X-Sender: jlloyd@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Sun, 02 Feb 2003 14:48:37 -0500
To: Pete Rutledge <prutledg@hq.nasa.gov>
From: James Lloyd <jlloyd@hq.nasa.gov>
Subject: Fwd: RE: ET Hazard reports

From: "Mullane, Dan" <Daniel.J.Mullane@nasa.gov>
To: "'boconnor@hq.nasa.gov'" <boconnor@hq.nasa.gov>,
"'jlloyd@hq.nasa.gov'" <jlloyd@hq.nasa.gov>
Cc: "Goodson, Amanda" <Amanda.H.Goodson@nasa.gov>,
"Adams, Alex" <Alex.C.Adams@nasa.gov>,
"Walker, Angelia" <Angelia.D.Walker@nasa.gov>,
"'Mark D. (JSC-NC) Erminger (E-mail)'" <mark.d.erminger1@jsc.nasa.gov>
Subject: RE: ET Hazard reports
Date: Sun, 2 Feb 2003 12:25:26 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Sorry, my initial e-mail only included Integrated HR. Here is the ET HR.

-----Original Message-----
From: Mullane, Dan
Sent: Sunday, February 02, 2003 12:06 PM
To: 'boconnor@hq.nasa.gov'; 'jlloyd@hq.nasa.gov'
Cc: Goodson, Amanda; Adams, Alex; Walker, Angelia; Mark D. (JSC-NC) Erminger (E-mail)
Subject: ET Hazard reports

Bryan,

Mark Erminger said that you requested the Accepted Risk HR associated with ET Foam Loss. Attached are the is the Integrated HR and the and ET Project HR associated with ET Foam Loss. Note that both HR's are classified as Accepted Risk.

Dan

-----Original Message-----
From: Grant, Regina
Sent: Sunday, February 02, 2003 11:58 AM
To: Mullane, Dan
Subject: Report

boconnor []

Regina C. Grant
Executive Support Assistant to the Director

Safety & Mission Assurance Office
(256) 544-3284
regina.c.grant@nasa.gov

T.02 Loss of TPS.doc

Clear Day Bkgrd2.JPG

Jim

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT

HAZARD REPORT NUMBER:	T.02	**REVISION:** I	**DCN:** 035	**REPORT DATE:** **REVISED:**	December 5, 1991 February 03, 2000	DCN 035
HAZARD TITLE:	**Loss of TPS**					
HAZARD SEVERITY:	Catastrophic		**LIKELIHOOD OF OCCURRENCE:**		Remote	
HAZARD CLASSIFICATION:	Accepted Risk		**HAZARD REPORT STATUS:**		Closed	
SYSTEM:	Structural/TPS		**SUBSYSTEM:**		TPS	
INTERFACES:	GUCA, GO2 Vent Hood, RSR/SRM and Orbiter					
MISSION PHASE:	Prelaunch (Propellant Loading, FRF, Tanking, Detanking and Launch Aborts), Ascent, Decent					
VEHICLE EFFECTIVITY:	ET-102 and up					DCN 035

HAZARDOUS CONDITION DESCRIPTION:

Loss of TPS as a result of debonds may impair the ET's thermal insulating capability and create debris. During prelaunch this could cause ice formation, excessive propellant boiloff or excessive intertank pressure due to vent clogging by TPS debris. TPS loss in flight could cause excessive skin temperature from aerodynamic heating, resulting in RSS auto-ignition, structural overheating, propellant overheating or TPS debris which could impact the Orbiter. After ET/Orbiter separation, premature structural overheating could result in premature ET breakup with debris landing outside of the predicted footprint or reaching orbital velocity. This breakup could possibly enter the path of the Orbiter **(NOTE: *Text for all RSS components will remain in this report for historical purposes*).**

ACCEPTANCE RATIONALE:

Extensive testing on primer and TPS application minimize the potential for TPS debonding.

Plug pull samples demonstrate acceptable TPS bond strength.

TPS inspections are performed at MAF prior to customer acceptance.

TPS inspections are performed in the checkout and integration cells at KSC.

TPS inspections are performed on the launch pad following rollout.

ACCEPTANCE RATIONALE (cont.)

TPS inspections are performed prior to, during and following propellant loading.

OTV cameras monitor the TPS integrity throughout launch pad operations until lift-off.

Acceptance rationale for the SLWT due to changes in material:

Test Report MMC TDC NO. 826-3000-04, AL-LI/Primer/TPS Interface Integrity Evaluations, Dated October 15, 1996; Test Report MMC-TDC No. 826-3000-10, Cryo-Effects Panel for Cryogenic Temperature Effects on 2195 to 2195 Al-Li Welds, Dated March 15, 1997; and Test Report MMC-TDC No. 826-3000-11, Combined Environments Tests, TPS/Primer/Al-Li (2195), Dated April 22, 1997. [See OTHER REFERENCES (k), (l), and (m)]. These tests met the success criteria and exhibited no failure trends or anomalies that would compromise an External Tank Mission. Results of these evaluations show the current Primer/TPS system is compatible with the Al-Li substrate materials and is capable of withstanding the stress/strains associated with it.

ACCEPTED RISK CAUSE(S):

1. TPS Debond:

Although thorough witness sampling and tests are performed on the TPS and numerous and continuous inspections are made from the time of application through launch, there is no method of non-destructive evaluation of the TPS to assure detection of debonds. For this reason, the potential hazard of undetected TPS debonds has been classified as an Accepted Risk.

2. Lightning:

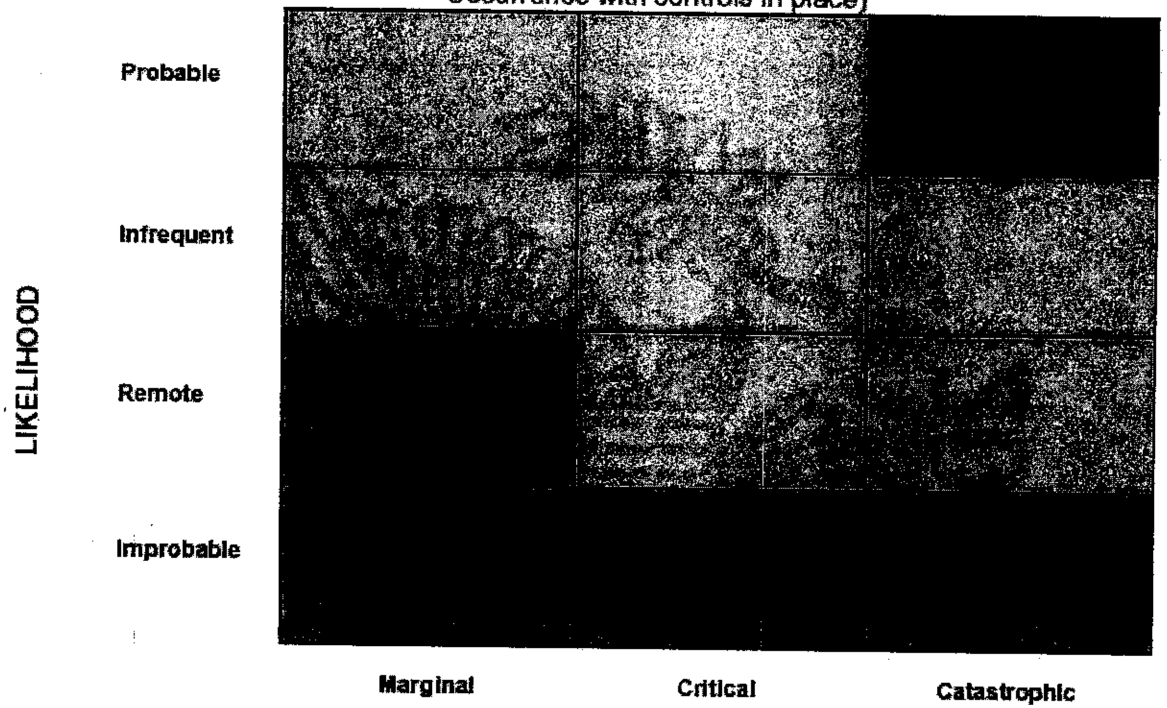
Rationale for Accepted Risk classification of lightning as a cause for loss of TPS is summarized in Hazard Report E.03, Lightning.

