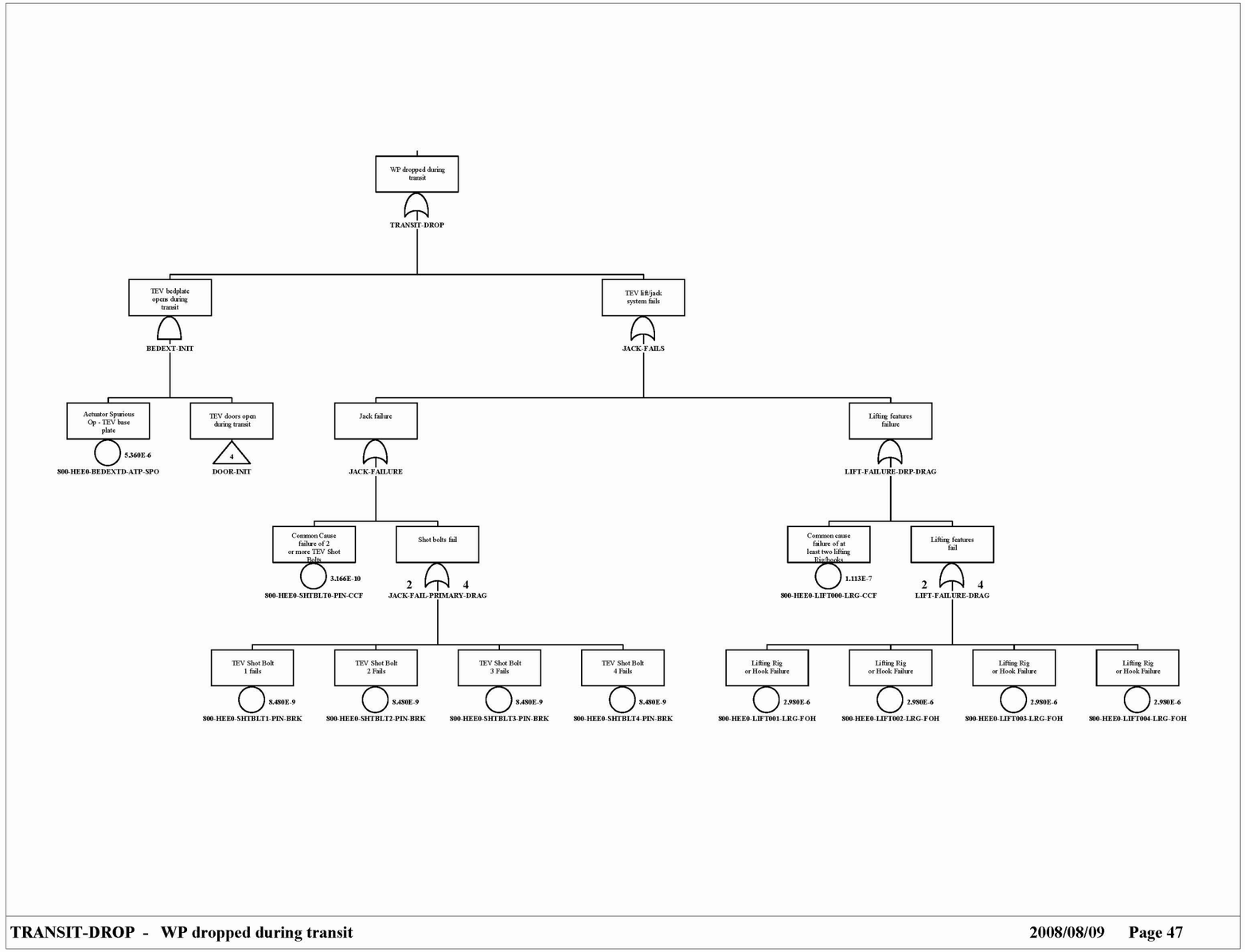

Source: Original

Figure B1.4-38. TRANSIT- DROP (1 of 2) Waste Package Dropped During Transit

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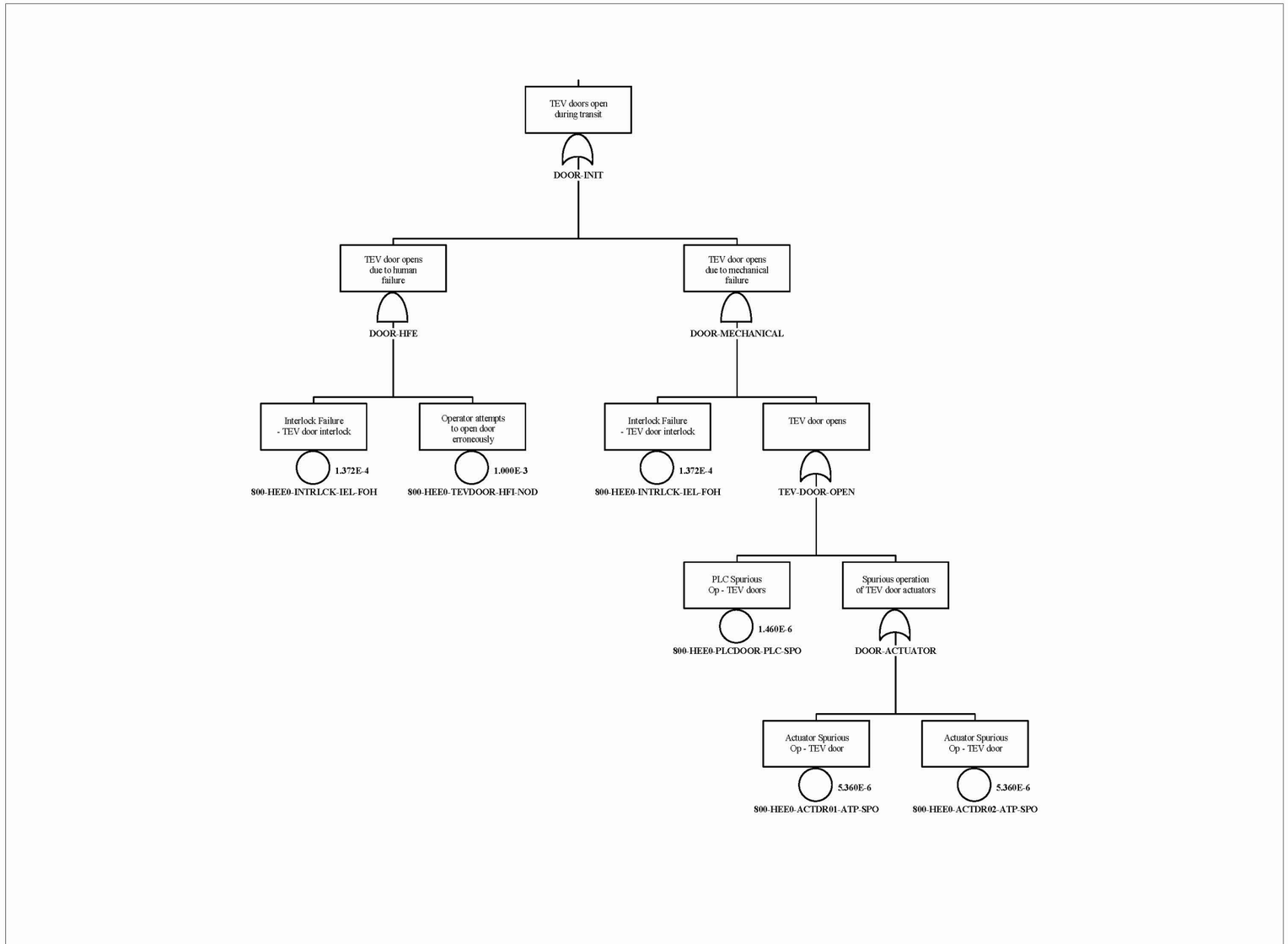

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Figure B1.4-39. TRANSIT- DROP (2 of 2) Waste Package Dropped During Transit

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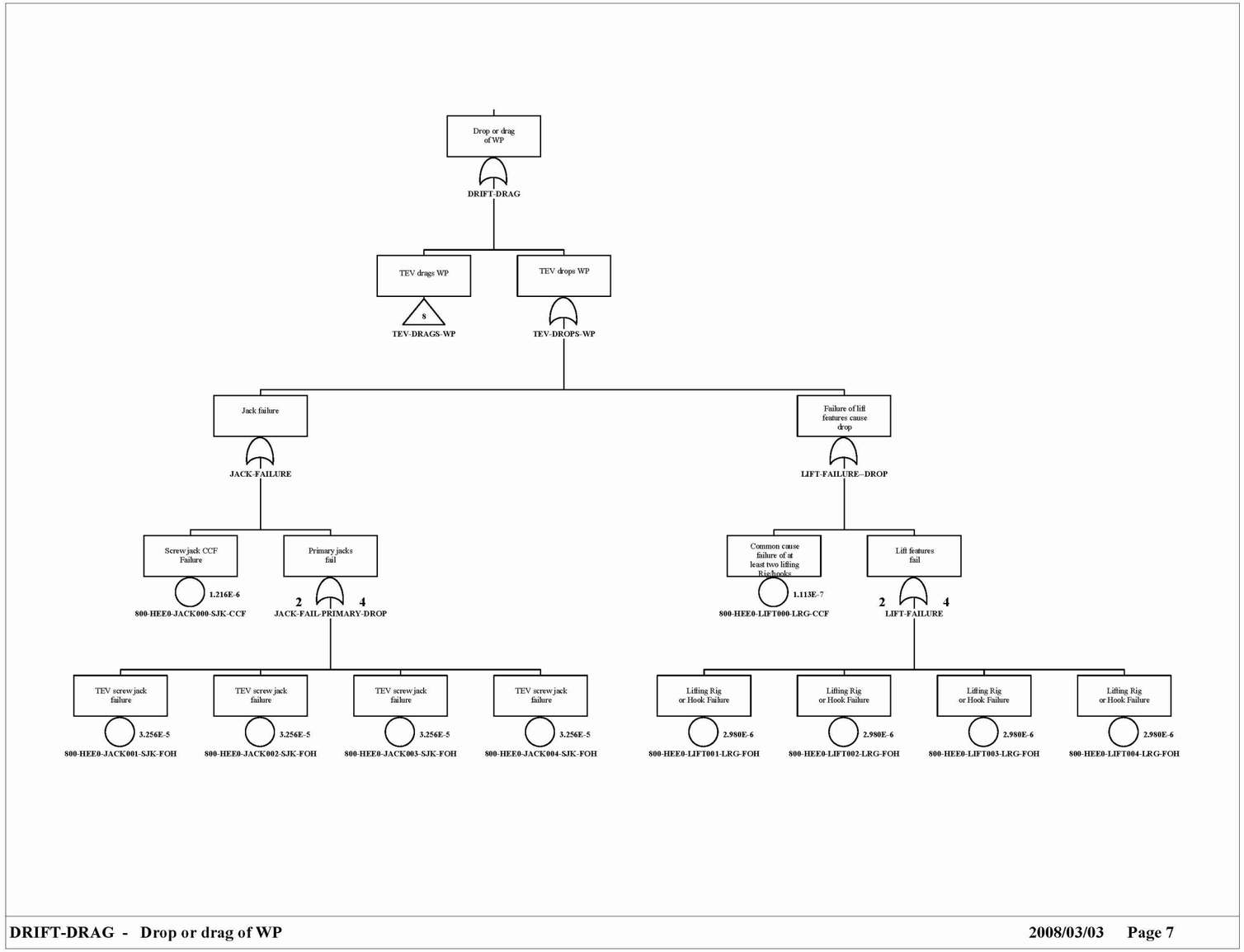

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Figure B1.4-40. DRIFT-DRAG (1 of 3) – Drop or Drag of Waste Package by TEV in Emplacement Drift

