Table B7.3-1. 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	—	—	—	Failure to notice leak	—
HVAC Maintenance	—	—	—	Trains can not switch	—
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.

Source: Original

B7.4 HEATING, VENTILATION, AND AIR CONDITIONING RELATED FAILURE SCENARIO

There is a single top event for ITS HVAC failure which is stated as; Confinement zone exhaust system fails to maintain HEPA filtered flow.

B7.4.1 Failure to Maintain Delta Pressure

B7.4.1.1 Description

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

B7.4.1.2 Success Criteria

The purpose of the ITS 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 Δps to maintain airflow

toward the center of the facility where it is exhausted through HEPA filters to the atmosphere. Consequently the success criterion for the ITS HVAC is to maintain these Δps and associated exhaust flow through HEPA filters.

To accomplish this one of two HVAC trains must be operational with all exhaust flow passing through the HEPA filters before it is discharged to the atmosphere. The sizing of the exhaust motor and fan assembly will maintain the required Δps in sustained winds of up to 40 mph with less than 3 second gusts up to 90 mph. In addition, Δps may be lost for a period of time not to exceed 7 minutes in the WHF if and only if one of the shield or confinement doors is open.

B7.4.1.3 Design Requirements and Features

Requirements

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

Alarms are on a panel in the continuously manned central control station and responded to by operators. Alarm conditions are: fan tripped, fan failure, fan low Δp, and low discharge flow. Operators are not required to respond to the alarm (ITS-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

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

Testing and Maintenance

Requirements

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

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

Testing that requires the exhaust fan to run is performed on the active HVAC system.

Features

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

B7.4.1.4 Fault Tree Model

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

The fault tree model for the failure to maintain delta pressure in the facility includes those components that have been designated as ITS. There is only one exception and that is the inclusion of non-ITS supply fans that impact the exhaust fan run speed required to maintain Δp.

Interlocks in the ITS HVAC system address the potential for opening two or more of the confinement and shield doors as discussed under the door interlocks. (Note: There is no physical connection between this door interlock and the HVAC system.)

The mission time for the ITS HVAC system is currently set to 720 hours (Ref. B7.1.9). From section 6.2.2.7.3, a boundary condition for all GROA facilities regarding canister breach within a building is that it takes 720 hours to clean up the radiological spill in the facility. The HVAC system must be working during this time period to prevent an unfiltered release. 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 that of the active system. For ease of implementation in SAPHIRE, the rate data are maintained constant and the mission time is set to ½ the mission time or 360 hours.

For sequences that involve releases during the cask drying and inerting process, the ITS HVAC system was also evaluated for a mission time of 24 hours. The figures and tables in this section show the information for the 720-hour mission time ITS HVAC model unless otherwise noted. The fault tree structure and data are identical in the two models, with the exception of the mission times. Results are show in section B7.4.1.6 for both mission times.

B7.4.1.5 Basic Event Data

Table B7.4-1 contains a list of basic events used in the loss of delta pressure in the WHF. The model contains undeveloped transfers to ITS power systems. These failures are addressed in Attachment B8. Reliability data for basic events are detailed in Attachment C with the following exceptions:

A. Two are associated with human error. HFE detailed analysis is in Section 6.4 and Attachment E:

   1. Failure to properly restore system after maintenance.
   2. 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 Δp as a direct result of opening a vestibule door and the time it takes for the HVAC exhaust fans to re-establish delta pressure.

D. Two common-cause failures:

   1. Common-cause failures of the HEPA filters in the degraded mode.
   2. Common-cause failures of the non-ITS supply fans.

Table B7.4-1. Basic Event Probability for the HVAC Loss of Delta Pressure in the WHF

Name	Description	Calc Type	Calculated Probability	Failure Probability	Lambda	Mission time
050-EXCESSIVE-WIND-SPEED	Loss of dp due to sustained wind speeds exceeding 30 MPH	1	4.700E-03	4.700E-03	—	—
050-VCTO-AHU0001-FAN-FTR	AHU 0001 fan fails to run	3	5.059E-02	—	7.210E-05	7.200E+02
050-VCTO-AHU0002-FAN-FTR	AHU 0002 fan fails to run	3	5.059E-02	—	7.210E-05	7.200E+02
050-VCTO-AHU0003-FAN-FTR	AHU 0003 fan fails to run	3	2.562E-02	—	7.210E-05	3.600E+02
050-VCTO-AHU0003-FAN-FTS	AHU 0003 fan fais to start	1	2.020E-03	2.020E-03	—	—
050-VCTO-BDMP00A-UDM-FOH	Train A fan discharge backdraft damper fails closed	3	1.614E-02	—	2.260E-05	7.200E+02
050-VCTO-BDMP00B-DMP-FOD	Train B backdraft damper fails to open when fan starts	1	8.710E-04	8.710E-04	—	—
050-VCTO-BDMP00B-UDM-FOH	Train B fan discharge backdraft damper fails closed	3	8.103E-03	—	2.260E-05	3.600E+02
050-VCTO-DCT0A-DTC-RUP	Train A Duct Ruptures	3	2.675E-03	—	3.720E-06	7.200E+02
050-VCTO-DCT0B-DTC-RUP	Train B Duct Ruptures	3	1.338E-03	—	3.720E-06	3.600E+02
050-VCTO-DMP000A-DMP-FRO	Train A fan discharge manual isolaton damper fails closed	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-DMP000B-DMP-FRO	Train B fan discharge manual isolaton damper fails closed	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-DMPF00A-DMP-FRO	Train A fan inlet manual isolation damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-DMPF00B-DMP-FRO	Train B fan inlet manual isolation damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	3	5.059E-02	—	7.210E-05	7.200E+02
050-VCTO-FAN00A-PRM-FOH	Train A exhaust fan fails due to ASD malfunction	3	3.873E-04	—	5.380E-07	7.200E+02
050-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	3	2.562E-02	—	7.210E-05	3.600E+02
050-VCTO-FAN00B-FAN-FTS	Train B exhaust fan fails to start	1	2.020E-03	2.020E-03	—	—
050-VCTO-FAN00B-PRM-FOH	Train B exhaust fan fails due to ASD malfunction	3	1.937E-04	—	5.380E-07	3.600E+02
050-VCTO-FANBASD-CTL-FOD	Train B ASD start logic signal fails	1	2.030E-03	2.030E-03	—	—
050-VCTO-HEPA-	CCF of 2 of 3 filter plenums	C	9.531E-05	—	—	—

Table B7.4-1. Basic Event Probability for the HVAC Loss of Delta Pressure in the WHF (Continued)

Name	Description	Calc Type	Calculated Probability	Failure Probability	Lambda	Mission time
CCF						
050-VCTO-HEPAB-CCF	Common Cause Failure of HEPA Filters (2 of 3)	C	4.769E-05	—	—	—
050-VCTO-HEPALK-HFI-NOD	Operaor fails to shift trains when alarm occurs	1	1.000E+00	1.000E+00	—	—
050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1	1.000E-01	1.000E-01	—	—
050-VCTO-PLEN01-DMS-FOH	Train A plenum 01 moisture separator/demi ster plugs	3	6.545E-03	—	9.120E-06	7.200E+02
050-VCTO-PLEN01-HEP-LEK	Train A Plenum 01 HEPA filters leak	3	2.158E-03	—	3.000E-06	7.200E+02
050-VCTO-PLEN01-HEP-PLG	Train A Plenum 01 HEPA filters plug	3	3.070E-03	—	4.270E-06	7.200E+02
050-VCTO-PLEN01I-DMP-FRO	Train A filter plenum 01 inlet damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-PLEN01O-DMP-FRO	Train A filter plenum 01 outlet damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-PLEN02-DMS-FOH	Train A plenum 02 moisture seperator/demi ster plugs	3	6.545E-03	—	9.120E-06	7.200E+02
050-VCTO-PLEN02-HEP-LEK	Train A Plenum 02 HEPA filters leak	3	2.158E-03	—	3.000E-06	7.200E+02
050-VCTO-PLEN02-HEP-PLG	Train A Plenum 02 HEPA filters plug	3	3.070E-03	—	4.270E-06	7.200E+02
050-VCTO-PLEN02I-DMP-FRO	Train A filter plenum 02 inlet damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-PLEN02O-DMP-FRO	Train A filter plenum 02 outlet damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-PLEN03-DMS-FOH	Train A plenum 03 moisture seperator/demi ster plugs	3	6.545E-03	—	9.120E-06	7.200E+02
050-VCTO-PLEN03-HEP-LEK	Train A Plenum 03 HEPA filters leak	3	2.158E-03	—	3.000E-06	7.200E+02
050-VCTO-PLEN03-HEP-PLG	Train A Plenum 03 HEPA filters plug	3	3.070E-03	—	4.270E-06	7.200E+02
050-VCTO-PLEN03I-DMP-FRO	Train A filter plenum 03 inlet damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-PLEN03O-DMP-FRO	Train A filter plenum 03 outlet damper fails to remain open	3	6.033E-05	—	8.380E-08	7.200E+02
050-VCTO-PLEN05-DMS-FOH	Train B plenum 05 moisture seperator/demi ster plugs	3	3.278E-03	—	9.120E-06	3.600E+02
050-VCTO-PLEN05-HEP-LEK	Train B Plenum 05 HEPA filters leak	3	1.079E-03	—	3.000E-06	3.600E+02
050-VCTO-PLEN05-HEP-PLG	Train B Plenum 05 HEPA filters plug	3	1.536E-03	—	4.270E-06	3.600E+02
050-VCTO-PLEN05I-DMP-FRO	Train B filter plenum 05 inlet damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-PLEN05O-DMP-FRO	Train B filter plenum 05 outlet damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02