SUBMITTAL SIGNATURES (Original signatures on file):

PREPARED BY:	CONCURRENCE:	DESIGN ENGINEER CONCURRENCE:	SAFETY MANAGER APPROVAL:
s/s J. L. Greenwood	s/s G. R. Lain	s/s G. C. Copeland	s/s S. A. Turner
J. L. Greenwood Senior Safety Engineer, System Safety	G.R. Lain Chief, System Safety	G.C. Copeland ET Chief Engineer	S. A. Turner Manager, Safety and Health

RISK MATRIX

(Hazard Severity Level and Likelihood of Occurrence with controls in place)



2 HAZARD CAUSES

SEVERITY LEVELS

Legend: Unacceptable Risk ■ Accepted Risk ▒ Controlled ■

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: June 26, 1995

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
			Note: The hazard reduction precedence sequence steps used in the control of this hazard are design and procedures. The methods used in the closure of this hazard analysis report are tests and inspections.	
1. (AR) TPS Debond	1. Structural Failure Fire/Explosion Loss of Vehicle Loss of Life	1. No debris shall emanate from the critical zone of the ET on the launch pad or during ascent except for such material which may result from normal TPS recession due to ascent heating, OTHER REFERENCE (f), para. 3.2.1.1.17.	1. The potential for TPS debonding is minimized by design. Controls for the prevention of TPS debonds are identified in the following paragraphs:	1. Tests and inspections for the prevention of TPS debonds are identified in the following paragraphs:
a. Material Deficiency			a. Material property tests imposed during acceptance testing of the TPS raw materials reduce the potential for debonds that could result from material inadequacies. Material specification documents (STMs) specify the material property test(s) and pass/fail criteria for each TPS raw material. MMC-ET-RA04 FMEA/CIL REFERENCES (a) through (i) lists the STM document(s) for each TPS material.	a. Material property tests imposed by an STM verify that the TPS raw materials meet the specified material properties. Specific tests performed on TPS raw materials include cream time, rise time, tensile strength, density tests, etc. MMC-ET-RA04 FMEA/CIL REFERENCES (a) through (i) identifies the specific tests imposed on each TPS raw material.
b. Improper Application			b. Engineering Process Specifications (STPs) specify controls to be implemented during	b. Tests or inspections that verify the TPS has been properly applied include preparation of

DCN 024

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: December 7, 1992

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
			cleaning and application of primer, adhesive, ablator and foam to ensure design adequacy and proper application. The requirements associated with the application of TPS on flight articles and test panels include, surface cleanliness, environmental cure, spray parameters, thickness and tensile tests. Specific control(s) imposed on individual TPS components are identified in MMC-ET-RA04 FMEA/CIL REFERENCE (a) through (i).	a minimum of one witness (test) panel for each TPS application. Finished product requirements for the flight article are checked on the flight hardware or test panel by visual inspections, thickness measurements, density test, bond tension tests and flatwise tension tests. Conformance with STPs is verified by tests and/or inspections performed in accordance with Process Instructions (PIs) through Product Quality Verification Requirement (PQVR) checkpoints and identified in MMC-ET-RA04 FMEA/CIL REFERENCE (a) through (i). Visual inspections identified in MMC-ET-RA04 FMEA/CIL REFERENCES (a) through (i) and OTHER REFERENCES (h) are performed to verify TPS integrity is maintained and that no cracks or debonds are evident and the TPS meets acceptance criteria.
c. Degradation of TPS			c. Transportation and Handling Procedures provide controls against potential damage to the TPS during all ET moves. All major and critical moves	c. Monitoring of ET moves is verified by performance of OTHER REFERENCE (c).

DCN 017

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: March 1, 1996

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
c. Degradation of TPS (cont.)			are monitored by Quality personnel and periodically by Safety, OTHER REFERENCE (d).	
			Controls that assure the integrity of the TPS is maintained during processing in the integration cells of the VAB at KSC are identified in OMRSD REFERENCES (b), and (m). Acceptance criteria for determining TPS adequacy is defined in OTHER REFERENCE (l). If damage has occurred to the TPS, it would be detected and dispositioned at these control points.	Visual inspections of accessible areas in the checkout and integration cells to detect cracks, voids, divots or debonds are verified by performance of OMI REFERENCES (a), (b), (c).
			Vent holes are drilled in the TPS to the CPR-488/BX 250 interface on intertank debris critical zones for effectivity ET-21 (LWT-14) through ET-50 (LWT-43). This prevents divots or debonds during ascent due to differential pressures, OTHER REFERENCE (b). Effective with ET-51 (LWT-44) and up, a two-gun spray-on foam operation was implemented to eliminate the two step foam application previously used on the intertank thrust panels	Inspection of the vent holes to prevent TPS divots and debonds from ascent differential pressure on ET-21 through ET-50 is verified by performance of OTHER REFERENCE (a).

DCN 026

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: June 26, 1995

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
c. Degradation of TPS (cont.)			and stringer valleys. This process negates the requirement to drill vent holes, OTHER REFERENCE (j) and results in a risk reduction due to the elimination of a TPS debris source.	
			Requirements for assuring the integrity of the TPS following rollout to the launch pad, are specified in OMRSD REFERENCE (c). Post FRF TPS integrity requirements are specified in OMRSD REFERENCE (n) and (o).	Visual inspections of accessible areas on the Launch Pad to detect cracks, voids, divots or debonds are verified by performance of OMI REFERENCES (d) and (g). Fairings and inaccessible areas are inspected with binoculars, OMI REFERENCE (e).
			During propellant loading of the LH_2 tank pressurization requirements for TPS Enhancement (see BACKGROUND, paragraph 6) are controlled by OMRSD REFERENCE (h).	Verification of the LH_2 pressure transducers pressures during propellant loading as specified in OMI REFERENCE (g) verifies proper pressurization of the LH_2 tank for TPS enhancement.
			Prior to, during and following propellant loading, further monitoring of accessible areas is performed as specified in OMRSD REFERENCES (d), (f), (g), (i), (j), (k) and (l). In the event of a launch abort, involving detanking, these controls	Inspection of TPS accessible areas prior to, during and following propellant loading and post-loading (and repeated in the event of a detank) to detect offset cracks or visible defects are

DCN 024

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: December 7, 1992

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
c. Degradation of TPS (cont.)			are repeated during and immediately following detanking operations. OTV cameras mounted at several locations are used to monitor the TPS throughout launch pad operations, during propellant loading through launch or drain operations to provide additional TPS integrity data, as specified in OMRSD REFERENCES (f), (i) and (j). This inspection/monitoring process constitutes a continuing and final check in a series of checks for ensuring TPS flight integrity.	verified by performance of OMI REFERENCES (e) and (f). Inspection of the TPS during propellant loading through launch or drain operations by OTV cameras to detect visible defects is verified by performance of OMI REFERENCE (f).
d. Heater Malfunction			d. The prevention of TPS debonds due to bipod heater temperatures exceeding the TPS bondline temperature during detanking operations is controlled OMRSD REFERENCE (p). Controls for the prevention of TPS debonds due to a malfunctioning bipod heater are identified in ET Hazard Report E.04, Malfunction of Electric Heaters on ET.	d. Inspections that insure the deactivation of the bipod heaters during detanking operations is verified by performance of OMI REFERENCE (e). Tests and inspections for the prevention of TPS debonds due to a malfunctioning bipod heater are identified in ET Hazard Report E.04, Malfunction of Electric Heaters on ET.