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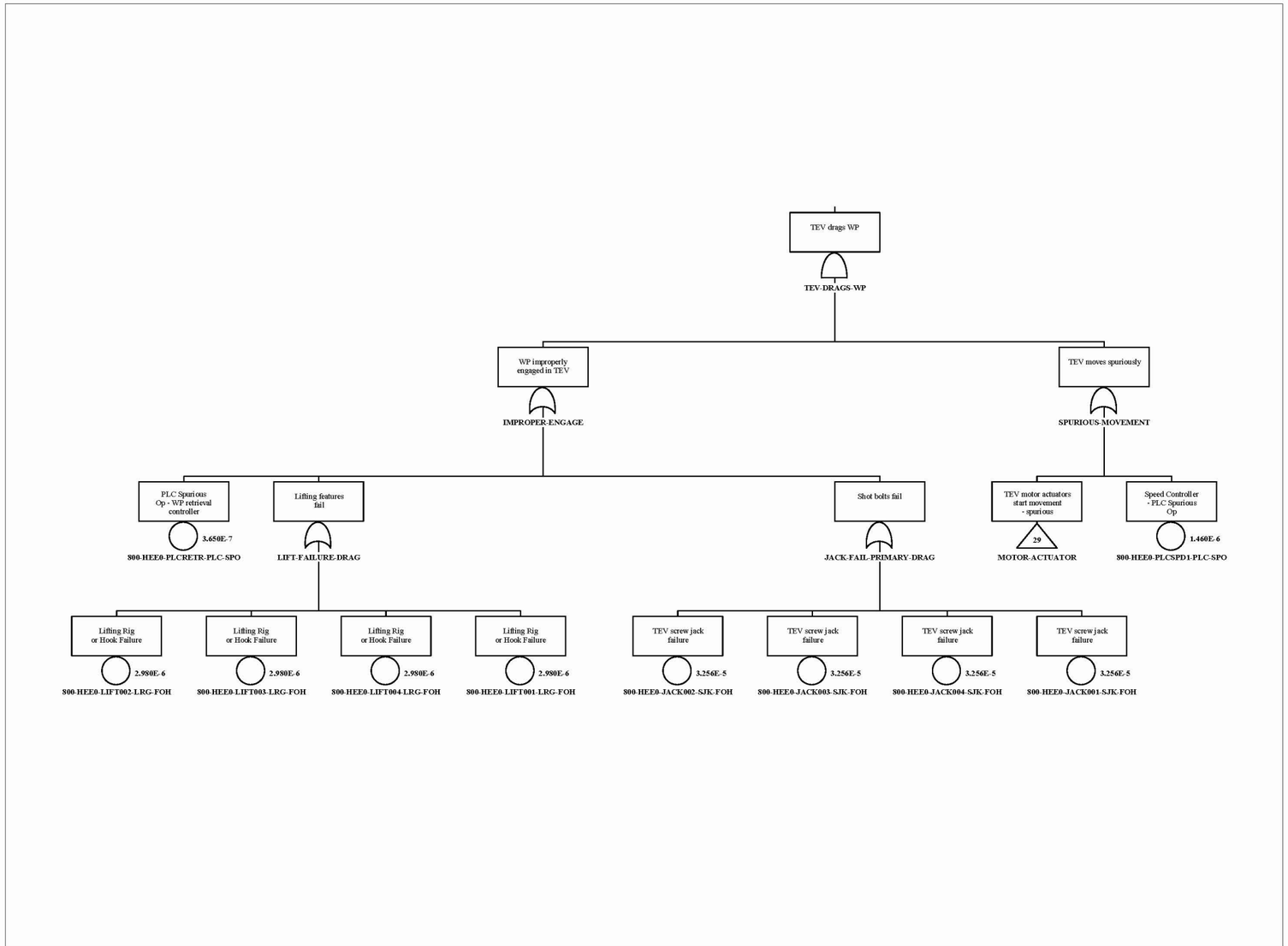

Source: Original

Figure B1.4-41. DRIFT-DRAG (2 of 3) – Drop or Drag of Waste Package by TEV in Emplacement Drift

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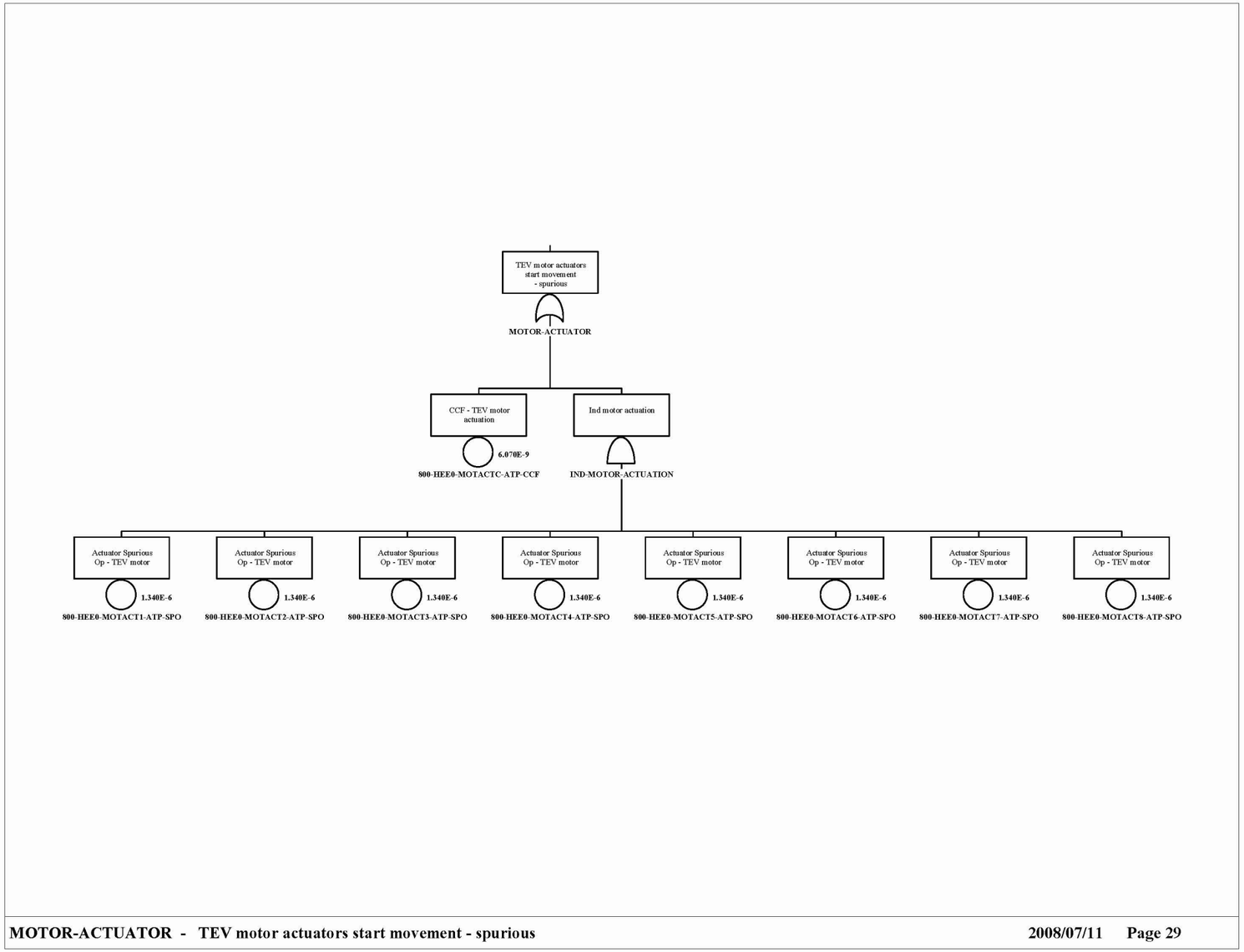

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Figure B1.4-42. DRIFT-DRAG (3 of 3) – Drop or Drag of Waste Package by TEV in Emplacement Drift

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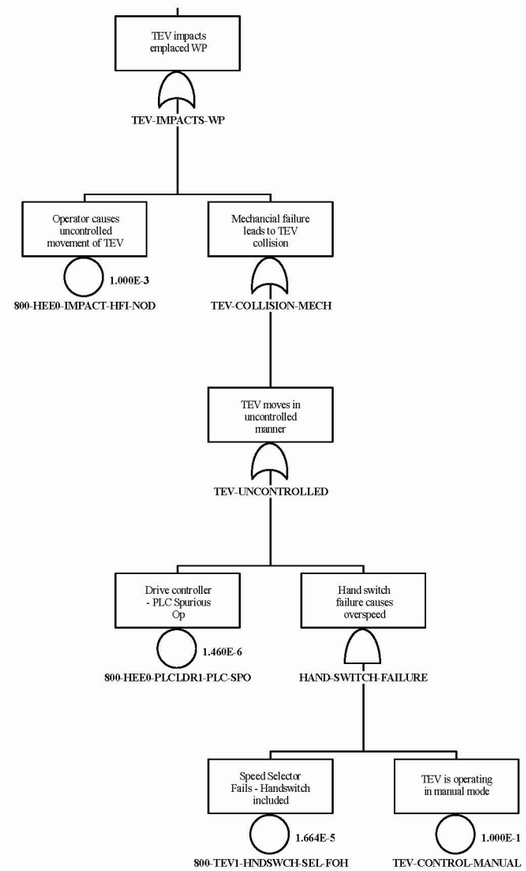

TEV-IMPACTS-WP - TEV impacts emplaced WP **2008/03/04** **Page 16**

Source: Original

Figure B1.4-43. TEV-IMPACTS-WP – TEV Impacts Waste Package in Emplacement Drift

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B2 HEATING VENTILATION AND AIR CONDITIONING FAULT TREE ANALYSIS

B2.1 REFERENCES

Design Inputs

The PCSA is a safety analysis based on a snapshot of the design. The reference design documents are appropriately documented as design inputs in this section. Since the safety analysis is based on a snapshot of the design, referencing subsequent revisions to the design documents (as described in EG-PRO-3DP-G04B-00037, *Calculations and Analyses* (Ref. 2.1.1, paragraph 3.2.2.F) that implement PCSA requirements flowing from the safety analysis would not be appropriate for the purpose of the PCSA.

B2.1.1 Not used.

B2.1.2 Not used.

B2.1.3 BSC (Bechtel SAIC Company) 2007. *CRCF 1 Composite Vent Flow Diagram Tertiary Conf ITS Exhaust & Non-ITS HVAC Supply Systems.* 060-M50-VCT0-00101-000 REV 00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071227.0013.

B2.1.4 BSC 2007. *CRCF 1 ITS Confinement Areas HEPA Exhaust System—Train A Ventilation & Instrumentation Diagram.* 060-M80-VCT0-00103-000 REV 00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071204.0005.

B2.1.5 BSC 2007. *CRCF 1 ITS Confinement Areas HEPA Exhaust System—Train B Ventilation & Instrumentation Diagram.* 060-M80-VCT0-00104-000 REV 00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071204.0006.

B2.1.6 BSC 2007. *CRCF 1 Equipment Sizing and Selection Calculation (ITS).* 060-M8C-VCT0-00500-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071220.0032.

Design Constraints

B2.1.7 NRC (Nuclear Regulatory Commission) 2007. *Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program.* HLWRS-ISG-03. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20070918.0096.

B2.2 CANISTER RECEIPT AND CLOSURE FACILITY HEATING, VENTILATION, AND AIR CONDITIONING SYSTEM DESCRIPTION

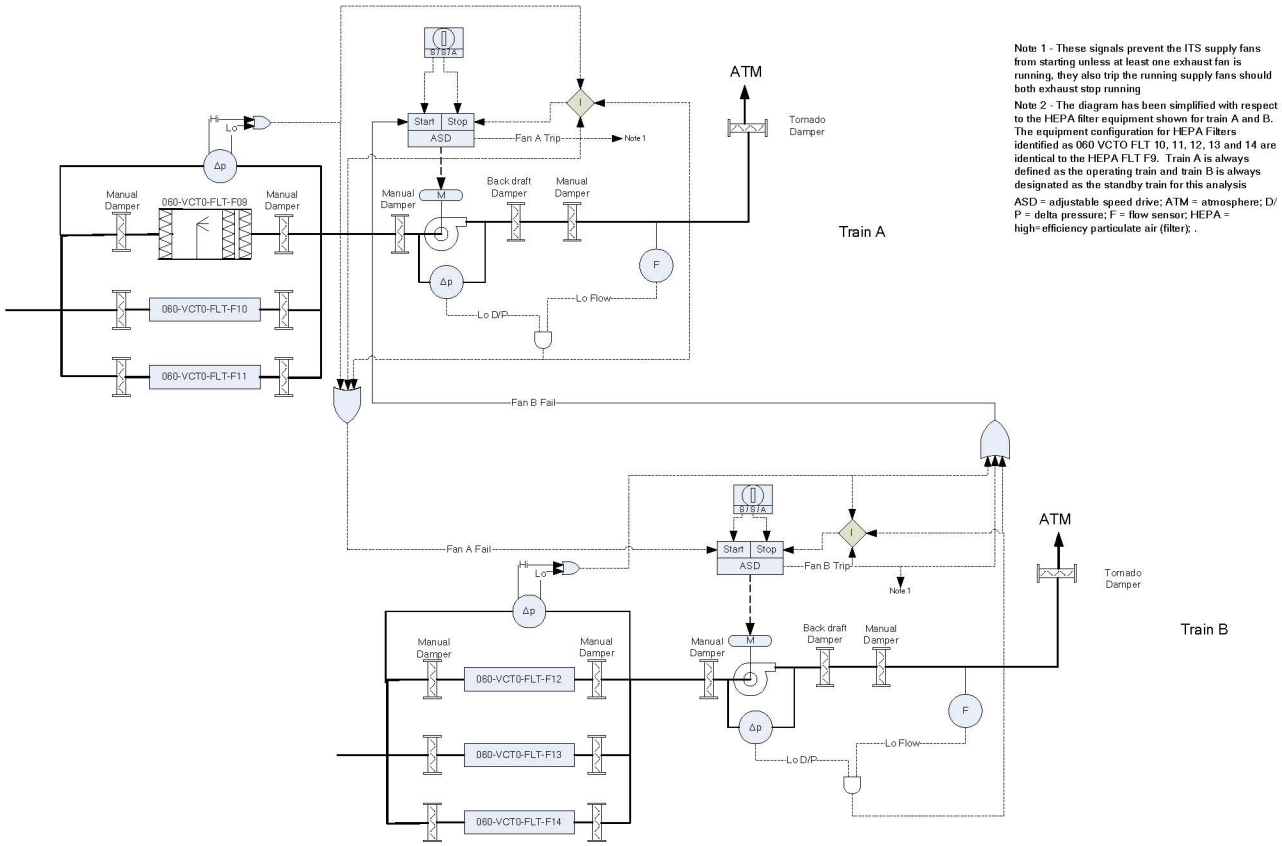
B2.2.1 Overview

The CRCF HVAC system provides high-efficiency particulate air (HEPA) filtered exhaust from the CRCF waste handling areas denoted as tertiary confinement (C2) zones. This filtration minimizes the potential of discharging radioactive material released during waste handling operations to the environment. The CRCF HVAC system consists of two identical trains. Each train consists of one exhaust fan, three parallel HEPA filtered exhaust plenums, isolation and backdraft dampers, and associated instrumentation and controls. The normal system status consists of one train in operation and the other train in standby. Each HVAC train exhausts air through separate discharge ducts into the atmosphere. Each train is equipped with a backdraft damper to ensure that there is no airflow from the atmosphere back through the standby train.