Table B7.4-1. Basic Event Probability for the HVAC Loss of Delta Pressure in the WHF (Continued)

Name	Description	Calc Type	Calculated Probability	Failure Probability	Lambda	Mission time
050-VCTO-PLEN06-DMS-FOH	Train B plenum 06 moisture seperator/demi ster plugs	3	3.278E-03	—	9.120E-06	3.600E+02
050-VCTO-PLEN06-HEP-LEK	Train B Plenum 06 HEPA filters leak	3	1.079E-03	—	3.000E-06	3.600E+02
050-VCTO-PLEN06-HEP-PLG	Train B Plenum 06 HEPA filters plug	3	1.536E-03	—	4.270E-06	3.600E+02
050-VCTO-PLEN06I-DMP-FRO	Train B filter plenum 06 inlet damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-PLEN06O-DMP-FRO	Train B filter plenum 06 outlet damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-PLEN07-DMS-FOH	Train B plenum 07 moisture seperator/demi ster plugs	3	3.278E-03	—	9.120E-06	3.600E+02
050-VCTO-PLEN07-HEP-LEK	Train B Plenum 07 HEPA filters leak	3	1.079E-03	—	3.000E-06	3.600E+02
050-VCTO-PLEN07-HEP-PLG	Train B Plenum 07 HEPA filters plug	3	1.536E-03	—	4.270E-06	3.600E+02
050-VCTO-PLEN07I-DMP-FRO	Train B filter plenum 07 inlet damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-PLEN07O-DMP-FRO	Train B filter plenum 07 inlet damper fails to remain open	3	3.017E-05	—	8.380E-08	3.600E+02
050-VCTO-RSH114-SRR-FOH	Exhaust high rad alarm fails	3	2.000E-05	—	2.000E-05	—
050-VCTO-SUPPLY-FAN-CCF	CCF of both operating supply fans	C	1.189E-03	—	—	—
050-VCTO-TDMP00A-DTM-FOH	Train A tornado damper fails closed when tornado conditions don't exist	3	1.614E-02	—	2.260E-05	7.200E+02
050-VCTO-TDMP00B-DTM-FOH	Train B tornado damper fails closed when tornado conditions don't exist	3	8.103E-03	—	2.260E-05	3.600E+02
050-VCTO-TRAINB-MAINT	Train B unavailable due to maintenance	1	4.570E-03	4.570E-03	—	—
050-VCTO-TRATRIP-CTL-FOD	Signal from train A tripped logic fails	1	2.030E-03	2.030E-03	—	—
LOSP	Loss of offsite power	1	2.990E-03	2.990E-03	—	—

NOTE: AHU = air handling unit; ASD = adjustable speed drive; Calc = calculation; CCF = common-cause failure; HEPA = high-efficiency particulate air; rad = radiation; WHF = Wet Handling Facility; P = pressure.

Source: Original

B7.4.1.5.1 Human Failure Events

There are two basic HFEs associated with human error listed in Table B7.4-2. They are: (1) failure to notice that there is a HEPA leak, and (2) leaving the start/stop/auto/maintenance switch on the standby train in the wrong position.

Table B7.4-2. Human Failure Events

Basic Event Name	Basic Event Description
050-VCTO-HEPALK-HFI-NOD	Operaor fails to shift trains when alarm occurs
050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position

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

Source: Original

B7.4.1.5.2 Common-Cause Failures

There are three common-cause failures identified in the HVAC model. Two of the common-causes are associated with the potential of a HEPA filter failure in the degraded mode for HEPA filters in the degraded mode where there is a two-of-three success situation. An alpha factor of 0.025 is used (Table C3-1, CCCG=3). The third common-cause is applied to the non-ITS supply fans where success is two-of-three in the degraded mode of operation. An alpha factor of 0.0235 is used (Table C3-1, CCCG-2).

B7.4.1.6 Uncertainty and Cut Set Generation

Figure B7.4-1 contains the uncertainty results obtained from running the fault trees for the loss of delta pressure in the WHF (720 hour mission time). Figure B7.4-1A contains the uncertainty results for the same fault trees using a 24-hour mission time. These results are used for sequences that involve cask drying and inerting. Figures B7.4-2 (720-hour mission time) and B7.4-2A (24-hour mission time) provide the cut set generation results for the loss of delta pressure in the WHF. These results are for the HVAC system coupled with loss of electrical power, which is discussed separately in Section B8.

Uncertainty Results

Name	050-DP-LOSS-WHF		
Random Seed	1234	Events	187
Sample Size	10000	Cut Sets	111787
Point estimate			3.078E-002
Mean Value			3.572E-002
5th Percentile Value			4.026E-003
Median Value			1.378E-002
95th Percentile Value			1.078E-001
Minimum Sample Value			1.094E-003
Maximum Sample Value			1.000E+000
Standard Deviation			9.890E-002
Skewness			7.202E+000
Kurtosis			6.116E+001
Elapsed Time			00:01:38.690

OK

Source: Original

Figure B7.4-1. Uncertainty Results of the "WHF Loss of Delta Pressure" Fault Tree (720-hour mission time)

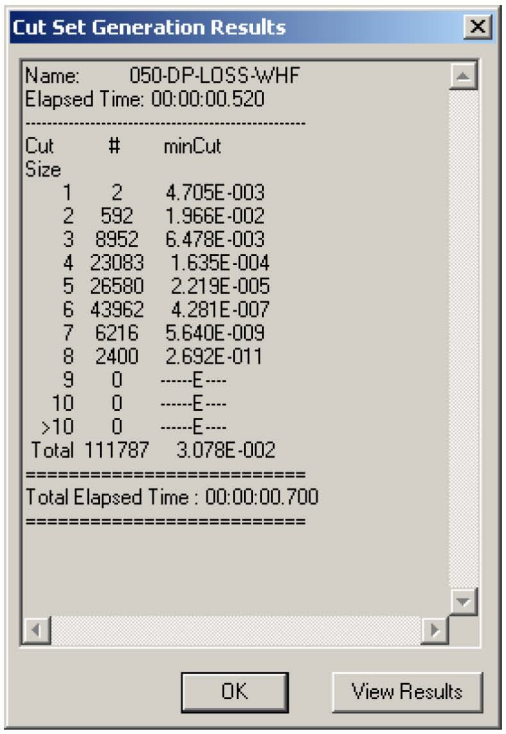
Uncertainty Results

Name	050-DP-LOSS-WHF		
Random Seed	1234	Events	186
Sample Size	10000	Cut Sets	111787
Point estimate			6.916E-004
Mean Value			9.969E-004
5th Percentile Value			1.140E-004
Median Value			3.953E-004
95th Percentile Value			2.129E-003
Minimum Sample Value			2.565E-005
Maximum Sample Value			9.976E-001
Standard Deviation			1.147E-002
Skewness			6.963E+001
Kurtosis			5.786E+003
Elapsed Time			00:07:38.130

OK

Source: Original

Figure B7.4-1A. Uncertainty Results of the "WHF Loss of Delta Pressure" Fault Tree (24-hour mission time)