DCN 024

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: June 26, 1995

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
e. Purge Malfunction (Overtemp-erature)			e. Controls for the prevention of TPS debonds due to an overheated purge gas are identified in ET Hazard Report P.04, Purge Malfunction.	e. Tests and inspections for the prevention of TPS debonds due to overheated purge gas are identified in ET Hazard Report P.04, Purge Malfunction.
f. LO_2/LH_2 Tank Buckling			f. Control for the prevention of TPS debonds due to LO_2/LH_2 tank buckling resulting from the loss of stabilization pressure are identified in ET Hazard Report S.03, LO_2 Tank Buckling or ET Hazard Report S.04, LH_2 Tank Buckling respectively.	f. Tests and inspections for the prevention of TPS debonds due to LO_2/LH_2 tank buckling resulting from the loss of stabilization pressure are identified in ET Hazard Report S.03, LO_2 Tank Buckling or ET Hazard Report S.04, LH_2 Tank Buckling respectively.
g. Propellant Leaks			g. Controls for the prevention of TPS debonds due to hydrogen or oxygen propellant leaks are identified in ET Hazard Report S.06, Hydrogen Leaks or ET Hazard Report S.07, Oxygen Leaks respectively.	g. Tests and inspections for the prevention of TPS debonds due to hydrogen or oxygen propellant leaks are identified in ET Hazard Report S.06, Hydrogen Leaks or ET Hazard Report S.07, Oxygen Leaks respectively.
			The prevention of TPS debonds due to incipient weld leaks are identified in ET Hazard Report S.08, Incipient Weld Leaks.	Tests and inspections for the prevention of TPS debonds due to incipient weld leaks are identified in ET Hazard Report S.08, Incipient Weld Leaks.

HAZARD TITLE: Loss of TPS

REPORT DATE: December 5, 1991
REVISED: December 7, 1992

CAUSE(S)	EFFECT(S)	SAFETY REQUIREMENT(S)	CONTROL(S)	VERIFICATION(S)
h. Overheated pressurization gas			h. LO_2 ullage gas temperatures are influenced by the SSME engine performance and power levels and aerodynamic heating environments which are beyond the scope of this report. RI Integration Hazard Report(s) identifies the controls associated with these issues.	h. An analysis is performed at MAF using RI supplied design environments and the maximum ICD supplied temperatures for pressure and gas to certify that the ET structural margins are not violated.
2. (AR) Lightning	2. Structural Failure Fire/Explosion Loss of Vehicle Loss of Life	2. No debris shall emanate from the critical zone of the ET on the launch pad or during ascent except for such material which may result from normal TPS recession due to ascent heating, OTHER REFERENCE (f), para. 3.2.1.1.17.	2. Controls for the prevention of TPS loss due to a lightning strike are identified in ET Hazard Report E.03, Lightning.	2. Tests and inspections for the prevention of TPS loss due to a lightning strike are identified in ET Hazard Report E.03, Lightning.

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MMC-ET-RA04 FMEA/CIL REFERENCES:

(a) Section 5.1, LH_2 Aft Dome; Criticality 1
(b) Section 5.2, LH_2 Barrel; Criticality 1
(c) Section 5.3, LH_2 Fwd Dome; Criticality 1
(d) Section 5.4, LO_2 Aft Dome; Criticality 1
(e) Section 5.5, LO_2 Barrel/Ogive; Criticality 1
(f) Section 5.6, Intertank; Criticality 1
(g) Section 5.7, Nose Cone; Criticality 1
(h) Section 5.8, Components; Criticality 1
(i) Section 7.4, Aft Cable Trays; Criticality 1

OMRSD REFERENCES:

(a) Deleted
(b) OMRSD File IV, TO9QAL.020, ET TPS Inspection in Integration Cell | DCN 026
(c) OMRSD File IV, TO9QAL.030, ET TPS Inspection on Pad
(d) OMRSD File II, SOOUOO.020, Post Cryo Loading Inspection | DCN 026
(e) Deleted
(f) OMRSD File II, SOOEOO.021, ET TPS Mon During Detank
(g) OMRSD File II, SOOEOO.031, Post Detank ET TPS Inspect
(h) OMRSD File II, SOOFEO.111, ORB MPS LH_2 Chilldown & Fill to ECO's
(i) OMRSD File II, SOOFBO.005, ET TPS Surface Monitoring
(j) OMRSD File II, SOOFBO.360, Monitor ET for Leakage
(k) OMRSD File II, SOOLOO.150, High Wind ET Nose Inspection
(l) OMRSD File II, SOOUOO.030, Prelaunch Shuttle/Pad Area Inspection
(m) OMRSD File IV, TO9QAL.070 Inspect I/T Area
(n) OMRSD File II, SOOJOO.140-C, Inspect ET Thermal Protection System
(o) OMRSD File II, SOOJOO.140-A, Inspect LOX Feedline at Penetration Internal to ET Intertank
(p) OMRSD File II, SOOEOO.A11, ET Bipod Heaters Deactivation

OMI REFERENCES:

(a) OMI-T6149, ET Receiving Inspection
(b) OMI-T5048, Install and Remove Intertank Access Kit
(c) OMI-S6016, SSV Pre Rollout Walkdown Inspections
(d) OMI-T6446, ET Post-Flight Readiness Firing (FRF) Inspection
(e) OMI-S0007VL3, Shuttle Launch Countdown (LPS)

OMI REFERENCES (cont.)

(f) OMI-S6444, SSV Ice and Debris Assessment
(g) OMI-S0007VL2, Shuttle Launch Countdown (LPS)
(h) Deleted

NSTS 16007 SHUTTLE LAUNCH COMMIT (LCC) CRITERIA REFERENCES:

None

OTHER REFERENCES:

(a) MMC-ET TCTI T09000B01736XX
(b) MMC-ECP BO1736, (CCBD ET3-00-6089), Vent Holes in Intertank TPS and Increase Bond Adhesion Tests for Two-Tone Foam Areas
(c) MMC MHP-3614, Move External Tank Assembly
(d) ET Standard Procedure 84.6, Access, Transportation and Handling Equipment
(e) MMC Memo No. 3521-84-128, Intertank Vent and Leak Area Blockage
(f) MMC-ET-CM02aA (CPT01M09A) External Tank Contract End Item Specification (CEI)
(g) MMC Memo No. 3571-79-10, Closure of Hazard 1.013D (TPS Cracking or Debonding)
(h) MMC-ET-TM04k-B, ET Flight Acceptance Requirements
(i) MMC Drawing 80901019010, TPS Post Build Assembly Acceptance Manual Offsite
(j) MMC-ECP B01787N, Revise Intertank Spray On Foam Operation To Incorporate Dual Gun Concept
(k) MMC-TDC No. 826-3000-04 Al-Li/Primer/TPS Integrity Evaluations, Dated October 15, 1996.
(l) MMC-TDC No. 826-3000-10 Cryo-Effects Panel for Cryogenic Temperature Effects on 2195 to 2195 Al-Li Welds, Dated March 15, 1997.
(m) MMC-TDC No. 826-3000-11 Combined Environments Test, TPS/Primer/Al-Li (2195) Compatibility Test, Dated April 22, 1997.

DCN 030

BACKGROUND:

1. The External Tank Thermal Protection System (TPS) is designed to maintain the quality of the propellants and to protect the primary structure and its subsystem components within design temperature limits during prelaunch, ascent, and descent mission phases. The TPS is a passive system having the following functions in each mission phase.

   a. Prelaunch Phase
      (1) Controls LO_2 and LH_2 boiloff rates.
      (2) Minimizes potential LO_2 and LH_2 propellant loading inaccuracies.
      (3) Insures LO_2 and LH_2 feedline interface temperatures.
      (4) Prevents air liquefaction on LH_2 tank and piping surfaces.