A simplified schematic of the system and its associated controls is provided in Figure B2.2-1. The general location of the major HVAC components and the general direction of air flow through the waste handling areas are depicted in Figure B2.2-2.

Additional information related to equipment sizing, air distribution, ventilation rates, and transport velocities required to maintain design negative pressures and flows within the C2 zones is provided in *CRCF 1 Equipment Sizing and Selection Calculation (ITS)* (Ref. B2.1.6, Section 6.1).

Major components that comprise the HVAC system include a series of dampers that isolate components and prevent reverse flow through the system, six HEPA filter plenums (three in each train) that remove particulate matter from the exhaust, and two exhaust fans (one in each train). Normal system control is provided by the DCMIS through adjustable speed drives (ASDs) associated with each fan.

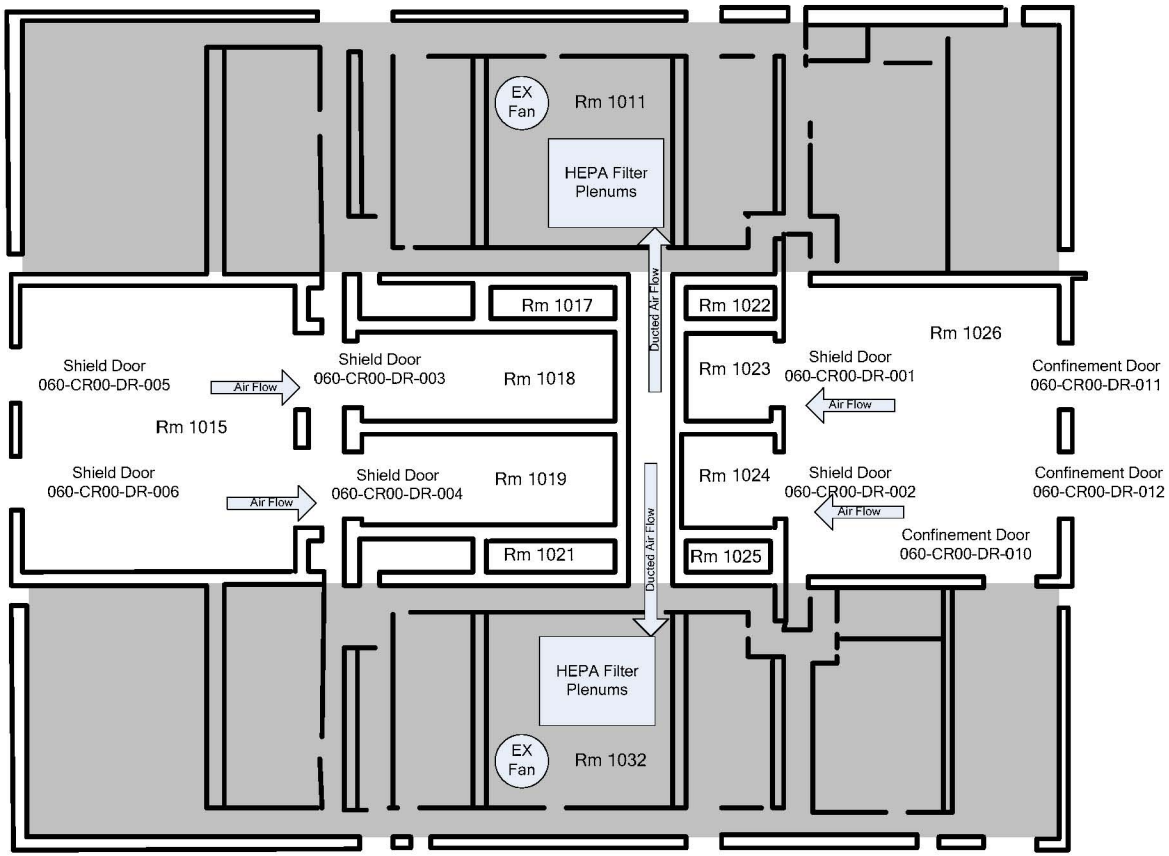


NOTE: The diagram has been simplified with respect to the HEPA filter equipment shown for train A and B. The equipment configuration for HEPA Filters identified as 060 VCTO FLT 10, 11, 12, 13 and 14 are identical to the HEPA FLT 9. In addition, train B has the same input/output dampers shown for train A. Train A is always defined as the operating train and train B is always designated as the standby train.

ASD = adjustable speed drive; ATM = atmosphere; CRCF = Canister Receipt and Closure Facility; DP = delta pressure; FSL = flow sensor low; ITS = important to safety; HEPA = high-efficiency particulate air (filter); PDSL = pressure differential sensor low.

Source: Original

Figure B2.2-1. Block Diagram of the CRCF HVAC System



Tertiary confinement zone (C2) is represented by the non-shaded areas
Air flow into the HEPA filter plenums is ducted from rooms 1022 through 1025 and Rooms 1017, 1018, 1019, and 1021

NOTE: EX = exhaust; HEPA = high-efficiency particulate air; Rm = room.

Source: Original

Figure B2.2-2. General Location for the CRCF HVAC System

B2.2.2 Damper Subsystem Description

The CRCF HVAC system uses manual, backdraft, and tornado dampers to control the airflow and pressure inside the containment area, to isolate components, and to prevent backflow through the standby system. With the exception of the tornado and backdraft dampers, all control dampers in the CRCF HVAC system are manual dampers. These dampers may be closed when maintenance is required on the standby train.

Manual dampers are located on the input and output sides of the HEPA filter plenum. These dampers are used to isolate the HEPA filter plenum, if required, during maintenance. There is a manual damper on the input side of the exhaust fan that is used to isolate the entire HEPA filter subsystem while maintenance is performed on the HEPA filters or the exhaust fan. One additional manual damper is located between the backdraft and the tornado damper which can be used to isolate the entire train.

A backdraft damper is located on the exhaust side of the fan. This damper is normally open for the operating train and closed on the standby train. This damper prevents reverse airflow through the standby system as a result of the negative delta pressure in the C2 areas.

A tornado damper is used to automatically control airflow to prevent the transmission of tornado pressure surges from outside the facility.

Failure modes considered for these dampers are summarized in the following Table B2.2-1.

Table B2.2-1. HVAC Damper Failure Modes

Damper Type	Failure Mode	Discussion
Manual Dampers	Fail to remain open	These dampers are normally open; these dampers are used to isolate equipment. They will block flow within a train if they fail to a closed position or were not restored to an open position if they were closed to isolate a component for maintenance.
Backdraft Dampers	Fail to open	Backdraft dampers close to prevent backflow through the system when the exhaust fan is not running. They are supposed to open when the exhaust fan starts. If the damper fails to open, flow will be blocked, failing the train.
	Fail to remain open	If the backdraft damper fails to remain open while the exhaust fan is running, flow through the train will be lost.
Tornado Dampers	Fail to remain open	The tornado damper closes and isolates its associated HVAC train during pressure transients caused by a tornado. If it closes at any time other than when tornado conditions exist it will block flow and defeat the train. If it operates as it is designed when tornado conditions exist it will close, blocking flow, and defeating its associated HVAC train. Both conditions are captured in the "tornado damper fails closed" event in the HVAC fault tree.
	Fail to close	If the tornado damper fails to close when tornado conditions exist it would allow pressure transients within the train that could damage ducting or components.

Source: Original

B2.2.3 HEPA Filters

Three parallel HEPA filter plenums are provided in each HVAC system train. Each plenum contains a preliminary bank of medium-efficiency roughing filters; followed by two banks of HEPA filters to provide for particulate removal. The unit also contains a mister/demister for maintaining proper humidity levels and a water deluge system for fire suppression. The roughing filters are 60% to 90% efficient in removing particulates and the HEPA filters remove particulates with 99.97% efficiency (Ref. B2.1.6, Appendix B). The HEPA filter plenums also contain an inlet test section, a combination test section, and an outlet test section; these sections and the deluge system are not modeled in the fault tree analysis.

The preliminary bank of roughing filters consists of a 3 × 3 array (nine filters). The roughing filters are followed by two banks of HEPA filters. Each bank consists of a 3 × 3 array (nine filters) for a total of 18 filters. Each filter plenum is sized for a maximum flow of 1,500 cfm (Ref. B2.1.6, Section 3.2.2).

Failure modes associated with the filter plenums considered in the analysis (Table B2.2-2) include the HEPA filter bank plugs and leaks, mister/demister plugs, and the medium roughing filter plugs and leaks. A bag-in/bag-out procedure is used to replace the HEPA filters.

Table B2.2-2. HEPA Filter Plenum Failure Modes

Plenum Component	Failure Mode	Discussion
Mister/Demister	Plugs	The demister removes entrained moisture from the air by causing the air to rapidly change direction as it flows through the demister panel. This panel can become plugged over time with a combination of particulates and moisture.
Filters including the HEPA and roughing filters	Plug	Plugging of the filters will reduce flow, failing the train. When the supply fans are operating, the flow rates require all three filter plenums to be operating in parallel to maintain the desired D/P. If the supply fans are inoperable the flow rates required to maintain the desired D/P are low enough that only two of the three filter plenums need to be in operation.
	Leak	Leaks through the filters include catastrophic failures that will be indicated by a large decrease in D/P across the filter plenum. This situation would cause the control system to stop the operating train and start the standby train. Small leaks, such as those that might occur around the filter housing seals, however, may not be accompanied by a decrease in plenum D/P of sufficient magnitude to initiate an automatic switch over to the standby system. In this case the reduced D/P could be accompanied by increased radiation levels indicated in the discharge ducting. In this particular case, the operator must recognize the indications of a small leak and initiate a manual switch over. Because leak data does not differentiate between small and large leaks, the leak failure modeled in the fault tree is accompanied by either a failure of the D/P sensing system or a failure of the operator to recognize the leaking condition.

NOTE: D/P = delta pressure.

Source: Original

B2.2.4 Direct Drive Exhaust Fan and Motor

The exhaust fan and motor are sized to provide a maximum airflow rate of 40,500 cfm with an exhaust fan motor rated at 200 hp (Ref. B2.1.6, Section 6.1.2). To meet delta pressure requirements for the CRCF, the exhaust system must provide an airflow rate of 35,010 cfm (Ref. B2.1.6, Appendix A, Table A-1). At this airflow rate, the exhaust system provides the total of 14.2 inches of water column required to maintain delta pressure in the facility (Ref. B2.1.6, Section 3.1.4).

The exhaust fan motor is rated at 1,800 rpm (Ref. B2.1.6, Section 3.1.5). However, the actual speed is controlled by the ASD. The ASD adjusts the speed to maintain the required delta pressure when facility doors are opened, when HEPA filters lose efficiency, or when external winds affect room pressures within the facility.

The failure modes for the exhaust fans are, fail to start and fail to run.

B2.2.5 Supply Fans

Two parallel air handling units (AHUs) supply ventilation to the Waste Package Loadout Room (Room 1015) and two parallel AHUs supply ventilation air to the Cask Preparation Room (Room 1026). These AHUs mix air recirculated from their associated areas with outside air to replenish leakage airflow that is exhausted by the CRCF HVAC exhaust system. These systems are not necessary required for the successful operation of the CRCF HVAC exhaust system. They do, however, determine the amount of air that must be exhausted by the operating HVAC exhaust system to maintain cascaded airflow and the required pressure differential within the C2 zone. When the supply fans are operating more air must be exhausted by the operating exhaust fan and the three filter plenums in the operating exhaust train must be operating to maintain the required airflow. Less air is required to be exhausted when the supply fans are not operating and the airflow through two HEPA filter plenums in the operating train is sufficient to maintain cascaded flow and the required pressure differential.

B2.2.6 Control Circuitry

Normal operation of the HVAC system is controlled by the DCMIS, which controls the operating mode of each train as determined by the operator (start, stop, or auto). The DCMIS also controls fan speed through an ASD to maintain facility airflow and pressures within normal operating limits. Functions considered important to safety (such as auto start of the standby train when the operating train fails) are provided by hardwired interlocks that bypass the normal controls provided by the DCMIS.