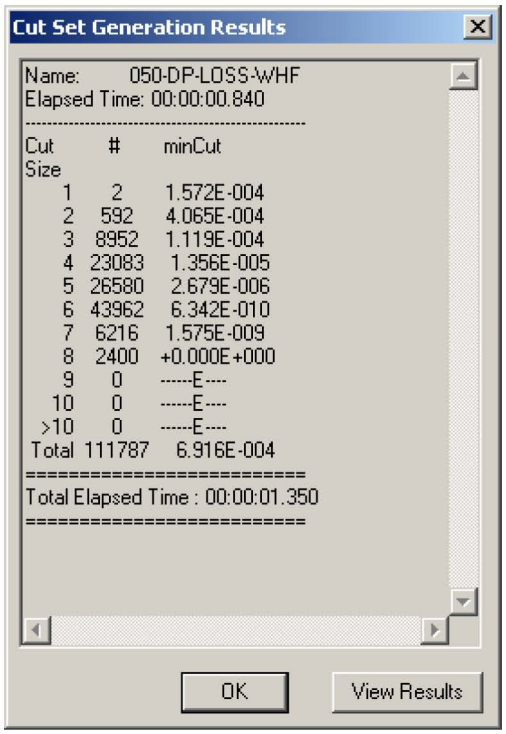
Cut Set Generation Results

```
Name:        050-DP-LOSS-WHF
Elapsed Time: 00:00:00.520
-----------------------------------------------
Cut        #       minCut
Size
    1      2       4.705E-003
    2    592       1.966E-002
    3   8952       6.478E-003
    4  23083       1.635E-004
    5  26580       2.219E-005
    6  43962       4.281E-007
    7   6216       5.640E-009
    8   2400       2.692E-011
    9      0       ------E----
   10      0       ------E----
  >10      0       ------E----
 Total 111787       3.078E-002
==========================
Total Elapsed Time : 00:00:00.700
==========================
```

OK View Results

Source: Original

Figure B7.4-2. Cut Set Generation Results of the "WHF Loss of Delta Pressure" Fault Tree (720-hour mission time)



Cut Set Generation Results

```
Name:        050-DP-LOSS-WHF
Elapsed Time: 00:00:00.840
-----------------------------------------------
Cut        #       minCut
Size
    1      2       1.572E-004
    2    592       4.065E-004
    3   8952       1.119E-004
    4  23083       1.356E-005
    5  26580       2.679E-006
    6  43962       6.342E-010
    7   6216       1.575E-009
    8   2400      +0.000E+000
    9      0       ------E----
   10      0       ------E----
  >10      0       ------E----
 Total 111787       6.916E-004
==========================
Total Elapsed Time : 00:00:01.350
==========================
```

OK View Results

Source: Original

Figure B7.4-2A. Cut Set Generation Results of the "WHF Loss of Delta Pressure" Fault Tree (24-hour mission time)

B7.4.1.7 Cut Sets

Table B7.4-3 contains the top 25 cut sets for the "Loss of Delta Pressure" in the WHF. Note that several cut sets in this table are the result of AC power failures that directly cause failure of HVAC. The AC power fault tree and the basic events contributing to AC power failures are presented in Section B8.4.

Table B7.4-3. Dominant Cut Sets for the Loss of Delta Pressure in the WHF

Fault Tree	Cut Set %	Probability /Frequency	Basic Event	Description	Event Probability
050-DP-LOSS-WHF	16.44	5.059E-03	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
	15.27	4.700E-03	050-EXCESSIVE-WIND-SPEED	Loss of dp due to sustained wind speeds exceeding 30 MPH	4.700E-03
	5.76	1.772E-03	26D-#EEY-ITSDG-A-#DG-FTR	ITS Diesel Generator A Fails to Run	7.698E-01
			26D-#EEY-ITSDGB-#DG-FTR	Diesel Generator Fails to Run	7.698E-01
			LOSP	Loss of offsite power	2.990E-03
050-DP-LOSS-WHF (con't)	5.24	1.614E-03	050-VCTO-BDMP00A-UDM-FOH	Train A fan discharge backdraft damper fails closed	1.614E-02
			050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
	5.24	1.614E-03	050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
			050-VCTO-TDMP00A-DTM-FOH	Train A tornado damper fails closed when tornado conditions don't exist	1.614E-02
	4.21	1.296E-03	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-02
	1.75	5.378E-04	050-#EEE-MCC0001-MCC-FOH	WHF ITS MCC 00001 Fails	5.378E-03
			050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
	1.34	4.136E-04	050-VCTO-BDMP00A-UDM-FOH	Train A fan discharge backdraft damper fails closed	1.614E-02
			050-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-02
	1.34	4.136E-04	050-VCTO-FAN00B-FAN-FTR	Train B exhaust fan fails to run	2.562E-02
			050-VCTO-TDMP00A-DTM-FOH	Train A tornado damper fails closed when tornado conditions don't exist	1.614E-02
	1.33	4.099E-04	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-TDMP00B-DTM-FOH	Train B tornado damper fails closed when tornado conditions don't exist	8.103E-03
	1.33	4.099E-04	050-VCTO-BDMP00B-UDM-FOH	Train B fan discharge backdraft damper fails closed	8.103E-03
			050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
	1.24	3.816E-04	050-#EEE-LDCNTRA-C52-	Load Center A Feed Circuit	3.816E-03

Fault Tree	Cut Set %	Probability /Frequency	Basic Event	Description	Event Probability
			SPO	Breaker Spurious Operation	
			050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
050-DP-LOSS-WHF (con't)	1.24	3.816E-04	050-#EEE-MCC0001-C52-SPO	WHF ITS MCC 0001 Feed Breaker Spurious Operation	3.816E-03
			050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
	0.95	2.938E-04	050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
			26D-#EEY-ITSDG-A-#DG-FTR	ITS Diesel Generator A Fails to Run	7.698E-01
			26D-#EEY-OB-SWGA-C52-SPO	13.8kV ITS SWGR A feed Breaker Spurious Operation	3.816E-03
	0.95	2.938E-04	050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
			26D-#EEY-ITSDG-A-#DG-FTR	ITS Diesel Generator A Fails to Run	7.698E-01
			27A-#EEE-BUS2DGA-C52-SPO	13.8kV Open Bus 2 ITS Load Breaker Spurious Operation	3.816E-03
	0.89	2.732E-04	050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
			26D-#EEESWGRDGA-AHU-FTR	13.8kV ITS Switchgear room Air Handling Unit Fails	2.732E-03
	0.88	2.721E-04	050-#EEE-MCC0002-MCC-FOH	WHF ITS MCC00002 Failure	5.378E-03
			050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
	0.83	2.559E-04	050-VCT0-EXH-004-FAN-FTR	WHF ITS Elec Exhaust Fan 00004 Fails to Run	5.059E-02
			050-VCT0-EXH-005-FAN-FTR	WHF ITS Elec Exhaust Fan 00005 Fails to Run	5.059E-02
			050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
	0.75	2.312E-04	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-TRAINB-MAINT	Train B unavailable due to maintenance	4.570E-03
	0.75	2.302E-04	050-VCTO-HFIA000-HFI-NOM	HVAC Train B control switch in wrong position	1.000E-01
			26D-#EEY-ITSDG-A-#DG-FTR	ITS Diesel Generator A Fails to Run	7.698E-01
			LOSP	Loss of offsite power	2.990E-03
	0.63	1.930E-04	050-#EEE-LDCNTRB-C52-SPO	WHF ITS Load Center Circuit Breaker (AC) Spur Op	3.816E-03
			050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
	0.63	1.930E-04	050-#EEE-MCC0002-C52-SPO	WHF MCC-00002 Feed Breaker Spurious Operation	3.816E-03
			050-VCTO-FAN00A-FAN-	Exhaust Fan in Train A Fails	5.059E-02

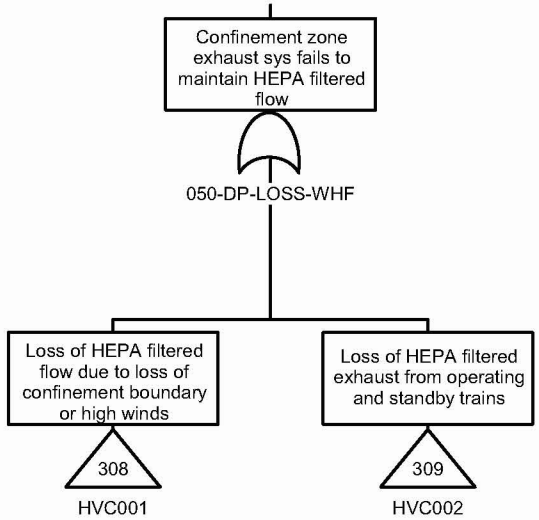
Fault Tree	Cut Set %	Probability /Frequency	Basic Event	Description	Event Probability
			FTR		
050-DP-LOSS-WHF (con't)	0.54	1.658E-04	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-PLEN05-DMS-FOH	Train B plenum 05 moisture seperator/ demi ster plugs	3.278E-03
	0.54	1.658E-04	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-PLEN06-DMS-FOH	Train B plenum 06 moisture seperator/demi ster plugs	3.278E-03
	0.54	1.658E-04	050-VCTO-FAN00A-FAN-FTR	Exhaust Fan in Train A Fails	5.059E-02
			050-VCTO-PLEN07-DMS-FOH	Train B plenum 07 moisture seperator/demi ster plugs	3.278E-03

NOTE: Elec = electrical; HVAC = heating, ventilation, and air conditioning; ITS = important to safety; MCC = motor control center; Op = operation; Spur = spurious; SWGR = switchgear; WHF = Wet Handling Facility.