BACKGROUND (cont.)

(5) Maintains structural and component temperatures within design limits.

(6) Minimizes ice formation on tank surface.

b. Ascent Phase

(1) Maintains the primary structural and subsystem components within design temperature limits.

(2) Minimizes unusable propellant due to stratification.

(3) Prevents film boiling of propellant.

c. Descent Phase

(1) Prevents premature structural overheating to assure low altitude ET breakup.
(2) Prevents RSS auto-ignition to assure low altitude ET breakup.
NOTE: *Text for all RSS components will remain for historical purposes*

2. The TPS configuration overview is as shown in Figures T.02-1, thru T.02-4. These configurations are determined by the properties and processabilities of the various TPS materials. The TPS materials used on the ET consist of two basic types; low density closed cell foams, used for high insulation efficiency, and denser ablative materials, used for high heat capability. The foam insulation materials used on the ET are NCFI 24-124 (NCFI 24-124 will replace CPR-488 beginning with ET-85 and up), NCFI 22-65 (NCFI 24-57 for ET-80 and up), SS1171 (SS1171 will replace BX-250 for ET- 85 and up) and PDL-4034 and Instafoam. The ablative material used are SLA-561 and MA-25s.

3. The TPS is designed to thermally protect the ET structure to assure a minimum structural factor of safety of 1.1 times the limit load up to MECO. From MECO until MECO + 225 seconds, the minimum ET structural factor of safety is 1.0, OTHER REFERENCE (f).

4. Development tests indicate TPS cracks are not a significant concern, OTHER REFERENCE (g).

a. Insignificant amounts of moisture and cryo-pumped air are accumulated in SOFI only areas.

b. Revaporization of moisture or cryo-pumped air stored in porous SLA (which is covered by SOFI) will not cause divots or other TPS failures during ascent or detanking.

5. Overpressurizing the intertank as a result of combinations of vent or leak area blockage from TPS debris has been examined by engineering analysis, OTHER REFERENCE (e). The potential of debonding with subsequent blockage is non-credible due to the intertank vent and leak area configuration.

BACKGROUND (cont.)

6. Ablator material used on the LH_2 tank, is an elastomer at room temperature and has a strain capability in excess of 2%, undergoes a change of state (glassifies) at approximately -180 degrees F and becomes brittle due to the silicone resin binder. The strain capability of the ablator after glassification is approximately 0.5%. It has been demonstrated by tests that only the loads applied to the ablator after glassification are effective in the glass state and since the glass state is much more critical than the elastomeric state, it is advantageous to apply loads before the ablator glassifies. The two primary loads (strains) applied to the ablator are due to the internal tank pressure (substrate strain) and filling of the tank with cryogen (thermal strain). Of these two loads, only the pressure induced loads can be applied prior to glassification. In order to reduce the ablator strains applied after glassification the LH_2 tank is pressurized prior to filling the tank with liquid hydrogen. This propellant loading procedure is termed "TPS enhancement".

7. Composite material assemblies are scheduled to replace several existing aluminum assemblies on the ET. The use of composite materials eliminates the need for TPS which results in a reduction in risk due to the elimination of a TPS debris source. The implementation schedule for these changes is identified below.

   a. ET-51 (LWT-44) a graphite/epoxy GH_2 pressurization line fairing.
   b. ET-87 and up (LWT-74) a graphite/polyimide LO_2 feedline fairing.
   c. ET-81 (LWT-74) a graphite/polyimide Intertank door.
   d. ET-88, 89 and up (LWT-86, 88) a graphite/phenolic Nose Cone

8. (k) MMC-TDC No. 826-3000-04 Al-Li/Primer/TPS Integrity Evaluations, Dated October 15, 1996.
   (l) MMC-TDC No. 826-3000-10 Cryo-Effects Panel for Cryogenic Temperature Effects on 2195 to 2195 Al-Li Welds, Dated March 15, 1997.
   (m) MMC-TDC No. 826-3000-11 Combined Environments Test, TPS/Primer/Al-Li (2195) Compatibility Test, Dated April 22, 1997.

   The SLWT is constructed of aluminum lithium alloy Type 2195. This is compared to the lightweight tank which is fabricated of Type 2219 aluminum. It was determined that Type 2195 was compatible with the thermal protection system. These evaluations, with the different TPS materials, would allow a conclusion to be reached as to the compatibility of the AL-LI substrate materials to withstand the higher stress/strains associated with the TPS.

9. Post flight inspection of STS-87 revealed out-of-family damage to the Orbiter tiles caused by foam loss from the ET Intertank panel. A rigorous test program was conducted and has demonstrated that foam venting reduces popcorn-type debris. Results from all performance testing and flight show that vented foam performs as well as or better than the non-vented foam configuration and measurably reduces foam loss. Reference Test Plan 82623a through 23f, Vent Cause and Corrective Action.

BACKGROUND (cont.)

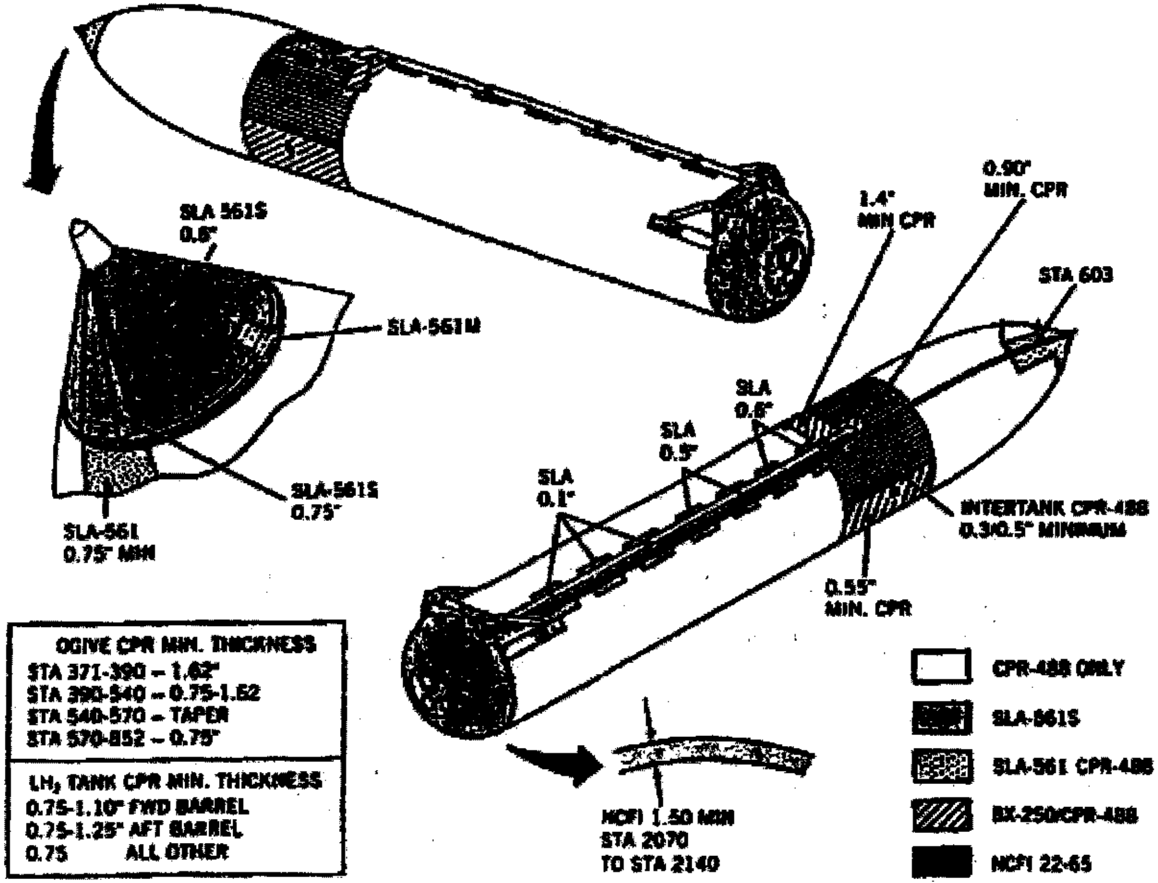
Areas proposed and approved for venting, includes Stringer Panels 1, 2, 3, bathtub areas, and an extension of a venting area to Sta. 1034 on panels. The vented stringer foam configuration is similar to the successfully flown configuration on STS-103/T-101.