The exhaust fan speed is controlled by an ASD, which receives duct differential pressure signals from the DCMIS. The non-programmable ASD adjusts the exhaust fan speed to maintain these parameters within the specified operating band.

ASDs associated with the supply fans adjust the fans speed in response to the temperature monitored in the room that they supply ((Ref. B2.1.4), Ref. B2.1.5), and (Ref. B2.1.3)). The supply fans are used to stabilize the airflow within the CRCF. The operation of these fans

impacts the airflow required to maintain the required pressure differential; consequently, they are accounted for in the loss of HEPA filter plenum section of the fault tree model.

Automatic transfer from the operating train to the standby train is accomplished when the following conditions are sensed in the operating train:

1. Low flow is sensed in the discharge plenum occurring concurrently with a low pressure differential sensed across the exhaust fan, or

2. An operating fan trip signal is provided by the operating fan ASD, indicating that the fan has tripped, or

3. A high pressure differential across the operating train filter plenums indicate that the plenum is plugged, or

4. A low pressure differential across the operating train filter plenums indicates that the plenum is leaking.

Under normal operations (including supply fans in operation), all three HEPA filter plenums in the train must be operating to achieve the exhaust flow rate of 35,010 cfm (Ref. B2.1.6, Section 6.1.1 (1)). Each HEPA filter plenum can filter 13,500 cfm at maximum efficiency (Ref. B2.1.6, Section 6.1.1 (2)). The design has some reserve capacity, but not enough to maintain the required delta pressure if one of the HEPA filters fails when the supply fans are operating. Under normal operations, the only redundancy in the design is the second train.

B2.2.7 Equipment Door Interlocks

In order to maintain the pressure differential in the C2 zone during the receipt or export of transportation casks, aging overpacks, or waste packages, the CRCF equipment access doors have been interlocked to preclude a loss of the pressure differential.

Equipment doors relied upon to maintain the pressure differential in the Cask Preparation Room (Room 1026) includes the Cask Unloading Room shield doors (060-CR00-DR-001 and 060-CR00-DR-002) and the confinement doors (060-CR00-DR-0010, 060-CR00-DR-0011, and 060-CR00-DR-0012). The shield doors are interlocked with the confinement doors and their associated Cask Unloading Room shield port to prevent them from opening unless all of the confinement doors and the port gate are closed. The confinement doors are interlocked with the shield doors to prevent them from opening unless both Cask Unloading Room shield doors are closed.

Equipment doors that help maintain the pressure differential in the loadout area and the Waste Package Positioning Room include the inner shield doors (060-CR00-DR-003 and 060-CR00-DR-004) between the loadout area and the Waste Package Positioning Room and the outer shield doors (060-CR00-DR-005 and 060-CR00-DR-006) between the Waste Package Loadout Room and the Waste Package Loadout Vestibule. The inner doors are interlocked to prevent them from opening unless both outer shield doors are closed, the waste package port slide gate is closed, and personnel access doors to the area are closed. The outer shield doors are only interlocked with a radiation detector in the loadout area that prevents them from opening if a high radiation

level exists in the loadout area. The outer shield doors are not prevented from opening if the Waste Package Positioning Room shield doors are already open. These interlocks are summarized in Table B2.2-3.

B2.2.8 CRCF HVAC System Normal Operations

Under normal operations with supply fans operating, all three HEPA filter plenums in the train must be operating to achieve the exhaust flow rate of 35,010 cfm (Ref. B2.1.6, Section 6.1.1 (1)). Each HEPA filter plenum can filter 13,500 cfm at maximum efficiency (Ref. B2.1.6, Section 6.1.1 (2)). The design has some reserve capacity but not enough to maintain the required delta pressure if one of the HEPA filters fails when the supply fans are operating. Under normal operations, the only redundancy in the design is the second train.

B2.2.9 CRCF HVAC System Off-Normal Operations

The CRCF HVAC system maintains the proper pressure differential throughout the Class C2 designated containment areas. Exhausted air from the CRCF is made-up from opening/closing doors to the outside, leaks in the structure, and from one of two supply fans which are controlled by the ASD on the operating train. One of these fans, in conjunction with other air makeup sources, can provide sufficient airflow through the C2 containment areas for the HVAC to maintain the required pressure differential. These supply fans are not connected to the ITS power system for the CRCF. Should these fans shut down, it becomes possible to maintain the pressure differential with two of three HEPA filters. This special case has been added to the fault trees for the failure to maintain the pressure differential in the CRCF. In this case, there is redundancy within the train and a common-cause failure mode has been added to the fault tree.

B2.2.10 ITS HVAC Testing and Maintenance

Under normal operations, train A continues to operate until a failure is detected or the train is shut down for maintenance. Normal maintenance renders train B unavailable for a period of 40 hours per year (the majority of operational-level maintenance can be performed on the operational train and, therefore, does not affect the overall availability of the standby train). During maintenance, the train B “start/stop/auto” switch is placed in the stop position. When maintenance is completed, the standby system (train B) is started and operating system (train A) is shut down and is now considered to be the standby train (train A). Maintenance may be scheduled consecutively for this train or at some future date. Under normal operations, maintenance does not result in the loss of/or the inability of the operating train to perform its intended function.

Testing is considered part of routine maintenance. When the maintenance has been completed, maintenance personnel commence operation of the standby train and check for normal operations including the pressure differential, the airflow rate, and ensure that all failure indicators are reset/off. Maintenance personnel also observe the forced shutdown of the operating system as the standby train commences to operate.

Flow rates are monitored as part of testing to ensure that the airflow balance is maintained.

Table B2.2-3. CRCF Confinement and Shield Door Interlocks

Door	Location	Function	Open Permissives	Close Permissives	Auto Opens	Auto Closes	Emergency Override
060-CR00-DR-000001	Between Cask Preparation Room (1026) and North Cask Unloading Room (1023)	Shield door	Conf DR 10 closed	None	None	None	Yes
			Conf DR 11 closed				
			Conf DR 12 closed				
			North cask port slide gate closed				
060-CR00-DR-000002	Between Cask Preparation room (1026) and South Cask Unloading Room (1024)	Shield door	Conf DR 10 closed	None	None	None	Yes
			Conf DR 11 closed				
			Conf DR 12 closed				
			South cask port slide gate closed				
060-CR00-DR-000003	Between North WP Positioning Room (1018) and WP Loadout Room (1015)	Shield door	North WP port slide gate closed	None	None	None	Yes
			North WP Loadout Room shield door (05) Closed				
			South WP Loadout Room shield door (06) closed				
			1st Floor north personnel access door (07) closed				
			1st Floor south personnel access door (08) closed				
			WP Loadout Room crane access door (09) closed				
060-CR00-DR-000004	Between South WP Positioning Room (1019) and WP Loadout Room (1015)	Shield door	South WP port slide gate closed	None	None	None	Yes
			North WP Loadout Room shield door (05) closed				
			South WP Loadout Room shield door (06) closed				
			1st Floor north personnel access door (07) closed				
			1st Floor south personnel access door (08) closed				
			WP Loadout Room crane access door (09) closed				
060-CR00-DR-000005	North door between WP Loadout Room (1015) and WP Loadout Vestibule (1014)	Shield door	Radiation level in WP Loadout Room not high	None	None	None	Yes

Table B2.2-3. CRCF Confinement and Shield Door Interlocks (Continued)

Door	Location	Function	Open Permissives	Close Permissives	Auto Opens	Auto Closes	Emergency Override
060-CR00-DR-000006	South door between WP Loadout Room (1015) and WP Loadout Vestibule (1014)	Shield door	Radiation level in WP Loadout Room not high	None	None	None	Yes
060-CR00-DR-000010	South end of Cask Preparation Room (1026) to Transportation Cask Vestibule	Confinement	North Cask Unloading Room shield door (01) closed South Cask Unloading Room shield door (02) closed	None	None	None	No
060-CR00-DR-000011	East end of Cask Preparation Room (1026) to north access to ST Vestibule	Confinement	North Cask Unloading Room shield door (01) closed South Cask Unloading Room shield door (02) closed	None	None	None	No
060-CR00-DR-000012	East end of Cask Preparation Room (1026) to South access to ST Vestibule	Confinement	North Cask Unloading Room shield door (01) closed South Cask Unloading Room shield door (02) closed	None	None	None	No

NOTE: Conf DR = confinement door; ST = site transporter; WP = waste package.

Source: Original

B2.3 DEPENDENCIES AND INTERACTIONS

Dependencies are broken down into five categories with respect to their interactions with structures, systems, and components. The five areas considered are addressed in Table B2.3-1 with the following dependencies:

1. Functional dependence
2. Environmental dependencies
3. Spatial dependence
4. Human dependence
5. Failures based on external events.

Table B2.3-1. Dependencies and Interactions Analysis

Structures, Systems, and Components	Dependencies and Interactions				
	Functional	Environ-mental	Spatial	Human	External Events
ASD	Flow and pressure sensors	—	—	—	—
	Speed control for fan/motor	—	—	—	—
Δp exhaust fans	—	Wind speed	—	—	—
Stop/start/auto switch position	—	—	—	Wrong position	—
Dampers	—	—	—	Wrong position	—
ITS power	HVAC shuts down	—	—	—	—
Non-ITS power	—	—	—	—	Supply fans stop
HEPA filter	—	—	—	Failure to notice leak	—
HVAC maintenance	—	—	—	Trains can not switch	—
Vestibule doors	Prep area and WP loadout area equipment doors are interlocked as described in Table B2.2-3	—	—	—	—
Alarm panel (non-ITS)	—	—	—	Failure to respond to HVAC alarm	—

NOTE: ASD = adjustable speed drive; ΔP = delta pressure; HEPA = high-efficiency particulate air; HVAC = heating, ventilation, and air conditioning; ITS = important to safety; WP = waste package.

Source: Original

B2.4 HEATING, VENTILATION, AND AIR CONDITIONING SYSTEM-RELATED FAILURE SCENARIO

There is a single top event for CRCF HVAC system failure: confinement zone exhaust system fails to maintain HEPA filtered flow. This model is also applicable to CRCF 2 and 3.

B2.4.1 Failure to Maintain Pressure Differential

B2.4.1.1 Description

The CRCF HVAC fault tree models the component failures, system failures, and human failures that contribute to failing to exhaust air from the C2 confinement zones through HEPA filters into the atmosphere. This failure includes loss of flow from the operating train and standby train and failures that bypass the HEPA filters while maintaining flow.

B2.4.1.2 Success Criteria

The purpose of the CRCF HVAC system is to maintain a positive airflow from the confinement boundary, through the operating areas to the HEPA filters, and into the atmosphere. The design of the system accomplishes this objective by functionally cascading pressure differentials to maintain airflow toward the center of the facility; from here the airflow is exhausted through HEPA filters into the atmosphere. Consequently, the success criterion for the CRCF HVAC system is to maintain these pressure differentials and associated exhaust flow through HEPA filters.

To accomplish this objective, one of two HVAC system trains must be operational with all exhaust flow passing through the HEPA filters before it is discharged into the atmosphere. The sizing of the exhaust motor and fan assembly will maintain the required pressure differentials in sustained winds of up to 40 mph with less than three second gusts up to 90 mph. In addition, pressure differentials may be lost for a period of time (not to exceed seven minutes in the CRCF) if and only if one of the shield or confinement doors is open.

B2.4.1.3 Design Requirements and Features

Requirements

There is only one HVAC system train in operation at any time. The second train is on standby except when it is off-line for maintenance.

The HVAC system alarm panel is continuously monitored in the CCCF. Alarm conditions include: fan tripped, fan failure, fan low pressure differential, and low discharge flow. Operators are not required to respond to the alarm (CRCF HVAC trains are switched automatically); however, operators are expected to notify maintenance that a switch has occurred and maintenance is required to determine the cause of the failure and correct it.

Design Features

The CRCF HVAC system is in normal operation with three HEPA filter plenums in operation. Each HEPA filter plenum consists of one 3 × 3 medium filter array and two 3 × 3 HEPA filter arrays.

Testing and Maintenance

Requirements

HVAC system maintenance personnel are notified when an alarm condition exists. Repairs are performed as soon as possible to return train to operational status.

While an HVAC system train is undergoing maintenance, the train is not available for service.

Testing that requires an operating exhaust fan is performed on the active (operating) HVAC system (rather than the inactive train).

Features

Normal maintenance is performed in accordance with the manufacturer's recommendations.

B2.4.1.4 Fault Tree Model

The top event in this fault tree is "Delta Pressure not Maintained in CRCF Facility." This event is defined as the inability of the CRCF HVAC system to maintain the pressure differential within the facility. The CRCF HVAC system is a two-train system. The configuration of the CRCF HVAC systems in each of the three CRCF facilities is essentially identical.

Interlocks in the CRCF HVAC system address the potential for opening two or more of the confinement and shield doors, as discussed previously. It should be noted that there is no physical connection between the door interlocks and the HVAC system.

The mission time for the CRCF HVAC system is currently set to 720 hours (Ref. B2.1.7). To take into account the differences in failure rates for active and standby systems, all basic events in the standby train are set to half of those of the active system. For ease of implementation in the SAPHIRE model, the rate data is maintained constant and the mission time is set to one-half of the mission time (e.g., 360 hours).

