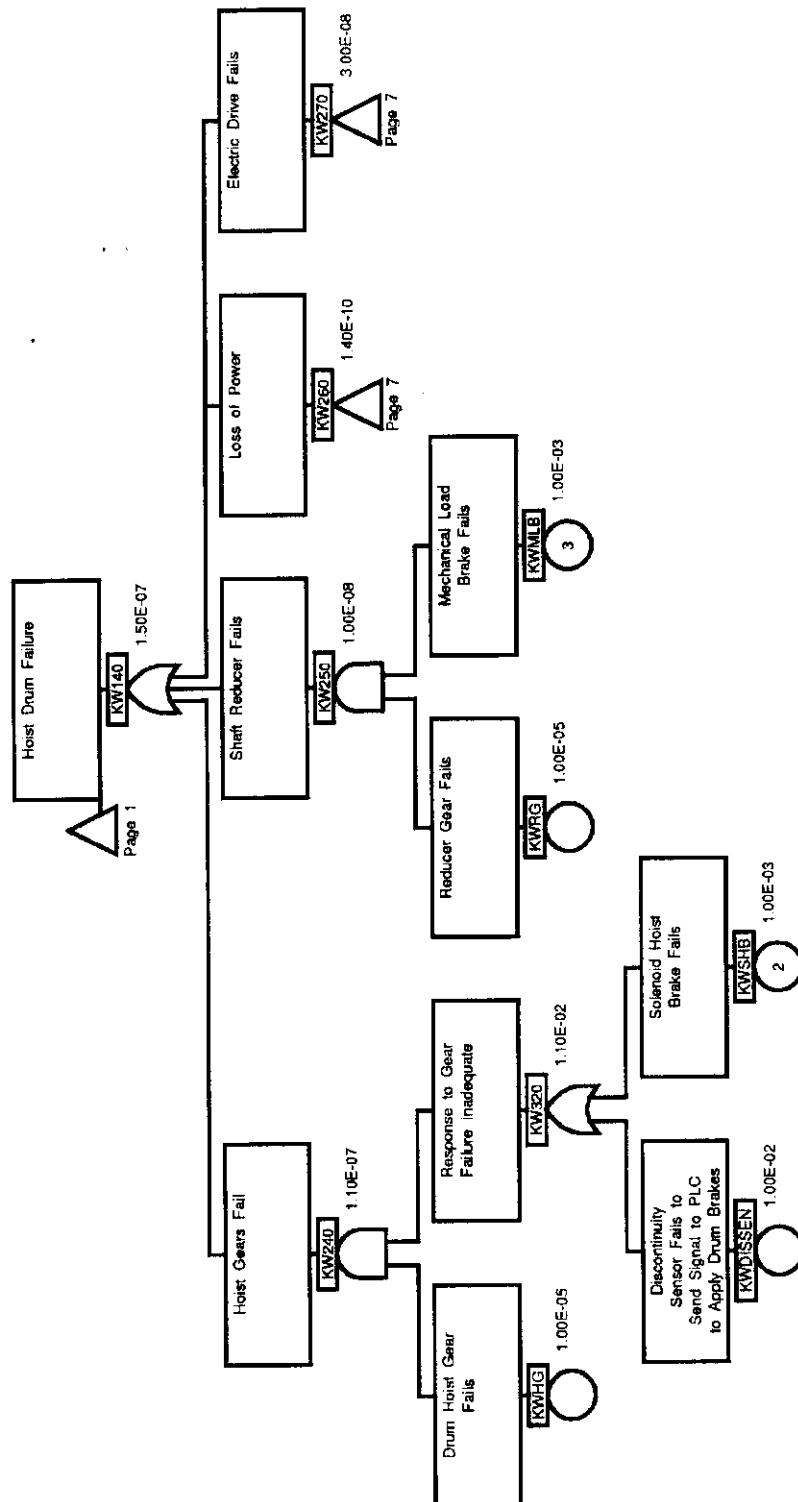


Figure 1. Multi-Canister Overpack Cask Drop in **K** West South Loadout Pit. (Sheet 7 of 8)