Source: Original

B7.4.1.8 HVAC Fault Trees

The following fault trees show the transfers to the ITS electrical system for the HVAC equipment. For specifics on the electrical system, refer to the "AC Power System Fault Tree Analysis" in Attachment B8.



050-DP-LOSS-WHF - Delta Pressure Not Maintained in CRCF facility 2008/08/13 Page 62

Source: Original

Figure B7.4-3. Delta Pressure not Maintained in WHF

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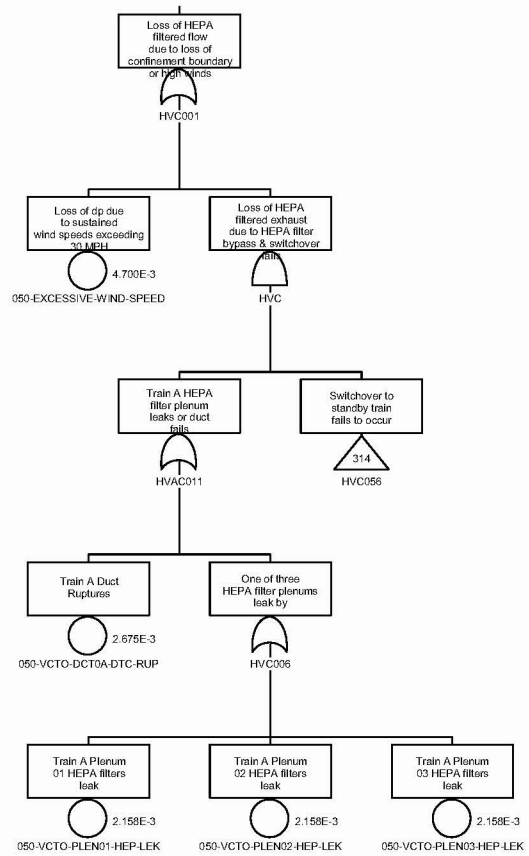

HVC001 - Loss of HEPA filtered flow due to loss of confinement boundary or high winds 2008/09/17 Page 308

Source: Original

Figure B7.4-4. Loss of HEPA Filtered Flow Due to Loss of Confinement Boundary or High Winds

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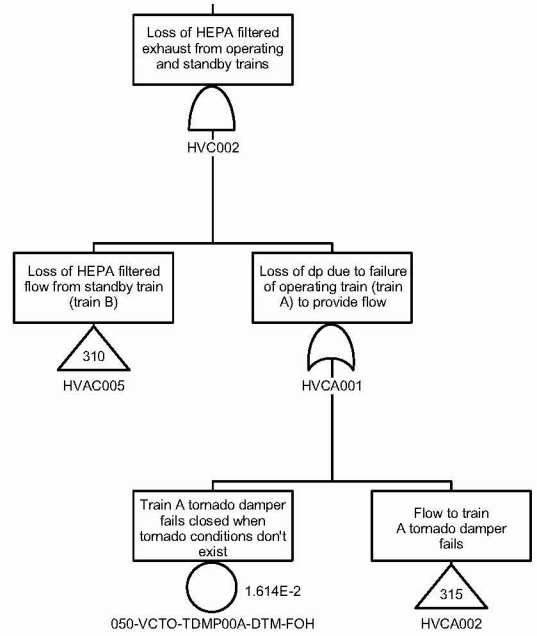

HVC002 - Loss of HEPA filtered exhaust from operating and standby trains 2008/08/13 Page 309

Source: Original

Figure B7.4-5. Loss of HEPA Filtered Exhaust from Operating and Standby Trains

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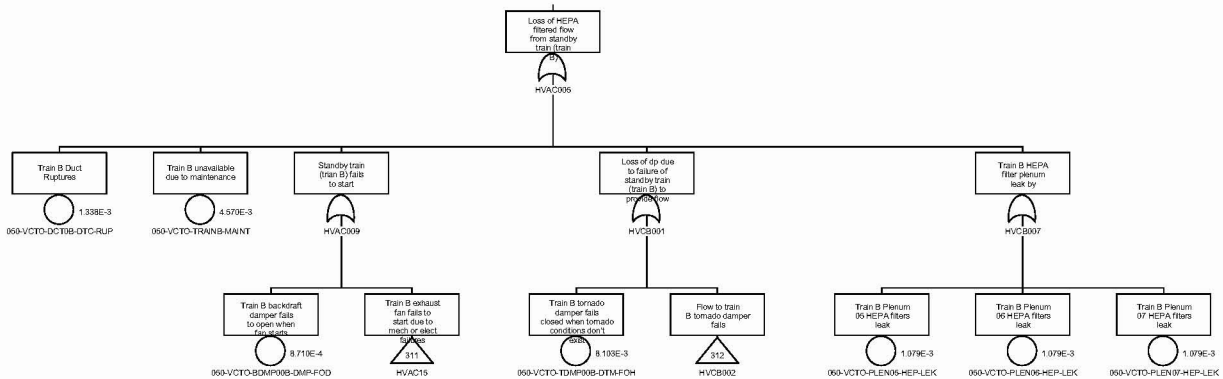

HVAC005 - Loss of HEPA filtered flow from standby train (train B) 2008/09/17 Page 310

Source: Original

Figure B7.4-6. Loss of HEPA Filtered Flow from Standby Train (Train B)

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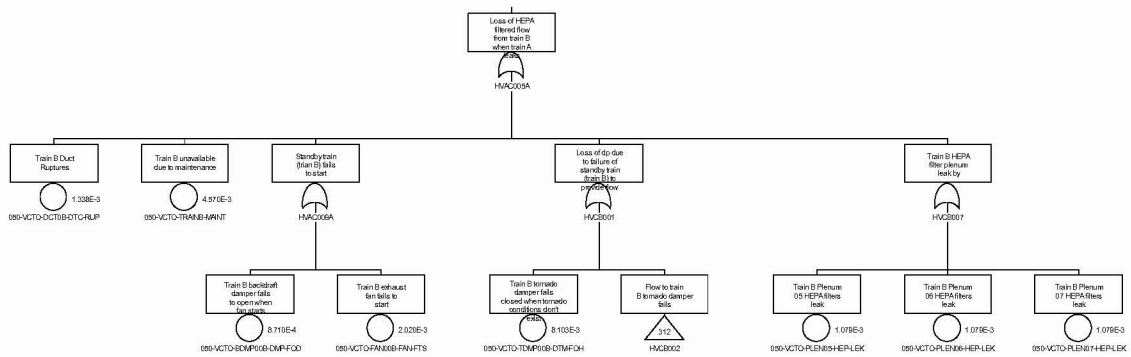

HVAC005A - Loss of HEPA filtered flow from train B when train A leaks 2008/11/04 Page 313

Source: Original

Figure B7.4-7. Loss of HEPA Filtered Flow from Train B When Train A Leaks

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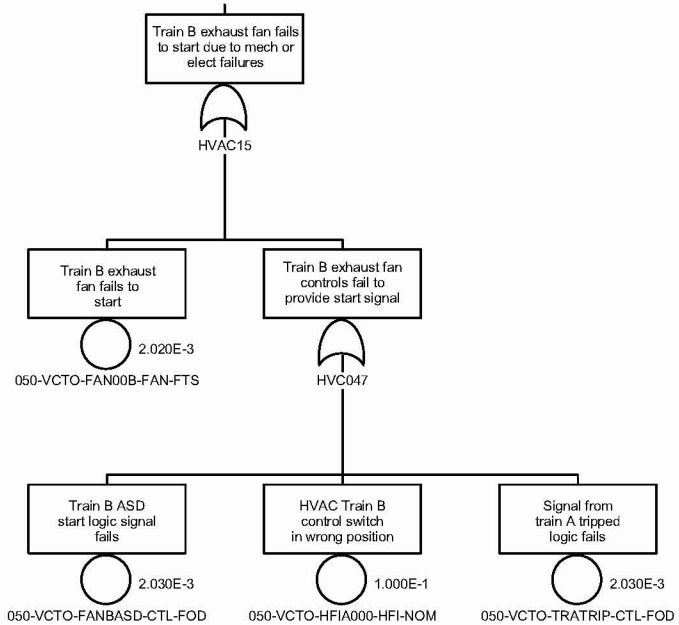