Post flight Orbiter (ET-101) tile damage assessment, which had Intertank Stringer Panels 1, 2, and 3 vented, showed a dramatic decrease in hits in comparison with recent flights. The under side of the orbiter had hits within the historical average range for shuttle missions.

DCN 035

STATUS OF OPEN WORK:

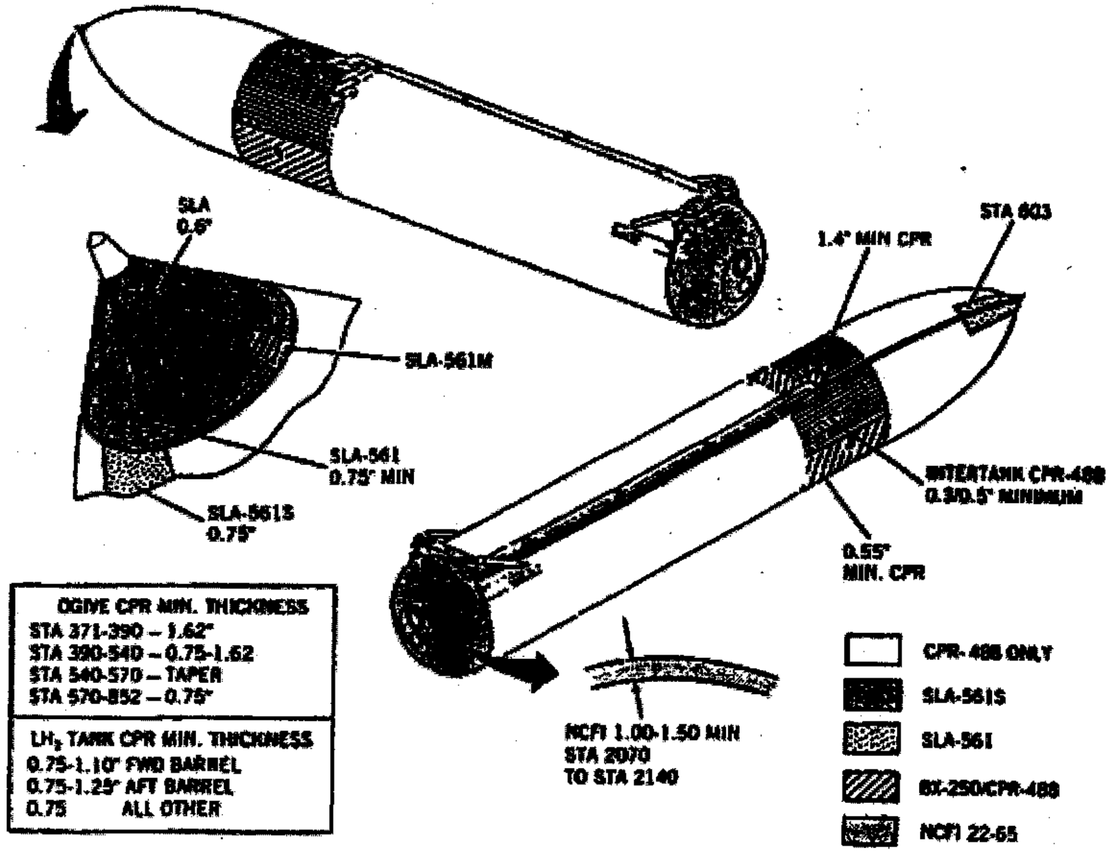
None



TPS CONFIGURATION (ET 23-30 AND 34)

Figure T.02-1

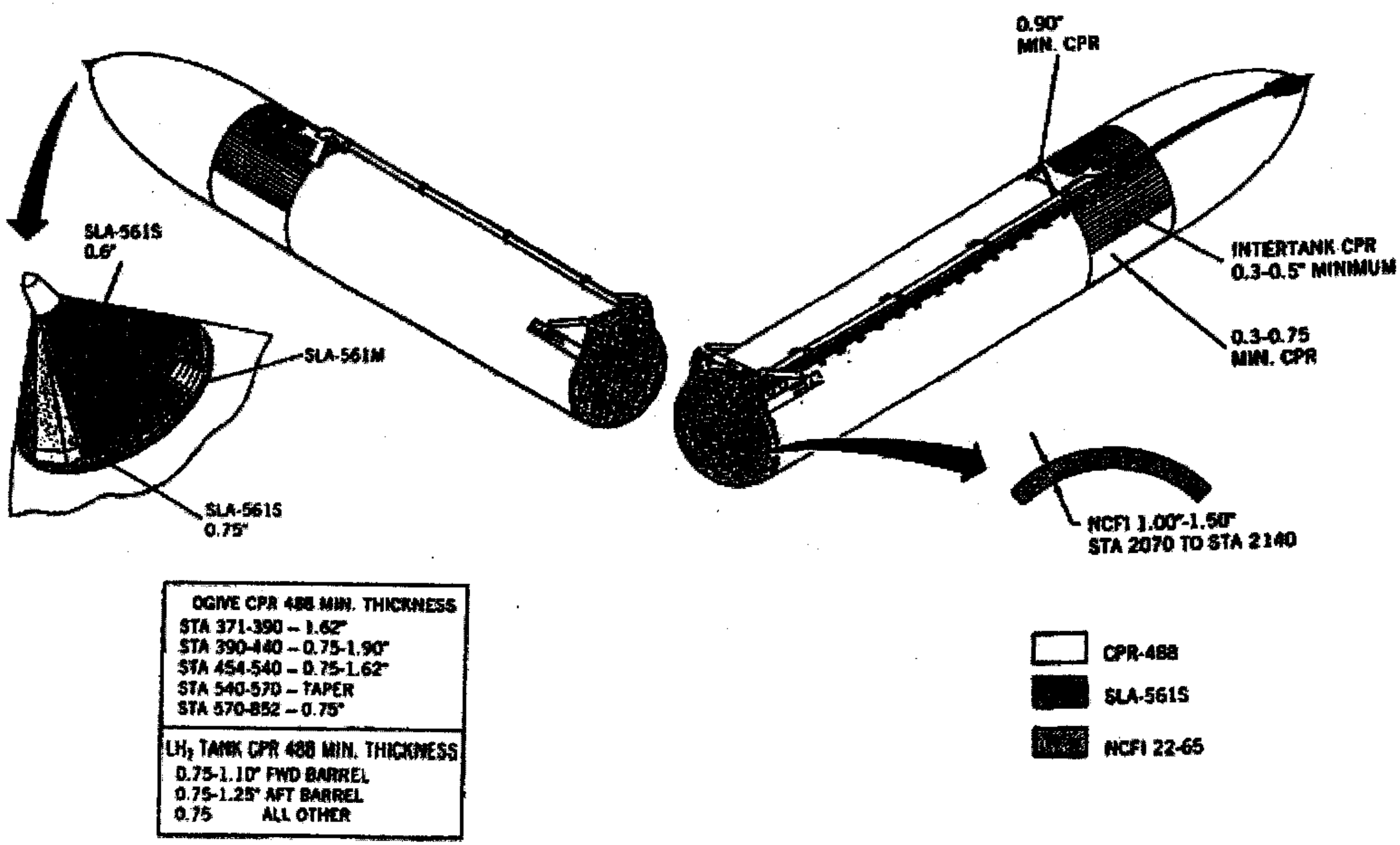
SYSTEM DESCRIPTION - TPS Configuration



TPS CONFIGURATION (ET 31-33 AND 35-60)