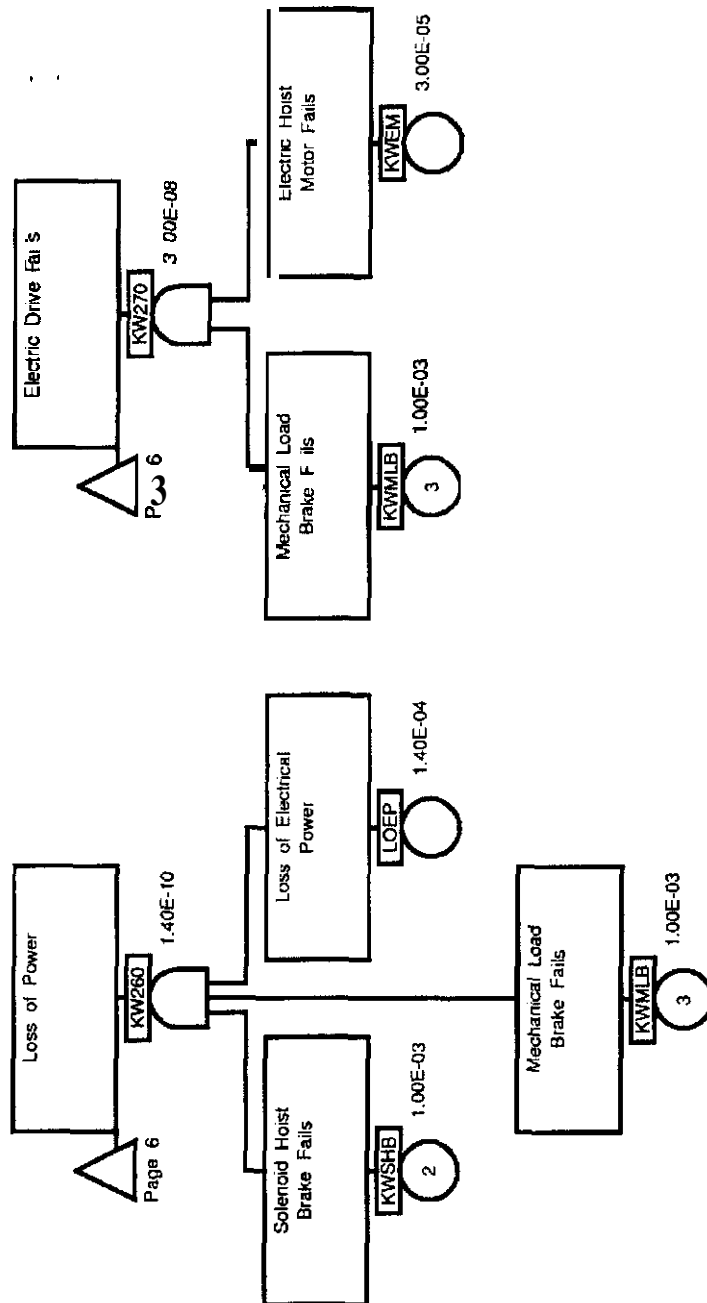


Figure 1. Multi-Canister Overpack **Cask** Drop in K West South Loadout Pit. (Sheet 8 of 8)