HVAC15 - Train B exhaust fan fails to start due to mech or elect failures 2008/08/13 Page 311

Source: Original

Figure B7.4-8. Train B Exhaust Fan Fails to Start Due to Mechanical or Electrical Failures

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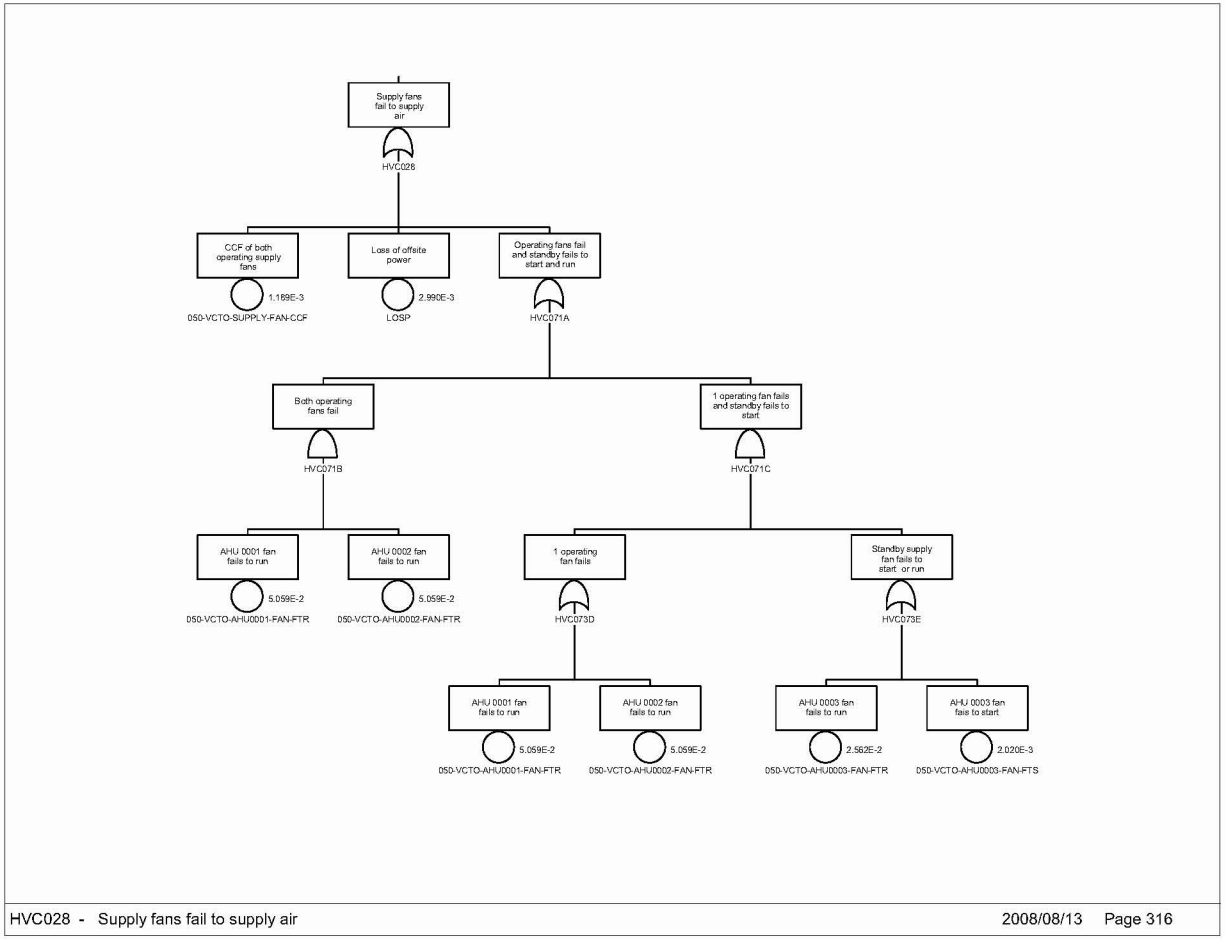

Source: Original

Figure B7.4-9. Supply Fans Fail to Supply Air

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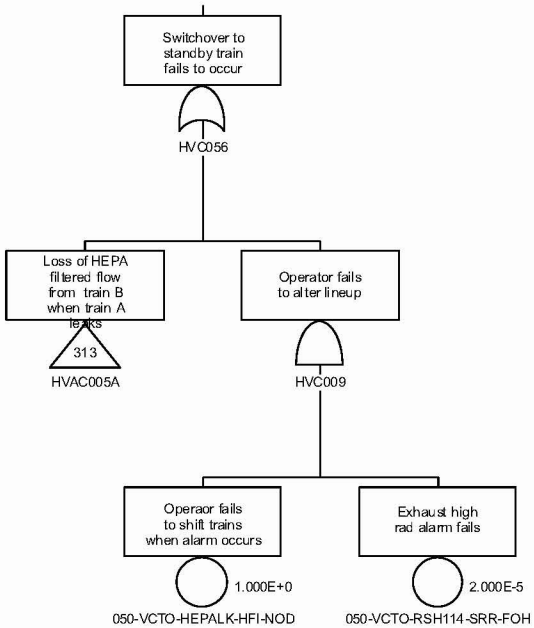

HVC056 - Switchover to standby train fails to occur 2008/08/13 Page 314

Source: Original

Figure B7.4-10. Switchover to Standby Train Fails to Occur

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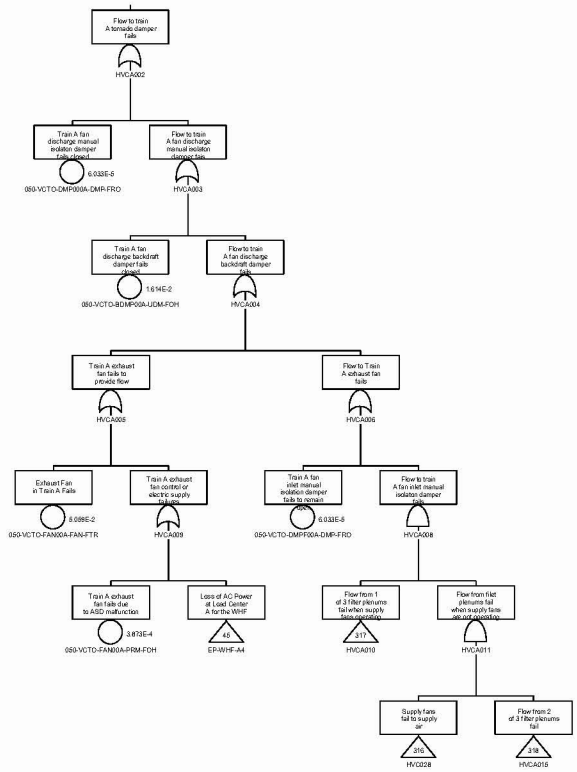