B2.4.1.5 Basic Event Data

Table B2.4-1 presents the list of basic events used in the loss of pressure differential in the CRCF model. The model contains undeveloped transfers to ITS power systems. These failures are addressed in Attachment B8. Reliability data for the basic events is detailed in Attachment C with the following exceptions:

A. Three basic events are associated with human error. An HFE detailed analysis is presented in Section 6.4 and Attachment E. These events include:

1. Opening two or more equipment doors.
2. Failure to properly restore system after maintenance.
3. Failure to notice HEPA filter leak.

B. Unavailability of the standby train due to scheduled maintenance, which is based on a conservative estimate.

C. Loss of the pressure differential as a direct result of opening a vestibule door and the amount of time required for the HVAC system exhaust fans to re-establish the pressure differential.

D. Two CCFs:

1. CCFs of the HEPA filters in the degraded mode.
2. CCFs of the supply fans.

Table B2.4-1. Basic Event Probability for the HVAC Failure to Maintain Delta Pressure in the CRCF

Name	Description	Calc. Type[a]	Calc. Prob.	Fail. Prob.	Lambda	Miss. Time[a]
060-EXCESSIVE-WIND-SPEED	Loss of pressure differential due to sustained wind speeds exceeding 30 mph	1	4.700E-03	4.700E-03	0.000E+00	0.000E+00
060-VCT0-EXH-005-FAN-FTR	CRCF ITS elec exhaust fan 00005 fails to run	3	5.059E-02	0.000E+00	7.210E-05	7.200E+02
060-VCT0-EXH-006-FAN-FTR	CRCF ITS elec exh. fan fails to run	3	5.059E-02	0.000E+00	7.210E-05	7.200E+02
060-VCTO-AHU0013-FAN-FTR	AHU 013 fan fails to run	3	5.059E-02	0.000E+00	7.210E-05	7.200E+02
060-VCTO-AHU0014-FAN-FTR	AHU 014 fan fails to run	3	2.562E-02	0.000E+00	7.210E-05	3.600E+02
060-VCTO-BDMP00A-UDM-FOH	Damper (backdraft) failure	3	1.614E-02	0.000E+00	2.260E-05	7.200E+02
060-VCTO-BDMP00B-DMP-FRO	Train B fan discharge backdraft damper fails closed	3	8.103E-03	0.000E+00	2.260E-05	3.600E+02
060-VCTO-BDMP00B-DMP-FTO	Train B backdraft damper fails to open when fan starts	1	8.710E-04	8.710E-04	0.000E+00	0.000E+00
060-VCTO-DCT0A-DTC-RUP	Train A duct ruptures	3	2.675E-03	0.000E+00	3.720E-06	7.200E+02
060-VCTO-DCT0B-DTC-RUP	Train B duct ruptures	3	1.338E-03	0.000E+00	3.720E-06	3.600E+02
060-VCTO-DMP000A-DMP-FRO	Train A fan discharge manual isolation damper fails closed	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02

Table B2.4-1. Basic Event Probability for the HVAC Failure to Maintain Delta Pressure in the CRCF (Continued)

Name	Description	Calc. Type[a]	Calc. Prob.	Fail. Prob.	Lambda	Miss. Time[a]
060-VCTO-DMP000B-DMP-FRO	Train B fan discharge manual isolation damper fails closed	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-DMPF00A-DMP-FRO	Train A fan inlet manual isolation damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02
060-VCTO-DMPF00B-DMP-FRO	Train B fan inlet manual isolation damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-DR0001-HFI-NOD	Operator opens 1 inner door and 1 outer door	1	1.000E-02	1.000E-02	0.000E+00	0.000E+00
060-VCTO-FAN00A-FAN-FTR	Exhaust Fan in train A fails	3	5.059E-02	0.000E+00	7.210E-05	7.200E+02
060-VCTO-FAN00A-PRM-FOH	Train A exhaust fan fails due to ASD malfunction	3	3.873E-04	0.000E+00	5.380E-07	7.200E+02
060-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	3	2.562E-02	0.000E+00	7.210E-05	3.600E+02
060-VCTO-FAN00B-FAN-FTS	Train B exhaust fan fails to start	1	2.020E-03	2.020E-03	0.000E+00	0.000E+00
060-VCTO-FAN00B-PRM-FOH	Train B exhaust fan fails due to ASD malfunction	3	1.937E-04	0.000E+00	5.380E-07	3.600E+02
060-VCTO-FANBASD-CTL-FOD	Train B ASD start logic signal fails	1	2.030E-03	2.030E-03	0.000E+00	0.000E+00
060-VCTO-HEPA-CCF	Common-cause failure of 2 of 3 filter plenums	C	9.531E-05	—	—	—
060-VCTO-HEPAB-CCF	Common-cause failure of HEPA Filters (2 of 3)	C	4.769E-05	—	—	—
060-VCTO-HEPALK-HFI-NOD	Operator fails to shift trains when alarm occurs	1	1.000E+00	1.000E+00	0.000E+00	0.000E+00
060-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1	1.000E-01	1.000E-01	0.000E+00	0.000E+00
060-VCTO-IEL0001-IEL-FOD	CRCF door interlock failure	1	2.750E-05	2.750E-05	0.000E+00	0.000E+00
060-VCTO-IEL0002-IEL-FOD	Interlock failure on demand	1	2.750E-05	2.750E-05	0.000E+00	0.000E+00
060-VCTO-PLEN09-DMS-FOH	Train A plenum 09 moisture separator/demister plugs	3	6.545E-03	0.000E+00	9.120E-06	7.200E+02
060-VCTO-PLEN09-HEP-LEK	Train A plenum 09 HEPA filters leak	3	2.158E-03	0.000E+00	3.000E-06	7.200E+02
060-VCTO-PLEN09-HEP-PLG	Train A plenum 09 HEPA filters plug	3	3.070E-03	0.000E+00	4.270E-06	7.200E+02
060-VCTO-PLEN09I-DMP-FRO	Train A filter plenum 09 inlet damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02

Table B2.4-1. Basic Event Probability for the HVAC Failure to Maintain Delta Pressure in the CRCF (Continued)

Name	Description	Calc. Type[a]	Calc. Prob.	Fail. Prob.	Lambda	Miss. Time[a]
060-VCTO-PLEN09O-DMP-FRO	Train A filter plenum 09 outlet damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02
060-VCTO-PLEN10-DMS-FOH	Train A plenum 10 moisture separator/demister plugs	3	6.545E-03	0.000E+00	9.120E-06	7.200E+02
060-VCTO-PLEN10-HEP-LEK	Train A plenum 10 HEPA filters leak	3	2.158E-03	0.000E+00	3.000E-06	7.200E+02
060-VCTO-PLEN10-HEP-PLG	Train A plenum 10 HEPA filters plug	3	3.070E-03	0.000E+00	4.270E-06	7.200E+02
060-VCTO-PLEN10I-DMP-FRO	Train A filter plenum 10 inlet damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02
060-VCTO-PLEN10O-DMP-FRO	Train A filter plenum 10 outlet damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02
060-VCTO-PLEN11-DMS-FOH	Train A plenum 11 moisture separator/demister plugs	3	6.545E-03	0.000E+00	9.120E-06	7.200E+02
060-VCTO-PLEN11-HEP-LEK	Train A plenum 11 HEPA filters leak	3	2.158E-03	0.000E+00	3.000E-06	7.200E+02
060-VCTO-PLEN11-HEP-PLG	Train A plenum 11 HEPA filters plug	3	3.070E-03	0.000E+00	4.270E-06	7.200E+02
060-VCTO-PLEN11I-DMP-FRO	Train A filter plenum 11 inlet damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02
060-VCTO-PLEN11O-DMP-FRO	Train A filter plenum 11 outlet damper fails to remain open	3	6.033E-05	0.000E+00	8.380E-08	7.200E+02
060-VCTO-PLEN12-DMS-FOH	Train B plenum 12 moisture separator/demister plugs	3	3.278E-03	0.000E+00	9.120E-06	3.600E+02
060-VCTO-PLEN12-HEP-LEK	Train B plenum 12 HEPA filters leak	3	1.079E-03	0.000E+00	3.000E-06	3.600E+02
060-VCTO-PLEN12-HEP-PLG	Train B plenum 12 HEPA filters plug	3	1.536E-03	0.000E+00	4.270E-06	3.600E+02
060-VCTO-PLEN12I-DMP-FRO	Train B filter plenum 12 inlet damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-PLEN12O-DMP-FRO	Train B filter plenum 12 outlet damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-PLEN13-DMS-FOH	Train B plenum 13 moisture separator/demister plugs	3	9.120E-06	0.000E+00	9.120E-06	0.000E+00
060-VCTO-PLEN13-HEP-LEK	Train B plenum 13 HEPA filters leak	3	3.000E-06	0.000E+00	3.000E-06	0.000E+00
060-VCTO-PLEN13-HEP-PLG	Train B plenum 13 HEPA filters plug	3	1.536E-03	0.000E+00	4.270E-06	3.600E+02
060-VCTO-PLEN13I-DMP-FRO	Train B filter plenum 13 inlet damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02

Table B2.4-1. Basic Event Probability for the HVAC Failure to Maintain Delta Pressure in the CRCF (Continued)

Name	Description	Calc. Type[a]	Calc. Prob.	Fail. Prob.	Lambda	Miss. Time[a]
060-VCTO-PLEN13O-DMP-FRO	Train B filter plenum 13 outlet damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-PLEN14-DMS-FOH	Train B plenum 14 moisture separator/demister plugs	3	3.278E-03	0.000E+00	9.120E-06	3.600E+02
060-VCTO-PLEN14-HEP-LEK	Train B plenum 14 HEPA filters leak	3	3.000E-06	0.000E+00	3.000E-06	0.000E+00
060-VCTO-PLEN14-HEP-PLG	Train B plenum 14 HEPA filters plug	3	1.536E-03	0.000E+00	4.270E-06	3.600E+02
060-VCTO-PLEN14I-DMP-FRO	Train B filter plenum 14 inlet damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-PLEN14O-DMP-FRO	Train B filter plenum 14 inlet damper fails to remain open	3	3.017E-05	0.000E+00	8.380E-08	3.600E+02
060-VCTO-RSH005-SRR-FOH	High rad door interlock permissive fails	3	8.804E-02	0.000E+00	1.280E-04	7.200E+02
060-VCTO-RSH114-SRR-FOH	Exhaust high rad alarm fails	3	2.000E-05	0.000E+00	2.000E-05	0.000E+00
060-VCTO-TDMP00A-DTM-FOD	Train A tornado damper fails closed when tornado conditions don't exist	3	1.614E-02	0.000E+00	2.260E-05	7.200E+02
060-VCTO-TDMP00B-DTM-FOH	Train B tornado damper fails closed when tornado conditions don't exist	3	8.103E-03	0.000E+00	2.260E-05	3.600E+02
060-VCTO-TRAINB-MAINT	Train B unavailable due to maintenance	1	4.570E-03	4.570E-03	0.000E+00	0.000E+00
060-VCTO-TRATRIP-CTL-FOD	Logic controller fails on demand	1	2.030E-03	2.030E-03	0.000E+00	0.000E+00
060-WP-LORM-NOT	High radiation source not present	1	9.500E-01	9.500E-01	0.000E+00	0.000E+00

NOTE: [a] For Calc. Type 3 with a mission time of 0, SAPHIRE performs the quantification using the system mission time. See Table 6.3-1 for calculation type definitions.

AHU = air handling unit; ASD = adjustable speed drive; Calc. = calculation; CRCF = Canister Receipt and Closure Facility; Elec = electric; Exh = exhaust; Fail. = failure; HEPA = high-efficiency particulate air; HVAC = heating, ventilation, and air conditioning, ITS = important to safety; Miss. = mission; P = pressure; Prob. = probability; rad = radiation.

Source: Original

B2.4.1.5.1 Human Failure Events

There are three basic human failure events (HFE) associated with human error listed in Table B2.4-2. They are for inadvertently opening two or more vestibule doors at the same time, failure to notice that there is a HEPA leak and leaving the start/stop/auto switch on the standby train in the wrong position.

Table B2.4-2. Human Failure Events

Basic Event Name	Basic Event Description
060-VCTO-DR00001-HFI-NOD	Operator opens 1 inner door and 1 outer door
060-VCTO-HEPALK-HFI-NOD	Operator fails to shift trains when alarm occurs
060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position

NOTE: HVAC = heating, ventilation, and air conditioning.

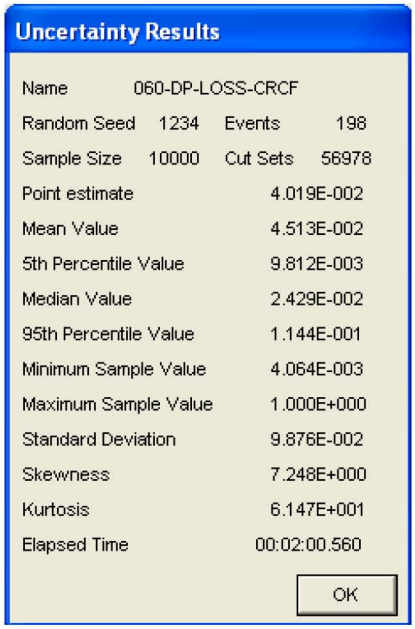
Source: Original

B2.4.1.5.2 Common-Cause Failures

There are two CCFs identified in the HVAC system model. The CCFs are associated with the potential of a HEPA filter failure while the HVAC system is operating in the degraded mode (e.g., operating with the supply fans inoperable). In the degraded mode the HEPA filters operate in a two-of-three success situation. The CCF compound event is developed from the appropriate alpha factors from Attachment C, Section C3, and the HEPA filter random failure probabilities for plugged failure.