<u>Gate/Event Name</u>	<u>Page</u>	<u>Zone</u>	<u>Gate/Event Name</u>	<u>Page</u>	<u>Zone</u>
DROP	1	5	KWLS2LH	4	4
KW110	1	3	KWLS2S	4	4
KW120	1	4	KWLS2UH	4	3
KW130	1	5	KWLS3	4	5
KW140	1	6	KWLS3	5	2
KW140	6	4	KWLS3LH	5	2
KW210	1	2	KWLS3S	5	2
KW220	1	4	KWLS3UH	5	1
KW230	1	5	KWLS4	4	6
KW230	3	2	KWLS4	5	4
KW240	6	2	KWLS4LH	5	4
KW250	6	4	KWLS4S	5	4
KW260	6	5	KWLS4UH	5	3
KW260	7	2	KWLS4UH	5	3
KW270	6	6	KWLS4UH	3	4
KW270	7	4	KWLS4UH	4	4
KW310	1	4	KWLS4UH	1	2
KW310	2	2	KWLS4UH	1	2
KW320	6	2	KWLS4UH	6	4
KW410	2	2	KWLS4UH	7	2
KW510	2	1	KWLS4UH	7	3
KWCASK	3	2	KWLS4UH	1	1
KWCCA	3	2	KWLS4UH	1	3
KWCCR	3	2	KWLS4UH	2	2
KWCLA	3	2	KWLS4UH	2	3
KWCRH	3	1	KWLS4UH	6	3
KWDISEN	6	2	KWLS4UH	6	3
KWEM	7	4	KWLS4UH	7	1
KWHG	6	1	KWLS4UH	7	2
KWIP	3	4	KWLS4UH		
KWLB	3	3	KWLS4UH		
KWLCA	2	1	KWLS4UH		
KWLCPOW	2	2	KWLS4UH		
KWLS1	4	2	KWLS4UH		
KWLS1LH	4	2	KWLS4UH		
KWLS1S	4	2	KWLS4UH		
KWLS1UH	4	1	KWLS4UH		
KWLS2	4	4	KWLS4UH		

Figure 2. Listing of the **CAFTA** Cutset Report. (Sheet 1 of 6)