HVCA002 - Flow to train A tornado damper fails 2008/08/13 Page 315

Source: Original

Figure B7.4-11. Flow to Train A Tornado Damper Fails

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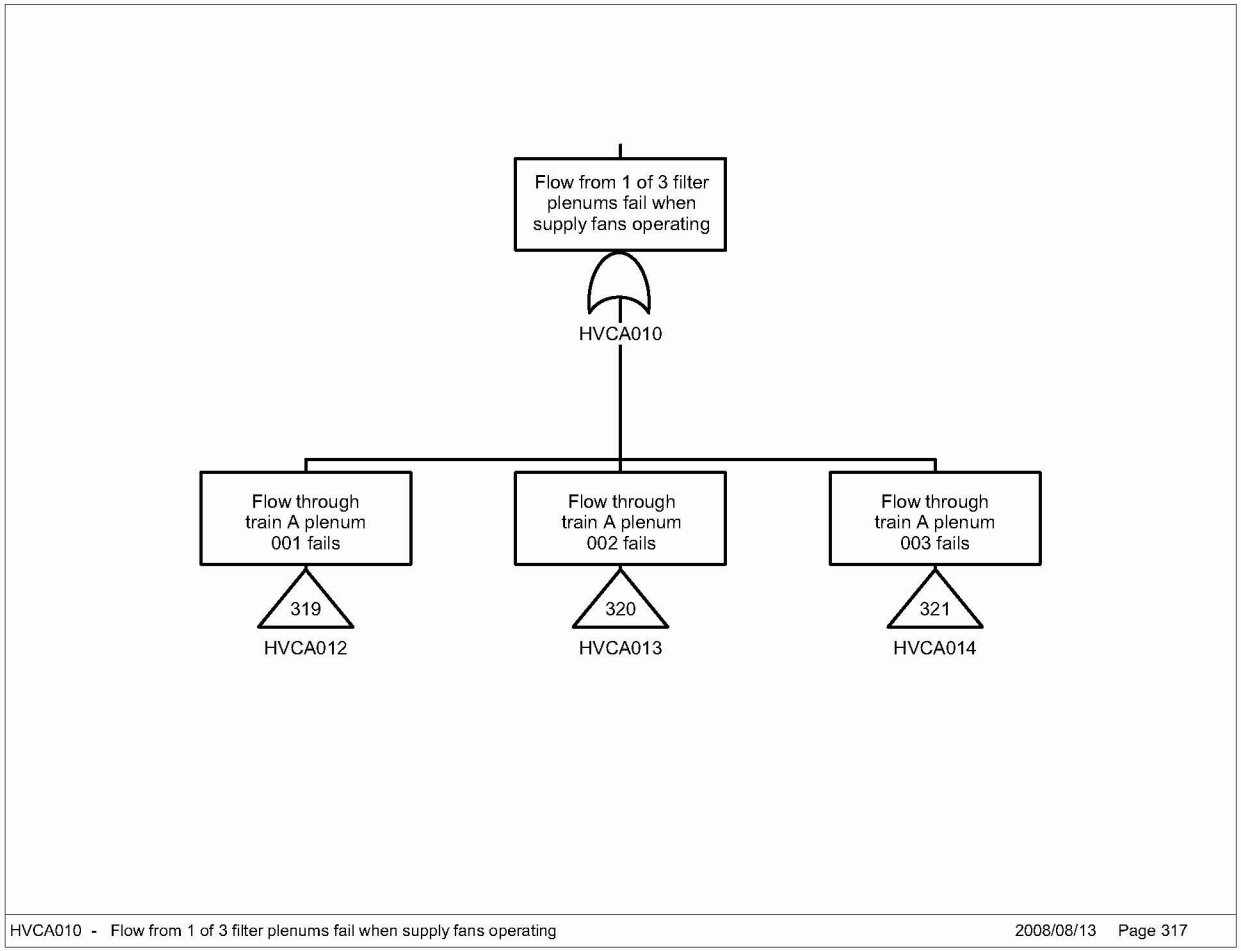

Source: Original

Figure B7.4-12. Flow From 1 of 3 Filter Plenums Fail When Supply Fans Operating

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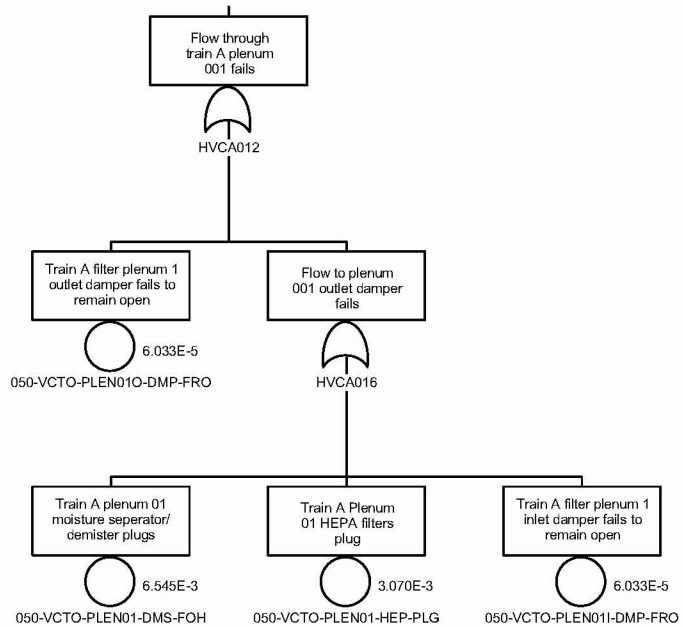

HVCA012 - Flow through train A plenum 001 fails 2008/08/13 Page 319

Source: Original

Figure B7.4-13. Flow Through Train A Plenum 001 Fails

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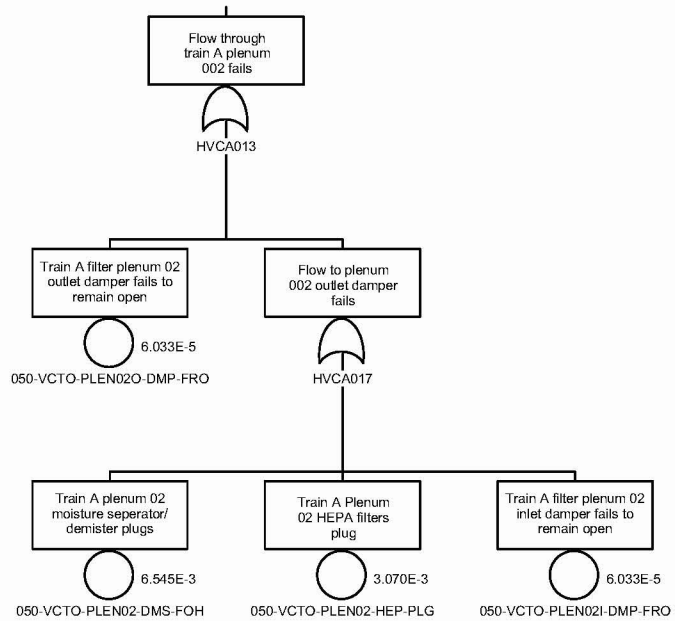

HVCA013 - Flow through train A plenum 002 fails 2008/08/13 Page 320

Source: Original

Figure B7.4-14. Flow Through Train A Plenum 002 Fails

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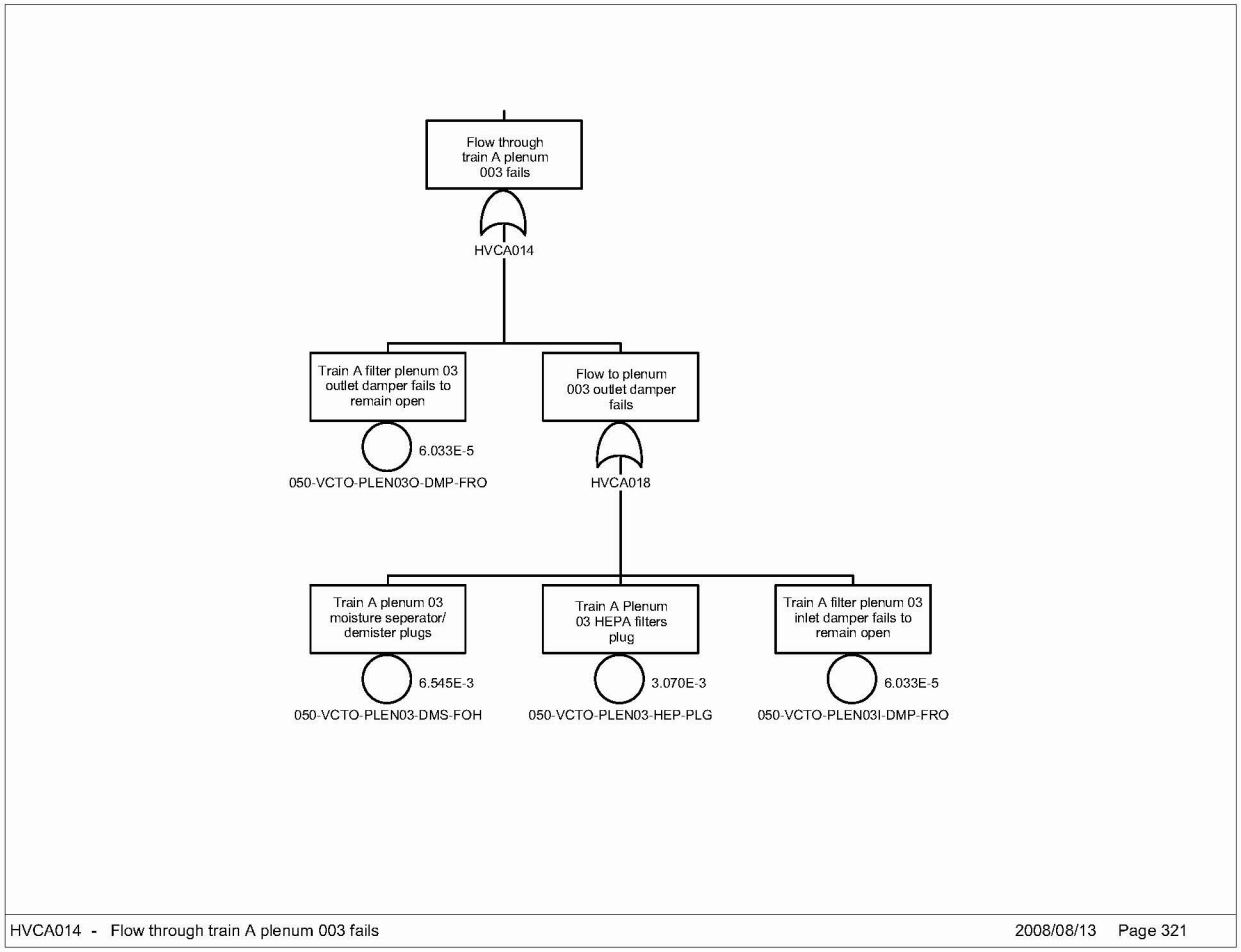