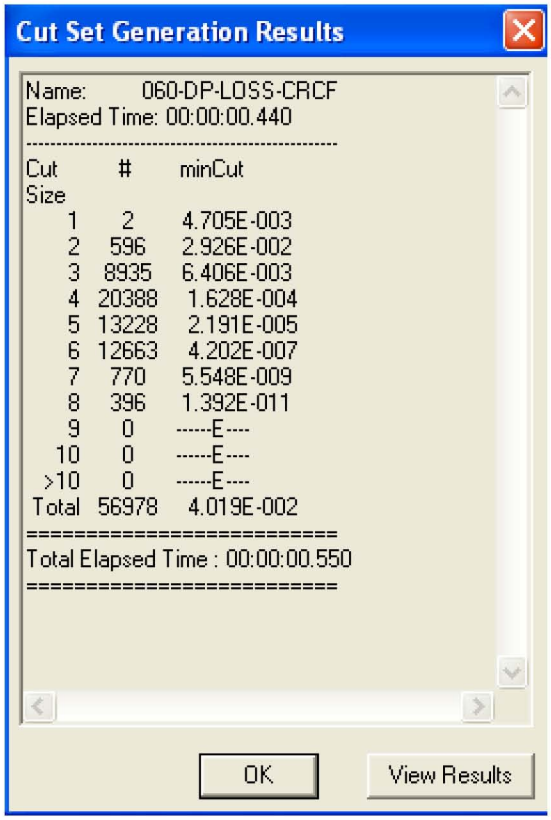
B2.4.1.6 Uncertainty and Cut Set Generation

Figure B2.4-1 contains the uncertainty results obtained from running the fault trees for "Failure to Maintain Delta Pressure" using a cutoff probability of 1E-12. Figure B2.4-2 provides the cut set generation results for the "Failure to Maintain Delta Pressure" fault tree. These results are for the HVAC system coupled with loss of electrical power, which is discussed separately in Section B3. If loss of electrical power is not included in the HVAC tree, the mean failure probability and standard deviation of the HVAC system alone are 3.1E-02 and 6.0E-02, respectively.



Source: Original

Figure B2.4-1. Uncertainty Results of the CRCF Failure to Maintain Delta Pressure Fault Tree



Source: Original

Figure B2.4-2. Cut Set Generation Results for the CRCF Failure to Maintain Delta Pressure Fault Tree

B2.4.1.7 Cut Sets

Table B2.4-3 contains the top 35 cut sets for the "Failure to Maintain Delta Pressure" fault tree.

B2.4.1.8 HVAC Fault Trees

For purposes of this report, the transfers to the ITS electrical system for the HVAC equipment is ignored. For specifics on the electrical system, refer to the "AC Power System Fault Tree Analysis" in Attachment B3.

Table B2.4-3. Dominant Cut Sets for the Failure to Maintain the Pressure Differential in the CRCF

Fault Tree	Cut Set %	Prob./Freq.	Basic Event	Description	Probability
060-DP-LOSS-CRCF	23.64	9.500E-003	060-VCTO-DR0001-HFI-NOD	Operator opens 1 inner door and 1 outer door	1.000E-002
			060-WP-LORM-NOT	High radiation source not present	9.500E-001
	12.59	5.059E-003	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
	11.70	4.700E-003	060-EXCESSIVE-WIND-SPEED	Loss of pressure differential due to sustained wind speeds exceeding 30 mph	4.700E-003
	4.41	1.772E-003	26D-#EEY-ITSDG-A-#DG-FTR	ITS diesel generator A fails to run	7.698E-001
			26D-#EEY-ITSDGB-#DG-FTR	ITS DG B fails to run	7.698E-001
			LOSP	Loss of offsite power	2.990E-003
	4.02	1.614E-003	060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
			060-VCTO-TDMP00A-DTM-FOD	Train A tornado damper fails closed when tornado conditions don't exist	1.614E-002
	4.02	1.614E-003	060-VCTO-BDMP00A-UDM-FOH	Damper (backdraft) failure	1.614E-002
			060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
	3.23	1.296E-003	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-002
	2.19	8.804E-004	060-VCTO-DR0001-HFI-NOD	Operator opens 1 inner door and 1 outer door	1.000E-002
			060-VCTO-RSH005-SRR-FOH	High radiation door interlock permissive fails	8.804E-002
	1.34	5.378E-004	060-#EEE-MCC0001-MCC-FOH	CRCF ITS MCC 00001 fails	5.378E-003
			060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
	1.03	4.135E-004	060-VCTO-BDMP00A-UDM-FOH	Damper (backdraft) failure	1.614E-002
			060-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-002
	1.03	4.135E-004	060-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-002
			060-VCTO-TDMP00A-DTM-FOD	Train A tornado damper fails closed when tornado conditions don't exist	1.614E-002
	1.02	4.099E-004	060-VCTO-BDMP00B-DMP-FRO	Train B fan discharge backdraft damper fails closed	8.103E-003
			060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002

Table B2.4-3. Dominant Cut Sets for the Failure to Maintain Delta Pressure in the CRCF (Continued)

Fault Tree	Cut Set %	Prob./Freq.	Basic Event	Description	Probability
060-DP-LOSS-CRCF (continued)	1.02	4.099E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-TDMP00B-DTM-FOH	Train B tornado damper fails closed when tornado conditions don't exist	8.103E-003
	0.95	3.816E-004	060-#EEE-MCC0001-C52-SPO	CRCF ITS MCC 0001 feed breaker spurious operation	3.816E-003
			060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
	0.95	3.816E-004	060-#EEE-LDCNTRA-C52-SPO	Load center A feed circuit breaker (AC) spurious operation	3.816E-003
			060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
	0.73	2.937E-004	060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
			26D-#EEY-ITSDG-A-#DG-FTR	ITS diesel generator A fails to run	7.698E-001
			26D-#EEY-OB-SWGA-C52-SPO	13.8 kV ITS SWGR A feed breaker spurious operation	3.816E-003
	0.73	2.937E-004	060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
			26D-#EEY-ITSDG-A-#DG-FTR	ITS diesel generator A fails to run	7.698E-001
			27A-#EEE-BUS2DGA-C52-SPO	13.8 kV open bus 2 ITS load breaker spurious operation	3.816E-003
	0.68	2.732E-004	060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
			26D-#EEESWGRDGA-AHU-FTR	13.8 kV ITS switchgear room air handling unit fails	2.732E-003
	0.68	2.721E-004	060-#EEE-MCC0002-MCC-FOH	CRCF ITS MCC00002 failure	5.378E-003
			060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
	0.64	2.559E-004	060-VCT0-EXH-005-FAN-FTR	CRCF ITS elec exhaust fan 00005 fails to run	5.059E-002
			060-VCT0-EXH-006-FAN-FTR	CRCF ITS elec exh. fan fails to run	5.059E-002
			060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
	0.58	2.312E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-TRAINB-MAINT	Train B unavailable due to maintenance	4.570E-003
	0.57	2.302E-004	060-VCTO-HFIA000-HFI-NOM	HVAC train B control switch in wrong position	1.000E-001
			26D-#EEY-ITSDG-A-#DG-FTR	ITS diesel generator A fails to run	7.698E-001
			LOSP	Loss of offsite power	2.990E-003
	0.48	1.930E-004	060-#EEE-MCC0002-C52-SPO	CRCR MCC-00002 feed breaker spurious operation	3.816E-003
			060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
	0.48	1.930E-004	060-#EEE-LDCNTRB-C52-SPO	CRCF ITS load center circuit breaker (AC) spur op	3.816E-003
			060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002

Table B2.4-3. Dominant Cut Sets for the Failure to Maintain Delta Pressure in the CRCF (Continued)

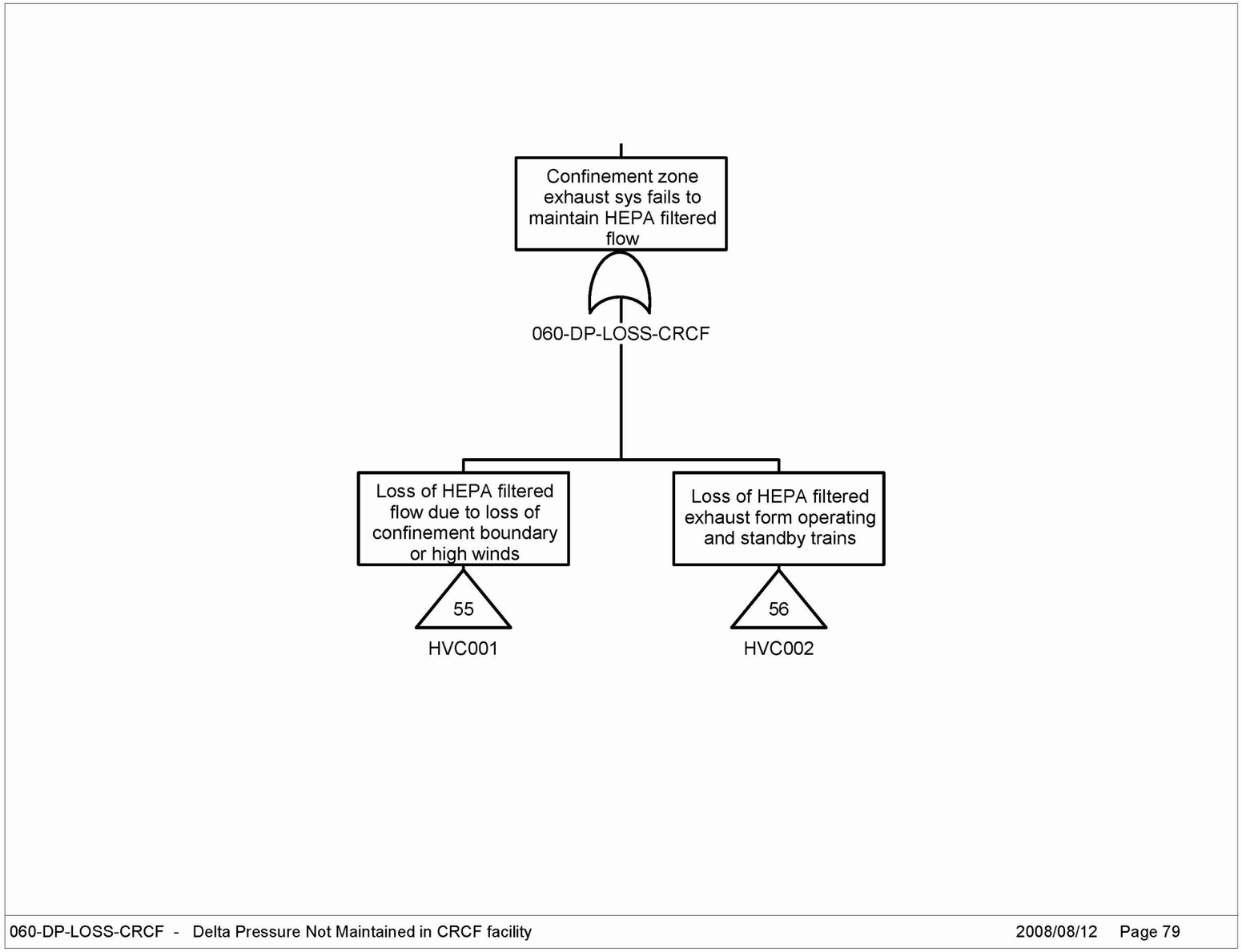
Fault Tree	Cut Set %	Prob./Freq.	Basic Event	Description	Probability
060-DP-LOSS-CRCF (continued)	0.41	1.658E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-PLEN14-DMS-FOH	Train B plenum 14 moisture separator/demister plugs	3.278E-003
	0.41	1.658E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-PLEN12-DMS-FOH	Train B plenum 12 moisture separator/demister plugs	3.278E-003
	0.37	1.486E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			26D-#EEY-ITSDGB-#DG-FTR	ITS DG B fails to run	7.698E-001
			26D-#EEY-OB-SWGB-C52-SPO	13.8 kV ITS SWGR feed breaker (AC) spurious op	3.816E-003
	0.37	1.486E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			26D-#EEY-ITSDGB-#DG-FTR	ITS DG B fails to run	7.698E-001
			27A-#EEE-BUS3DGB-C52-SPO	13.8 kV open bus 4 to ITS B load breaker (AC) spurious op	3.816E-003
	0.34	1.382E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			26D-#EEE-SWGRDGB-AHU-FTR	EDGF Switchgear Room air handling unit failure to run	2.732E-003
	0.34	1.378E-004	060-#EEE-MCC0001-MCC-FOH	CRCF ITS MCC 00001 fails	5.378E-003
			060-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-002
	0.33	1.308E-004	060-VCTO-BDMP00A-UDM-FOH	Damper (backdraft) failure	1.614E-002
			060-VCTO-BDMP00B-DMP-FRO	Train B fan discharge backdraft damper fails closed	8.103E-003
	0.33	1.308E-004	060-VCTO-BDMP00B-DMP-FRO	Train B fan discharge backdraft damper fails closed	8.103E-003
			060-VCTO-TDMP00A-DTM-FOD	Train A tornado damper fails closed when tornado conditions don't exist	1.614E-002
	0.33	1.308E-004	060-VCTO-BDMP00A-UDM-FOH	Damper (backdraft) failure	1.614E-002
			060-VCTO-TDMP00B-DTM-FOH	Train B tornado damper fails closed when tornado conditions don't exist	8.103E-003
	0.33	1.308E-004	060-VCTO-TDMP00A-DTM-FOD	Train A tornado damper fails closed when tornado conditions don't exist	1.614E-002
			060-VCTO-TDMP00B-DTM-FOH	Train B tornado damper fails closed when tornado conditions don't exist	8.103E-003
	0.32	1.295E-004	060-VCT0-EXH-007-FAN-FTR	CRCF ITS elec exhaust Fan 00007 fails to run	5.059E-002
			060-VCT0-EXH-008-FAN-FTR	CRCF ITS elec exhaust fan 8 fails to run	5.059E-002
			060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002