KWDRP.CUT		CUTSET REPORT	8-23-01	9:27	Page	1
Filter: 'ALL'		Truncation Limit: 1.00E-30				
MODULE/EVENT NAME	DESCRIPTION	B.E. PROB.	MOD./CS. PROB.			
-----	-----	----				
1) DROP					*1.48E-05	
1) KWQP2	Operator Hangs Up Load	3.00E-02			9.00E-06	
KWQP4MIS	Operator Error of Setting Both Load Cell	3.00E-04				
21 KWCCA	Crane Cable Fails	1.08E-06			1.08E-06	
31 KWCLA	Cask Lifting Attachment Fails	1.08E-06			1.08E-06	
41 KWCRH	Crane Hook Fails	1.08E-06			1.08E-06	
51 KWCDR	Crane Drum Fails	1.08E-06			1.08E-06	
6) KWLB	IP Lift Beam Fails	1.00E-06			1.00E-06	
7) KW130	Crane Trolley Failure: Material Detect,	1.00E-07			1.00E-07	
8) KW120	Crane Bridge Failure: Material Damage.	1.00E-07			1.00E-07	
9) KWDISSEN	Discontinuity Sensor Fails to Send Signa	1.00E-02			1.00E-07	
KWHG	Drum Hoist Gear Fails	1.00E-05				
10) KWLCPOW	125% Overload Signal Not Sent So Hoistin	1.00E-04			9.00E-08	
KWQP2	Operator Hangs Up Load	3.00E-02				
KWQP3	Operator Keep5 Hoisting After 110% Overl	3.00E-02				
11) KWEM	Electric Hoist Motor Fails	3.00E-05			3.00E-08	
KWMLB	Mechanical Load Brake Fails	1.00E-03				
121 KWLCA	110% Overload Alarm Fails to Function Wh	1.00E-02			3.00E-08	
KWLCPOW	125% Overload Signal Not Sent So Hoistin	1.00E-04				
KWQP2	Operator Hangs Up Load	3.00E-02				
131 KWHG	Drum Hoist Gear Fails	1.00E-05			1.00E-08	
KWSHB	Solenoid Hoist Brake Fails	1.00E-03				
14) KWMLB	Mechanical Load Brake Fails	1.00E-03			1.00E-08	
KWRG	Reducer Gear Fails	1.00E-05				
15) KWLSW1	First Limit Switch Fails to Stop Hoistin	3.00E-05			9.00E-09	
KWLSW2	Second Limit Switch Fails to Stop Hoisti	1.00E-02				
KWQP1	Operator Error Leading to "Two-Blocking"	3.00E-02				
161 KWMLB	Mechanical Load Brake Fails	1.00E-03			1.40E-10	
KWSHB	Solenoid Hoist Brake Fails	1.00E-03				
LOEP	Loss of Electrical Power	1.40E-04				
171 KWLS2S	IP Rigging Line #2 Lifting Sling Fails	1.00E-06			1.00E-18	
KWLS3S	IP Rigging Line #3 Lifting Sling Fails	1.00E-06				
KWLS4S	IP Rigging Line #4 Lifting Sling Fails	1.00E-06				
18) KWLS2S	IP Rigging Line #2 Lifting Sling Fails	1.00E-06			1.00E-18	
KWLS3LH	IP Rigging Line #3 Lower Hook Fails	1.00E-06				
KWLS4S	IP Rigging Line #4 Lifting Sling Fails	1.00E-06				
19) KWLS2S	IP Rigging Line #2 Lifting Sling Fails	1.00E-06			1.00E-18	
KWLS3LH	IP Rigging Line #3 Lower Hook Fails	1.00E-06				
KWLS4LH	IP Rigging Line #4 Lower Hook Fails	1.00E-06				
20) KWLS2LH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E 8	
KWLS3S	IP Rigging Line #3 Lifting Sling Fails	1.00E-06				
KWLS4LH	IP Rigging Line #4 Lower Hook Fails	1.00E-06				
211 KWLS2LH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E 8	
KWLS3UH	IP Rigging Line #3 Upper Hook Fails	1.00E-06				
KWLS4LH	IP Rigging Line #4 Lower Hook Fails	1.00E-06				
22) KWLS2LH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E 8	
KWLS3LH	IP Rigging Line #3 Lower Hook Falls	1.00E-06				
KWLS4S	IP Rigging Line #4 Lifting Sling Fails	1.00E-06				
231 KWLS2LH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E 8	
KWLS3UH	IP Rigging Line #3 Upper Hook Fails	1.00E-06				
KWLS4S	IP Rigging Line #4 Lifting Sling Fails	1.00E-06				
24) KWLS2LH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E-18	
KWLS3LH	IP Rigging Line #3 Lower Hook Fails	1.00E-06				
KWLS4UH	IP Rigging Line #4 Upper Hook Fails	1.00E-06				
25) KWLSZLH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E-18	
KWLS3S	IP Rigging Line #3 Lifting Sling Fails	1.00E-06				
KWLS4S	IP Rigging Line #4 Lifting Sling Fails	1.00E-06				
26) KWLS2LH	IP Rigging Line #2 Lower Hook Fails	1.00E-06			1.00E-18	
KWLS3UH	IP Rigging Line #3 Upper Hook Fails	1.00E-06				
KWLS4UH	IP Rigging Line #4 Upper Hook Fails	1.00E-06				

Figure 2. Listing of the CAFTA Cutset Report. (Sheet 2 of 6)

271	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	LOGE-06	
28)	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	upper Hook Fails	1.00E-06	
291	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
30)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IF Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
31)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
321	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
331	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
34)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	LOGE-18
	KWLSZS	IF Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
351	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
361	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
37)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
38)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
39)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
40)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
41)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
421	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	LOGE-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
43)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
441	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	LOGE-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4S	IF Rigging Line #4	Lifting Sling Fails	1.00E-06	
451	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	LOGE-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
461	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLSZUH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
47)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	LOGE-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
481	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
49)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	



Figure 2. Listing of the CAFTA Cutset Report. (Sheet 3 of 6)