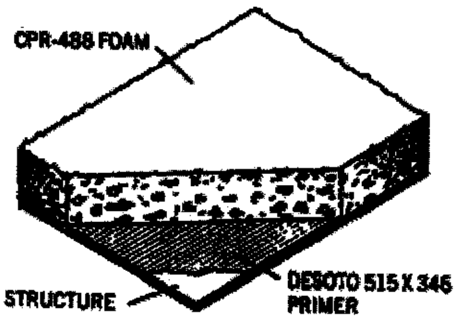
Figure T.02-2

SYSTEM DESCRIPTION - TPS Configuration



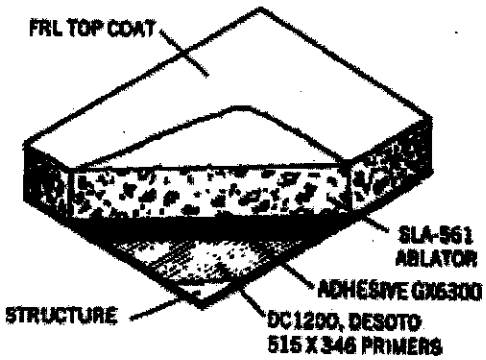
TPS CONFIGURATION (ET 51 AND UP)

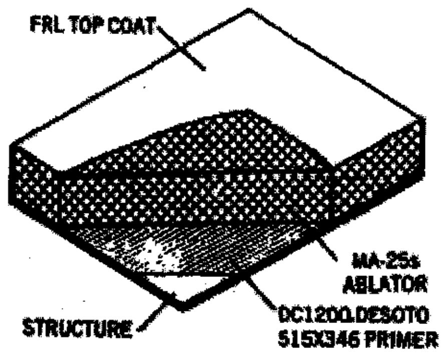
Figure T.02-3



- FLUOROCARBON-BLOWN RIGID POLYISOCYANURATE FOAM.
  - TWO COMPONENT LIQUID SYSTEM.
  - SPRAY ON APPLICATION.
- LIGHT TAN COLOR.
- DENSITY – 2.1 TO 2.6 LB/FT^3.
- TENSILE STRENGTH 35 PSI MINIMUM.
- HEATING RATE CAPABILITY 15 BTU/FT^2-SEC (NORMAL USE).
- TOTAL AREA – 13,200 FT^2.
- BONDLINE TEMP. LIMIT 300°F/–423°F

CPR-488 SAMPLE CROSS SECTION
(TYPICAL FOR BX-250, PDL-4034, NCFI 22-65 & INSTAFOAM)





SLA-561

- HIGHLY FILLED ELASTOMERIC SILICONE.
  - SILICA GLASS ECCOSPHERES
  - SILICA FIBERS
  - CORK
  - PHENOLIC MICROBALLOONS
- DARK GRAY COLOR
- DENSITY – 16 ± 1.0 LB/FT^3 MOLDED
  18 ± 1.0 LB/FT^3 SPRAYED
- HEAT CAPABILITY – 30 BTU/FT^2–SEC
- BONDLINE TEMP. LIMIT 600°F/–423°F

MA-25

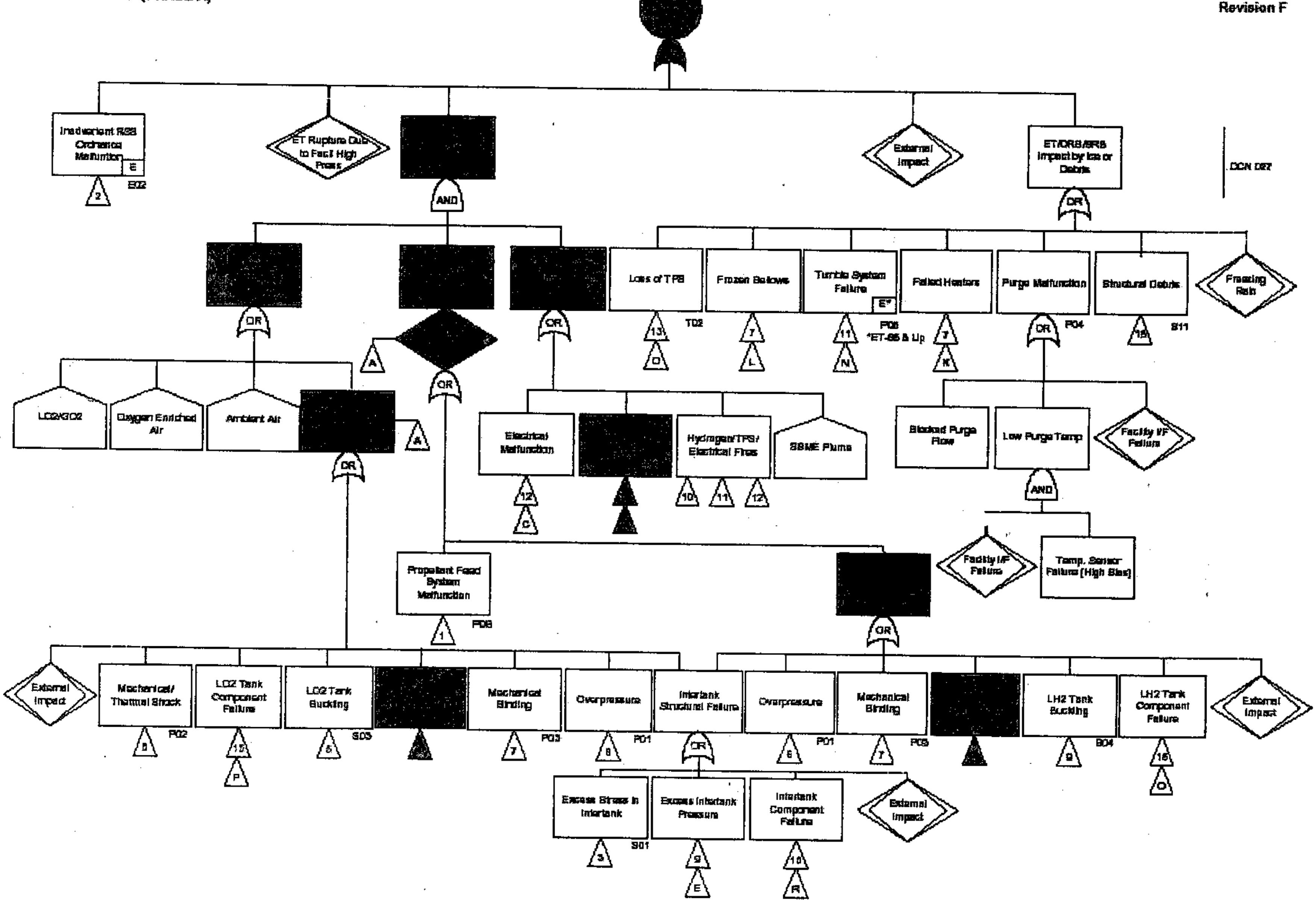
- SPRAYABLE FILLED ELASTOMERIC SILICONE.
  - SILICA GLASS ECCOSPHERES
  - SILICA FIBERS
  - IRON OXIDE
- REDDISH BROWN COLOR
- DENSITY 27 ± 3 BL/FT^3
- HEAT CAPABILITY – 75 BTU/FT^2–SEC
- BONDLINE TEMP. LIMIT 600°F/–200°F