Table B2.4-3. Dominant Cut Sets for the Failure to Maintain Delta Pressure in the CRCF (Continued)

Fault Tree	Cut Set %	Prob./Freq.	Basic Event	Description	Probability
060-DP-LOSS-CRCF (continued)	0.29	1.164E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			26D-#EEY-ITSDGB-#DG-FTR	ITS DG B fails to run	7.698E-001
			LOSP	Loss of offsite power	2.990E-003
	0.26	1.027E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-TRATRIP-CTL-FOD	Logic controller fails on demand	2.030E-003
	0.26	1.027E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-FANBASD-CTL-FOD	Train B ASD start logic signal fails	2.030E-003
	0.25	1.022E-004	060-VCTO-FAN00A-FAN-FTR	Exhaust fan in train A fails	5.059E-002
			060-VCTO-FAN00B-FAN-FTS	Train B exhaust fan fails to start	2.020E-003
	0.24	9.777E-005	060-#EEE-MCC0001-C52-SPO	CRCF ITS MCC 0001 feed breaker spurious operation	3.816E-003
			060-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-002

NOTE: AC = alternating current; ASD = adjustable speed drive; CRCF = canister receipt and closure facility; DG = diesel generator; EDGF = Emergency Diesel Generator Facility; Elec = electrical; Exh = exhaust; Freq. = frequency; HVAC = heating, ventilation, and air conditioning; ITS = important-to-safety; kV = kilovolt; MCC = motor control center; Prob. = probability; SWGR = switchgear.

Source: Original



Source: Original

Figure B2.4-3. Delta Pressure not Maintained in CRCF Facility

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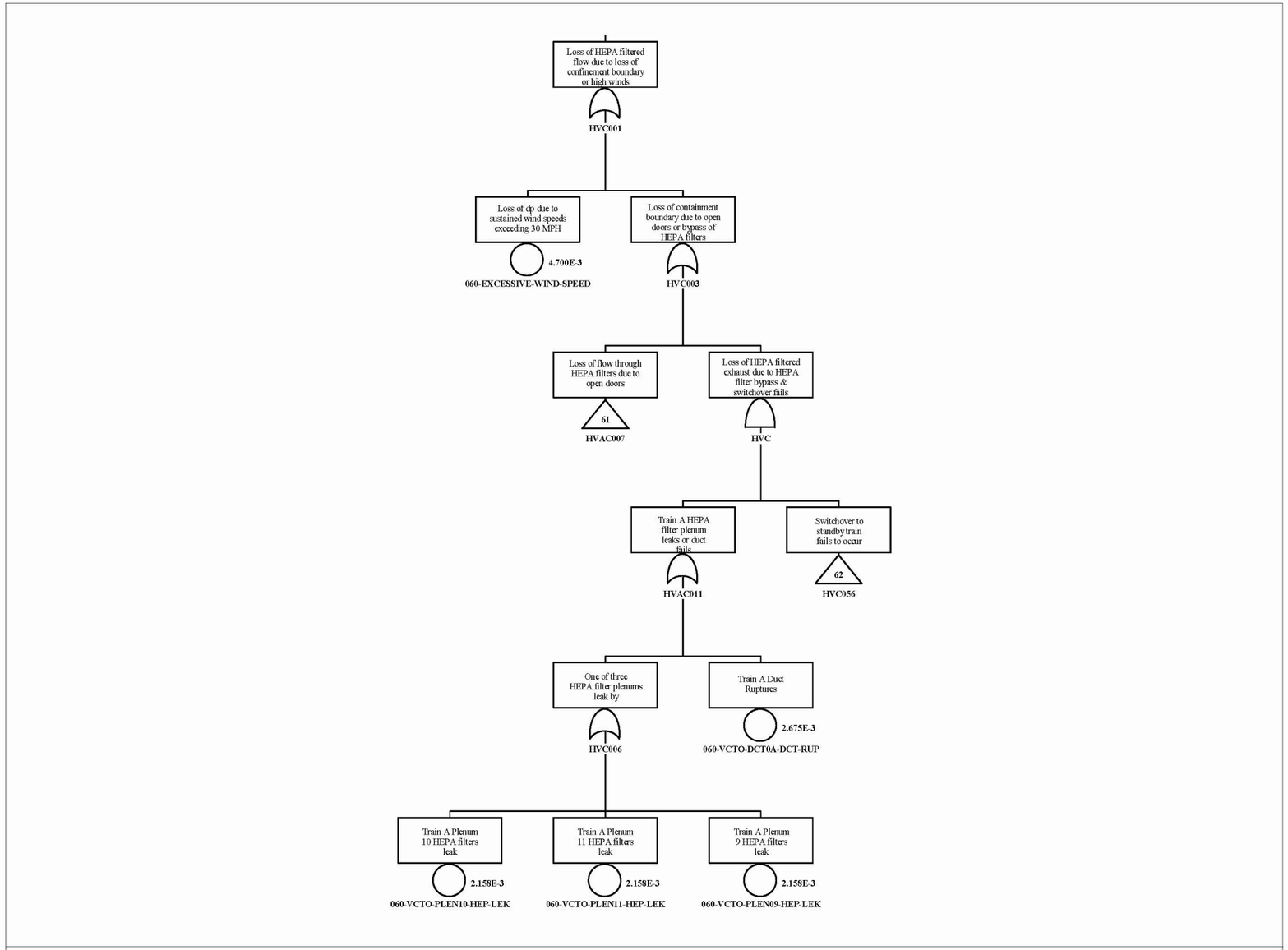

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Figure B2.4-4. Loss of HEPA Filtered Flow Due to Loss of Confinement Boundary or High Winds

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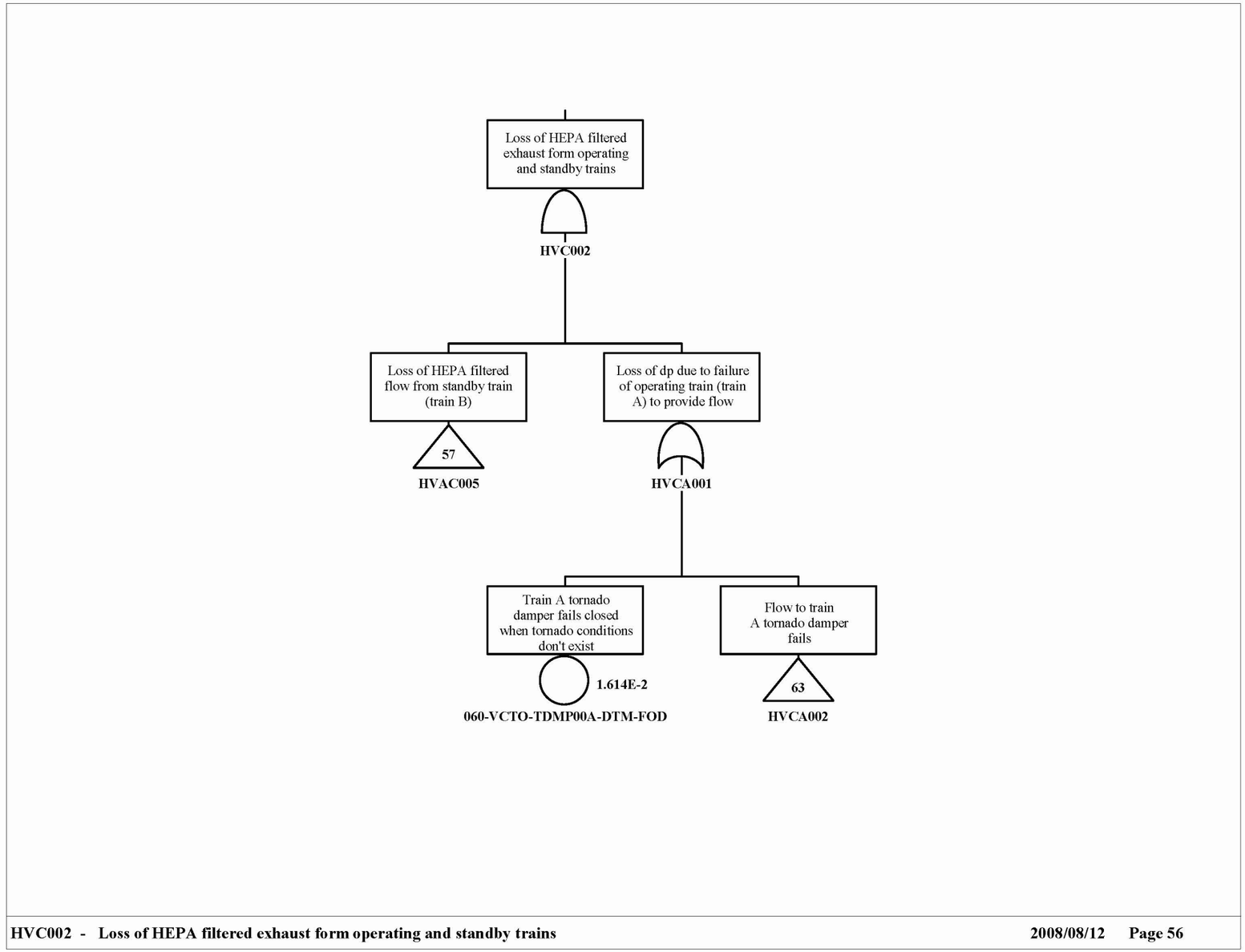

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Figure B2.4-5. Loss of HEPA Filtered Exhaust from Operating and Standby Trains

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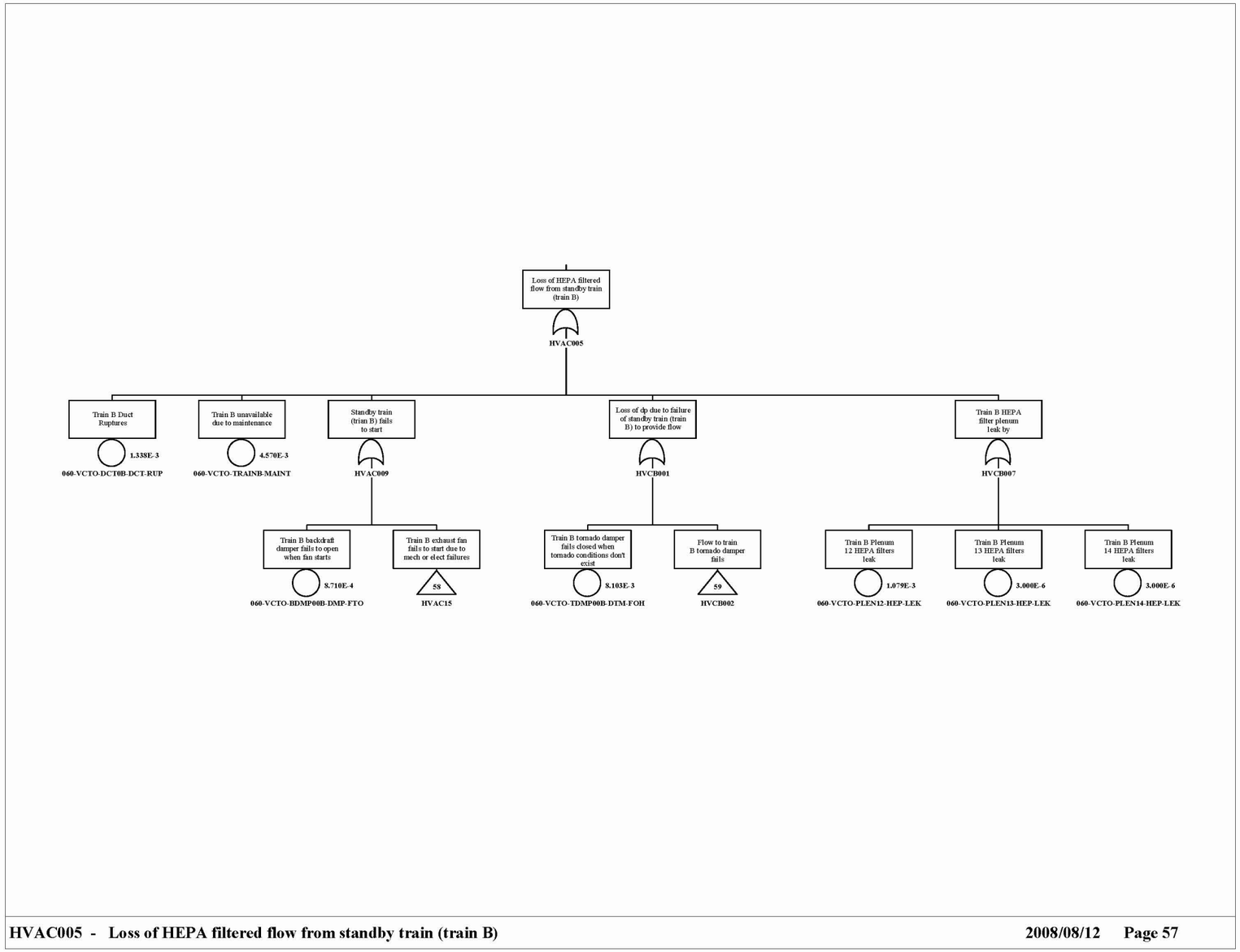