Source: Original

Figure B7.4-15. Flow Through Train A Plenum 003 Fails

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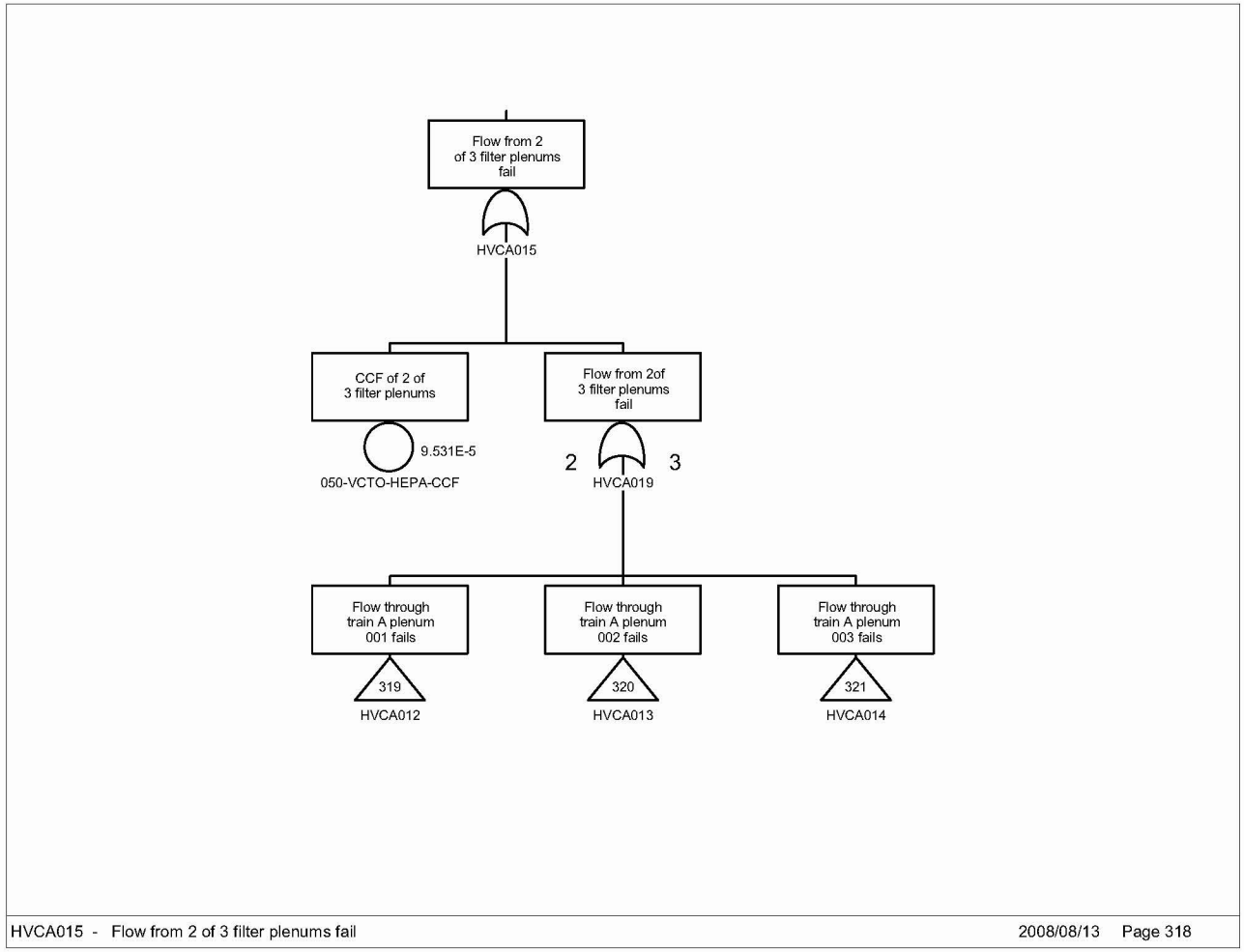

Source: Original

Figure B7.4-16. Flow from 2 of 3 Filter Plenums Fail

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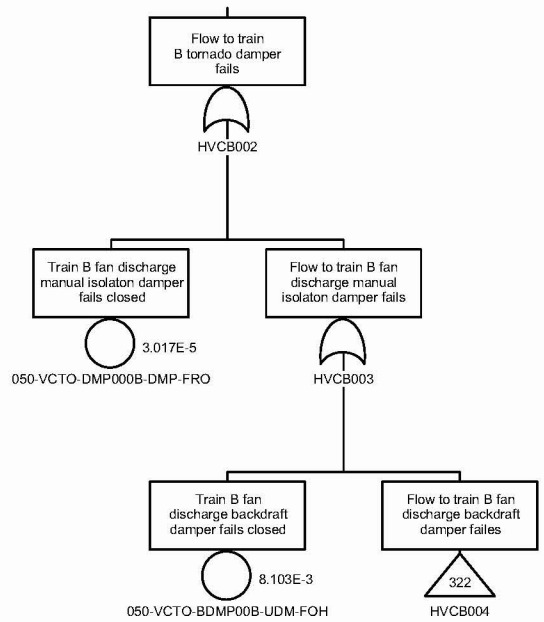

HVCB002 - Flow to train B tornado damper fails 2008/08/13 Page 312

Source: Original

Figure B7.4-17. Flow to Train B Tornado Damper Fails

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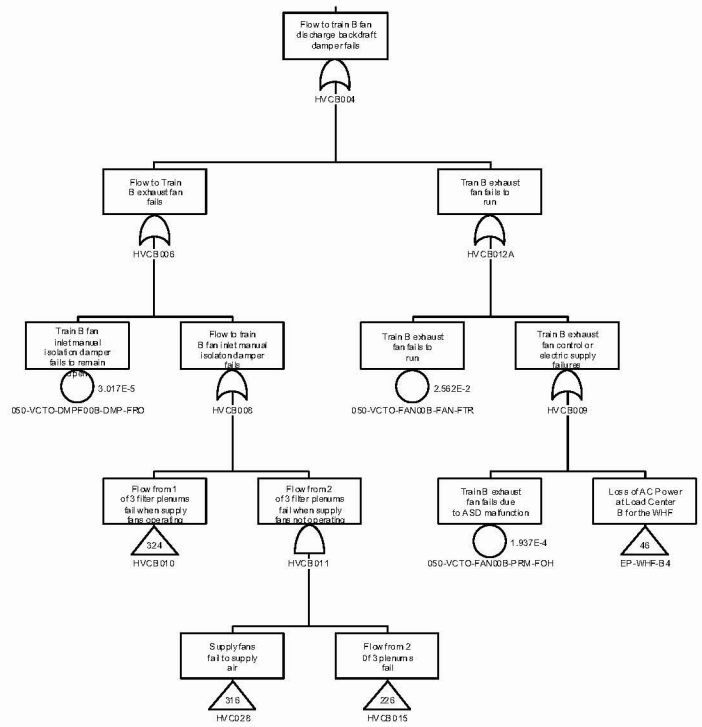

HVCB004 - Flow to train B fan discharge backdraft damper fails 2008/11/04 Page 322