50)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
51)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
52)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
53)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
54)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
55)	KWLS1UH	IP Rigging Line #1	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
56)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
57)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
58)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
59)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
60)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
61)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
62)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
63)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
64)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
65)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
66)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
67)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
68)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
69)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
70)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
71)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
72)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	

Figure 2. Listing of the CAFTA Cutset Report. (Sheet 4 of 6)

731	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
741	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
751	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLSZUH	IP Rigging Line #2	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
76)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
77)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
78)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
79)	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS4LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
801	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLSZUH	IP Rigging Line #2	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
811	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line <b>U3</b>	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line <b>U4</b>	Lower Hook Fails	1.00E-06	
821	KWLS1S	IP Rigging Line #1	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
83)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
84)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
851	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZS	IP Rigging Line #2	Lifting Sling <b>Fails</b>	1.00E-06	
	KWLS3UH	IP Rigging Line #3	<b>Upper</b> Hook Fails	1.00E-06	
86)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
871	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
881	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZS	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
89)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZS	IP Rigging Line #2	Lifting Sling <b>Fails</b>	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
901	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower <b>Hook</b> Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
91)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZUH	IP Rigging Line #2	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower <b>Hook</b> Fails	1.00E-06	
921	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZUH	IP Rigging Line #2	<b>Upper</b> Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
93)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
941	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower <b>Hook</b> Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper</b> Hook Fails	1.00E-06	
951	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	<b>Lower</b> Hook <b>Fails</b>	1.00E-06	

Figure 2. Listing of the CAFTA Cutset Report. (Sheet 5 of 6)

96)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
97)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZLH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
98)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
99)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
100)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
101)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZS	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
102)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
103)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
104)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSZLH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
105)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
106)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
107)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSLUH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
108)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLSLLH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
109)	KWLS1LH	IP Rigging Line #1	Lower Hook Fails	1.00E-06	1.00E-18
	KWLS2LH	IP Rigging Line #2	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
110)	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
111)	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
112)	KWLSZUH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
113)	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
114)	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
115)	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
116)	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
117)	KWLS2UH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4LH	IP Rigging Line #4	Lower Hook Fails	1.00E-06	
118)	KWLSZUH	IP Rigging Line #2	Upper Hook Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	Upper Hook Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	

Figure 2. Listing of the CAFTA Cutset Report. (Sheet 6 of 6)

119)	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper Hook</b> Fails	1.00E-06	
	KWLS4S	IP Rigging Line #4	Lifting Sling Fails	1.00E-06	
120)	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper Hook Fails</b>	1.00E-06	
	KWLS4LH	<b>IP</b> Rigging Line #4	<b>Lower Hook</b> Fails	1.00E-06	
1211	KWLS2UH	IP Rigging Line #2	<b>Upper Hook</b> Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper Hook</b> Fails	1.00E-06	
1221	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3S	IP Rigging Line #3	Lifting Sling Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	Upper Hook Fails	1.00E-06	
123)	KWLS2S	IP Rigging Line #2	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3LH	IP Rigging Line #3	Lower Hook Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper Hook</b> Fails	1.00E-06	
1241	KWLSZS	<b>IP</b> Rigging Line #2	Lifting Sling Fails	1.00E-06	1.00E-18
	KWLS3UH	IP Rigging Line #3	<b>Upper Hook</b> Fails	1.00E-06	
	KWLS4UH	IP Rigging Line #4	<b>Upper Hook</b> Fails	1.00E-06	

## CHECKLIST FOR TECHNICAL PEER REVIEW

Desk Instruction 2.0. Rev. 1

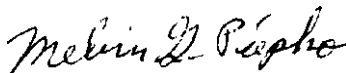
## CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed - SNF-5413, Rev. 1Title: Potential Multi-Canister Overpack Cask Drop in the K West Basin South Loadout PitAuthor: P. RittmannDate: September 18, 2001

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

M. G. Piepho

Technical Peer Reviewer (printed name and signature)



9/18/01

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 understandable to a technically qualified third party

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