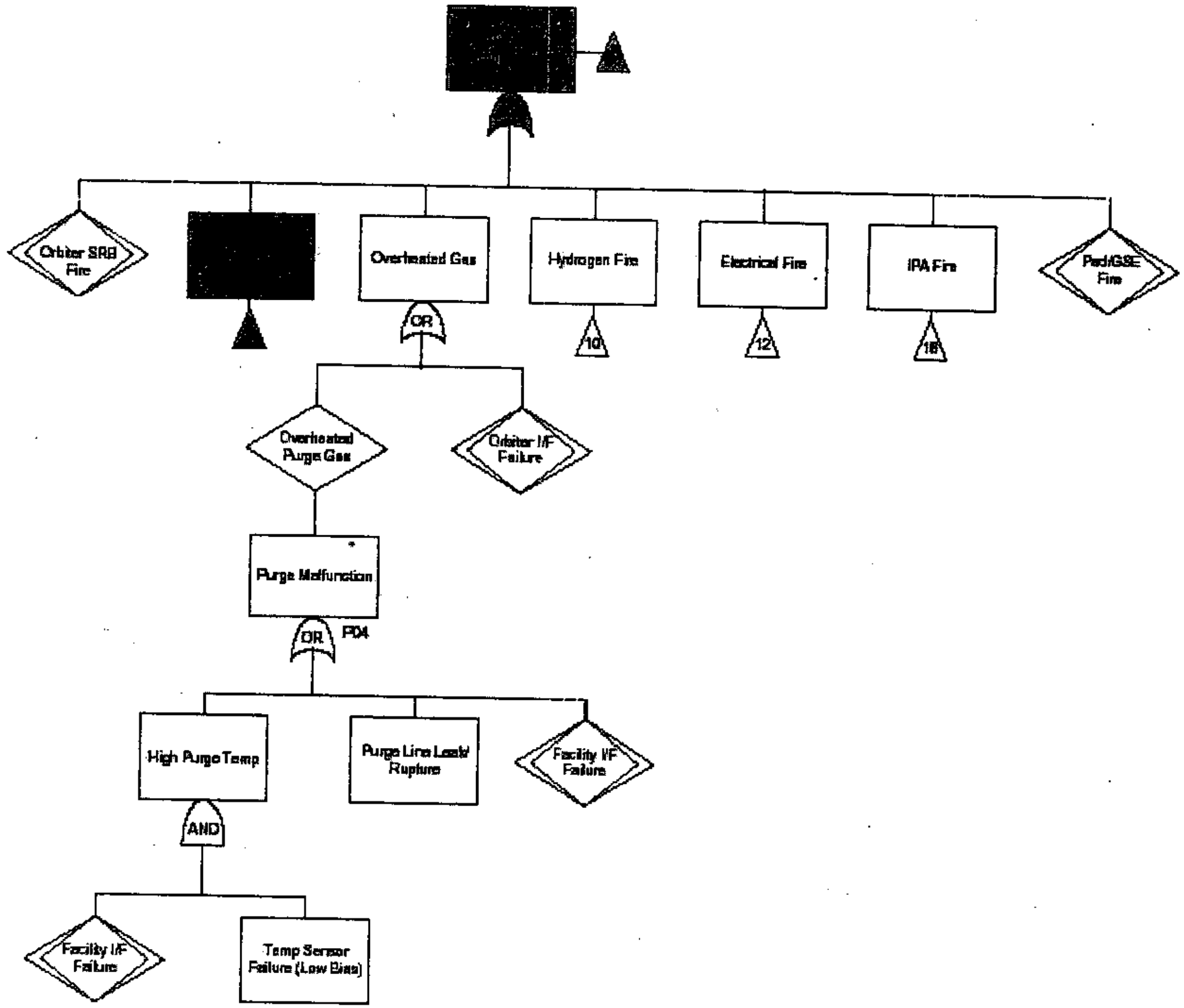
ABLATOR SAMPLE CROSS SECTION

Figure T.02-4

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT

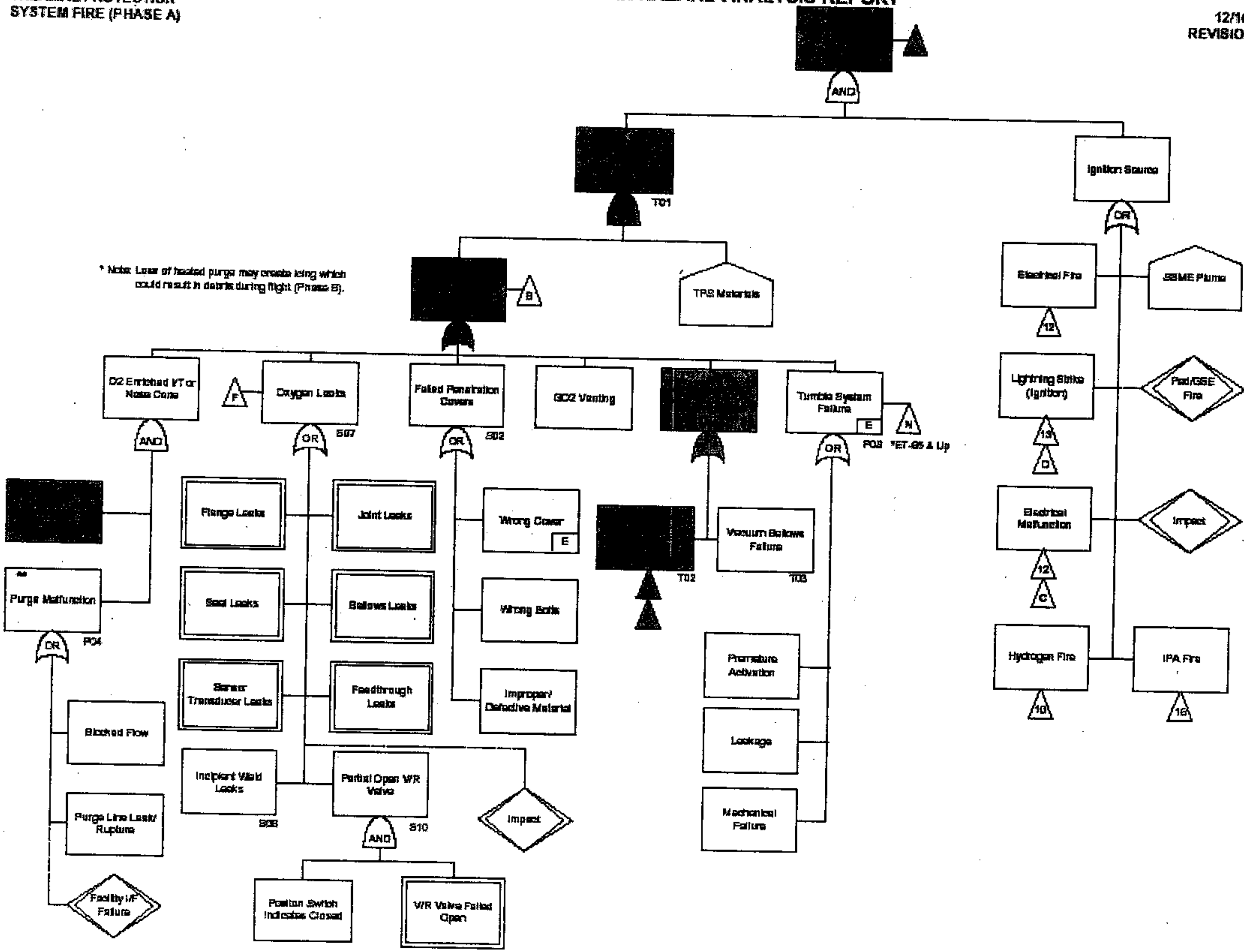
9/30/06
Revision F





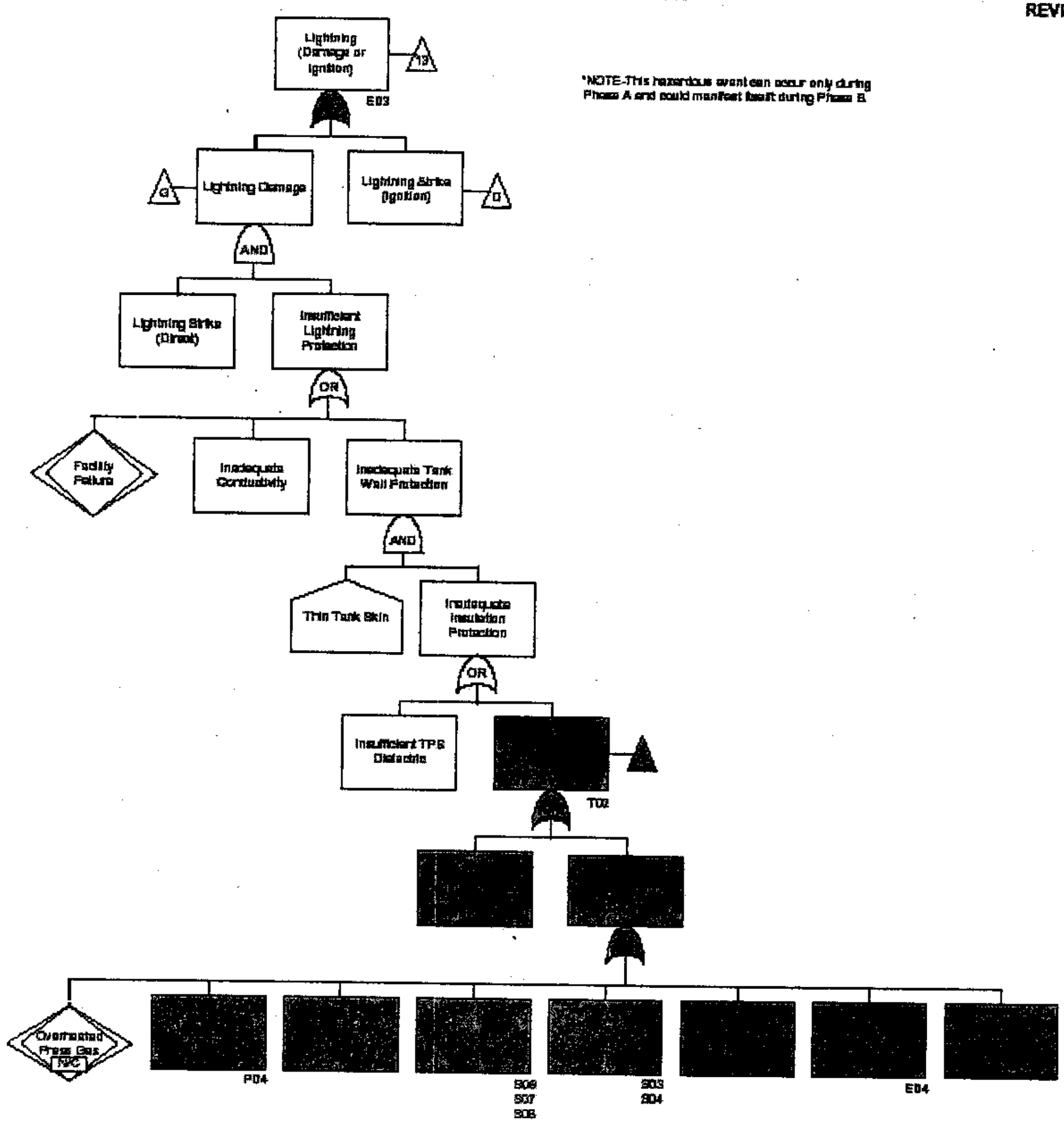
*Note - This hazardous event can only occur during Phase