Source: Original

Figure B7.4-18. Flow to Train B Fan Discharge Backdraft Damper Fails

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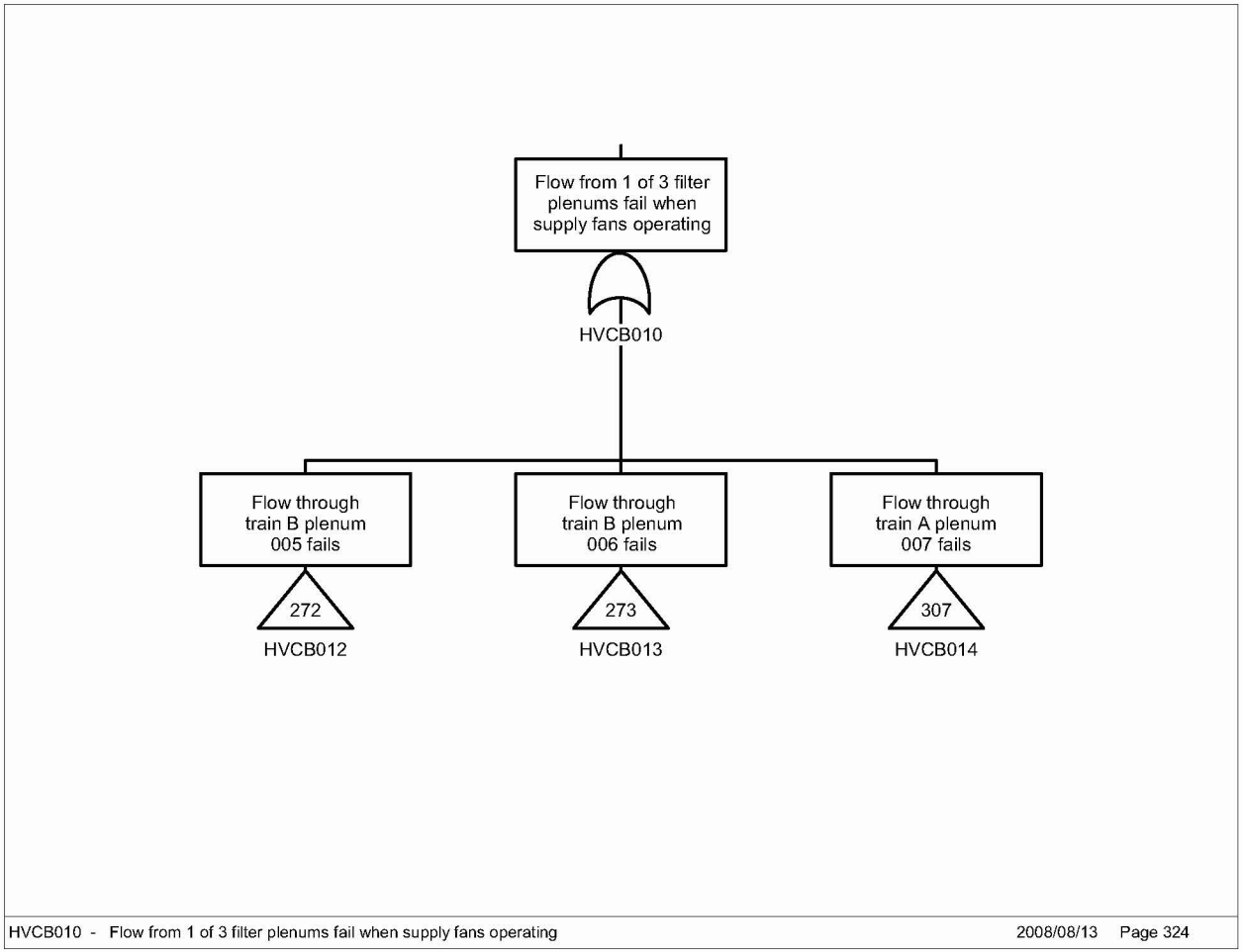

Source: Original

Figure B7.4-19. Flow From 1 of 3 Filter Plenums Fail When Supply Fans Operating

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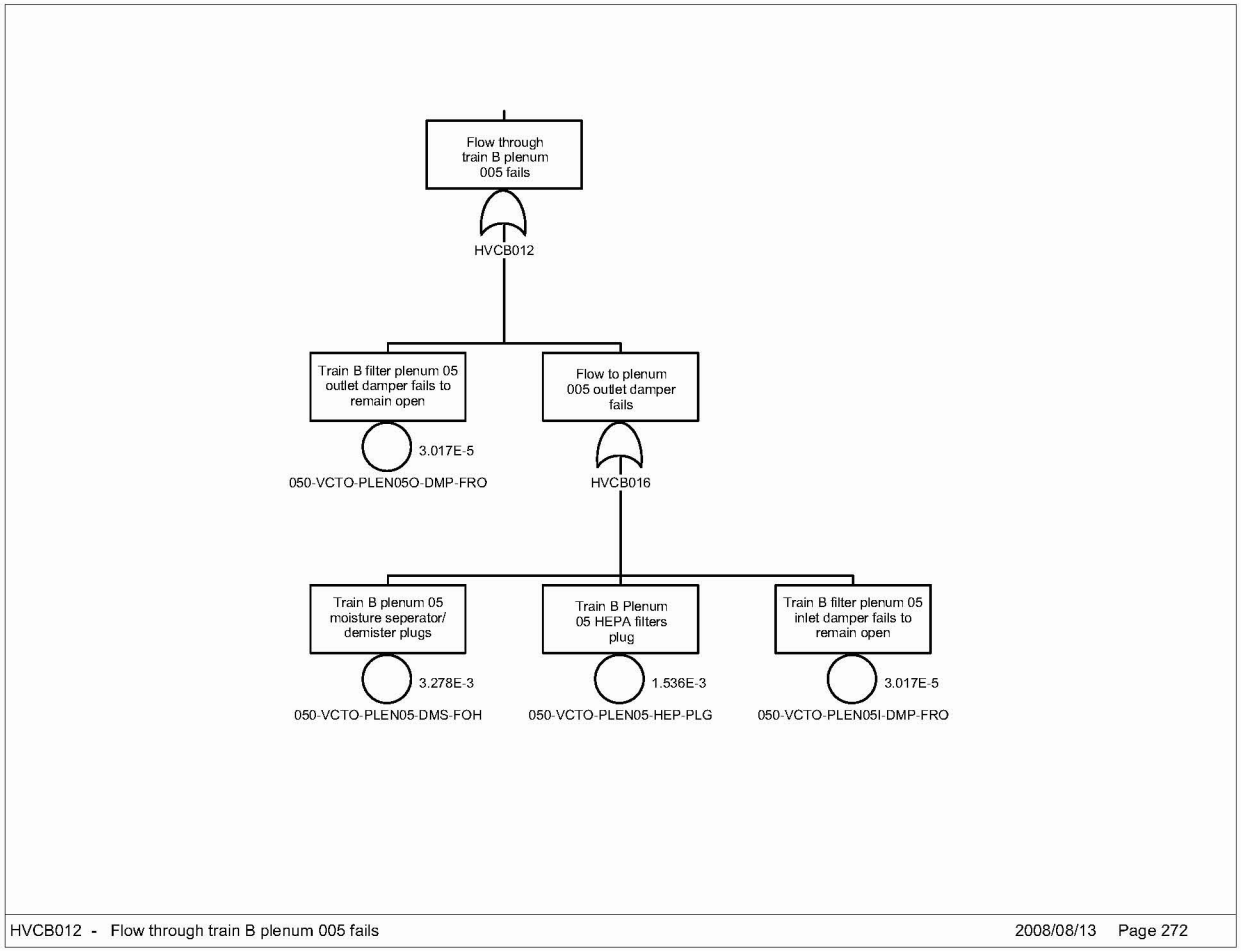

Source: Original

Figure B7.4-20. Flow Through Train B Plenum 005 Fails

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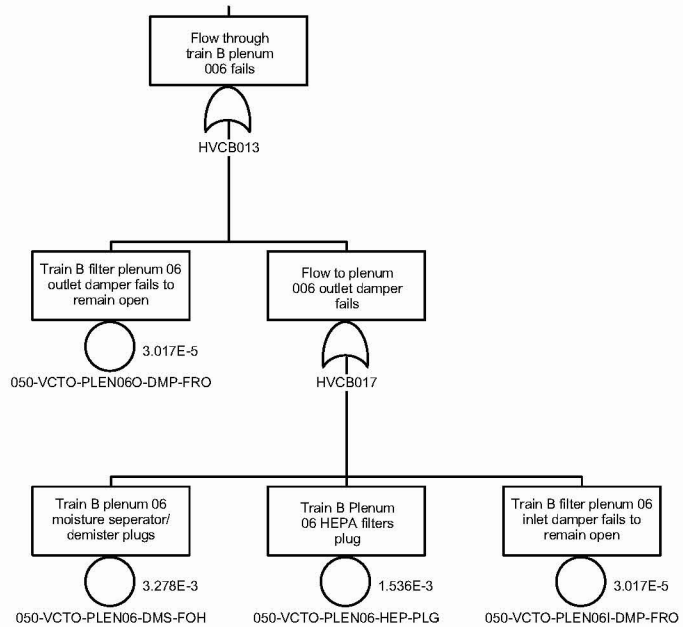

HVCB013 - Flow through train B plenum 006 fails 2008/08/13 Page 273

Source: Original

Figure B7.4-21. Flow Through Train B Plenum 006 Fails