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Figure B2.4-6. Loss of HEPA Filtered Flow from Standby Train (Train B)

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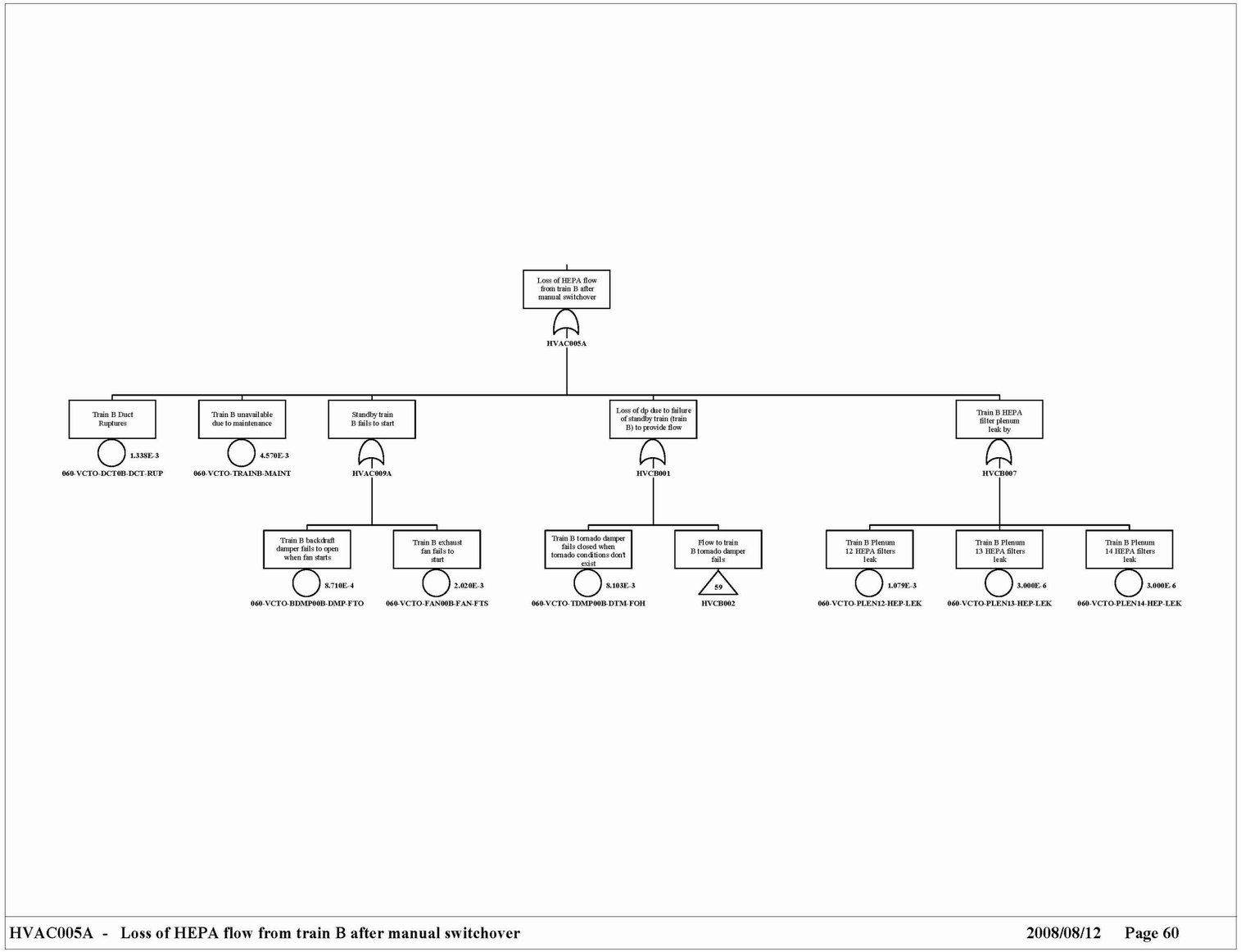

Source: Original

Figure B2.4-7. Loss of HEPA Flow from Train B after Manual Switchover

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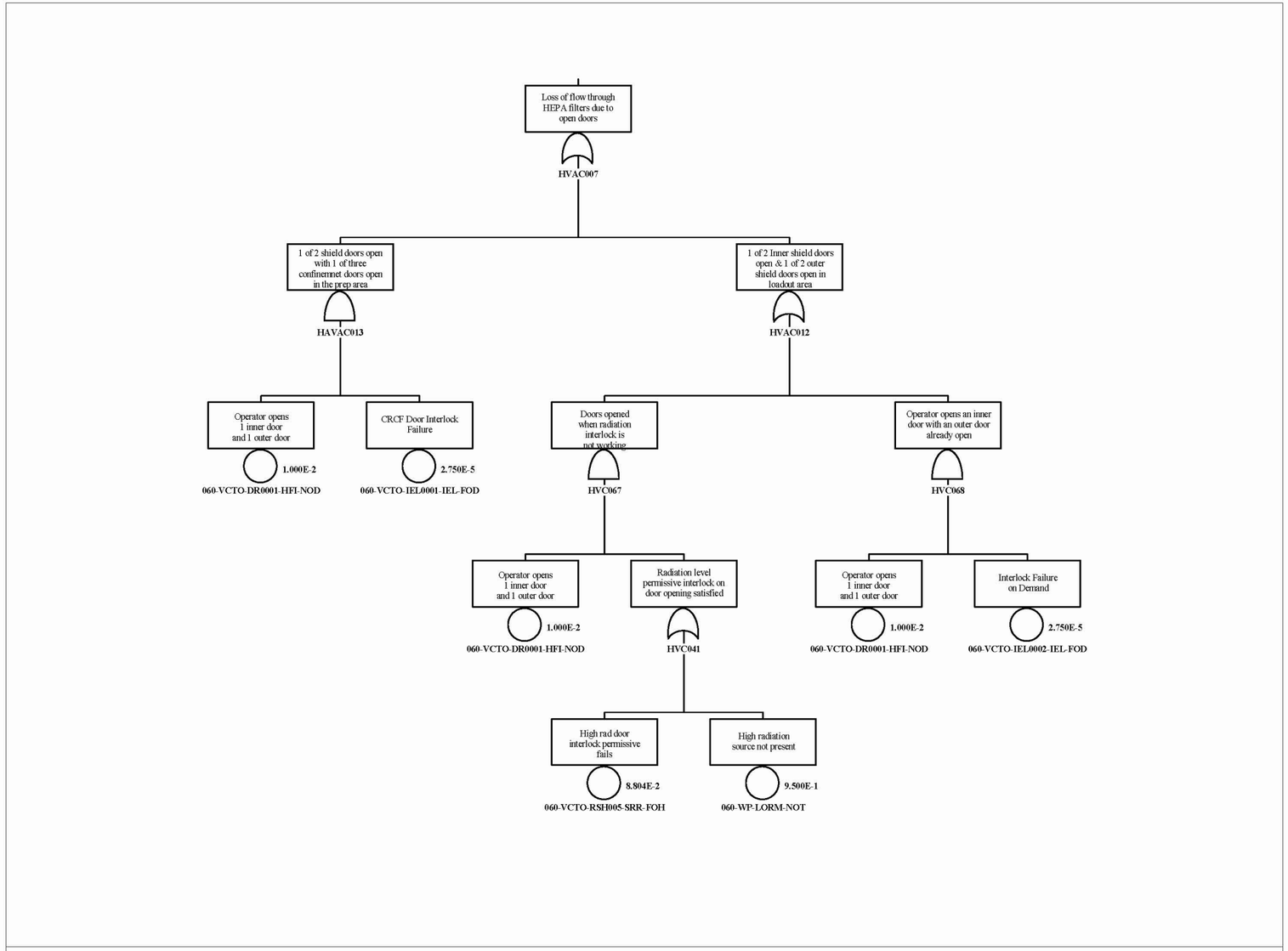

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Figure B2.4-8. Loss of Flow through HEPA Filters Due to Open Doors

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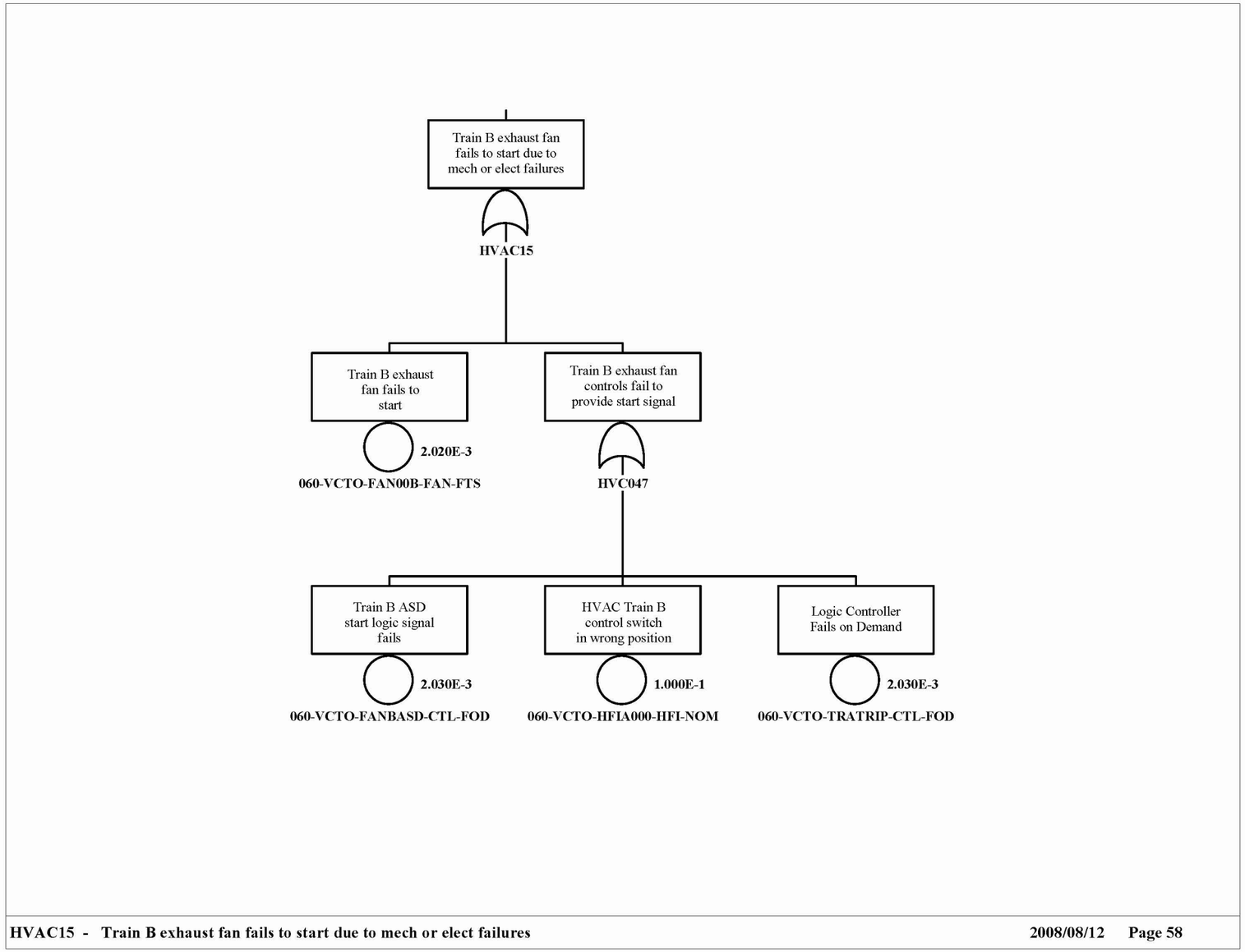

Source: Original

Figure B2.4-9. Train B Exhaust Fan Fails to Start Due to Mechanical or Electrical Failures

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