A and could manifest itself during Phase B.

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT



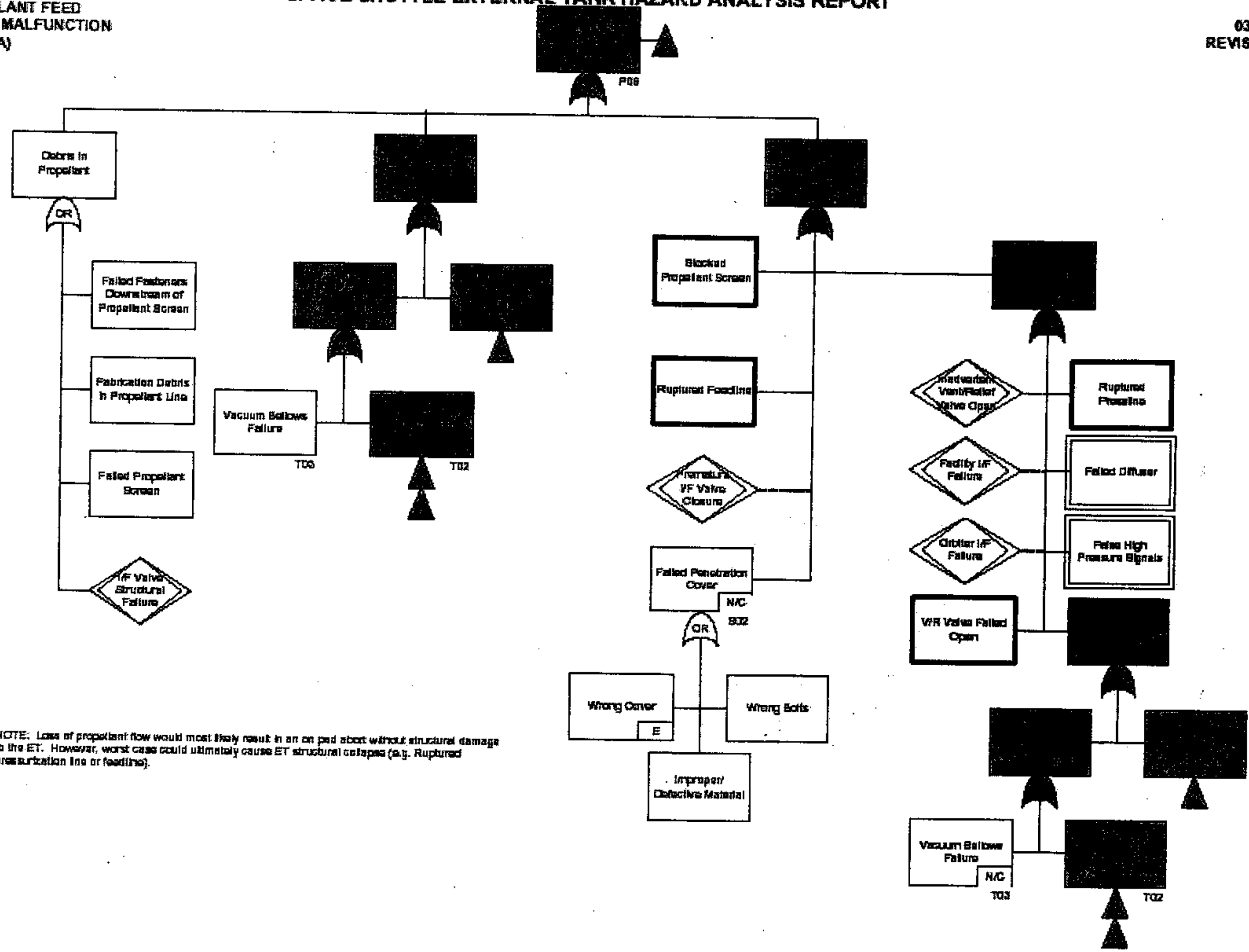
SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT

*NOTE-This hazardous event can occur only during Phase A and could manifest itself during Phase B.



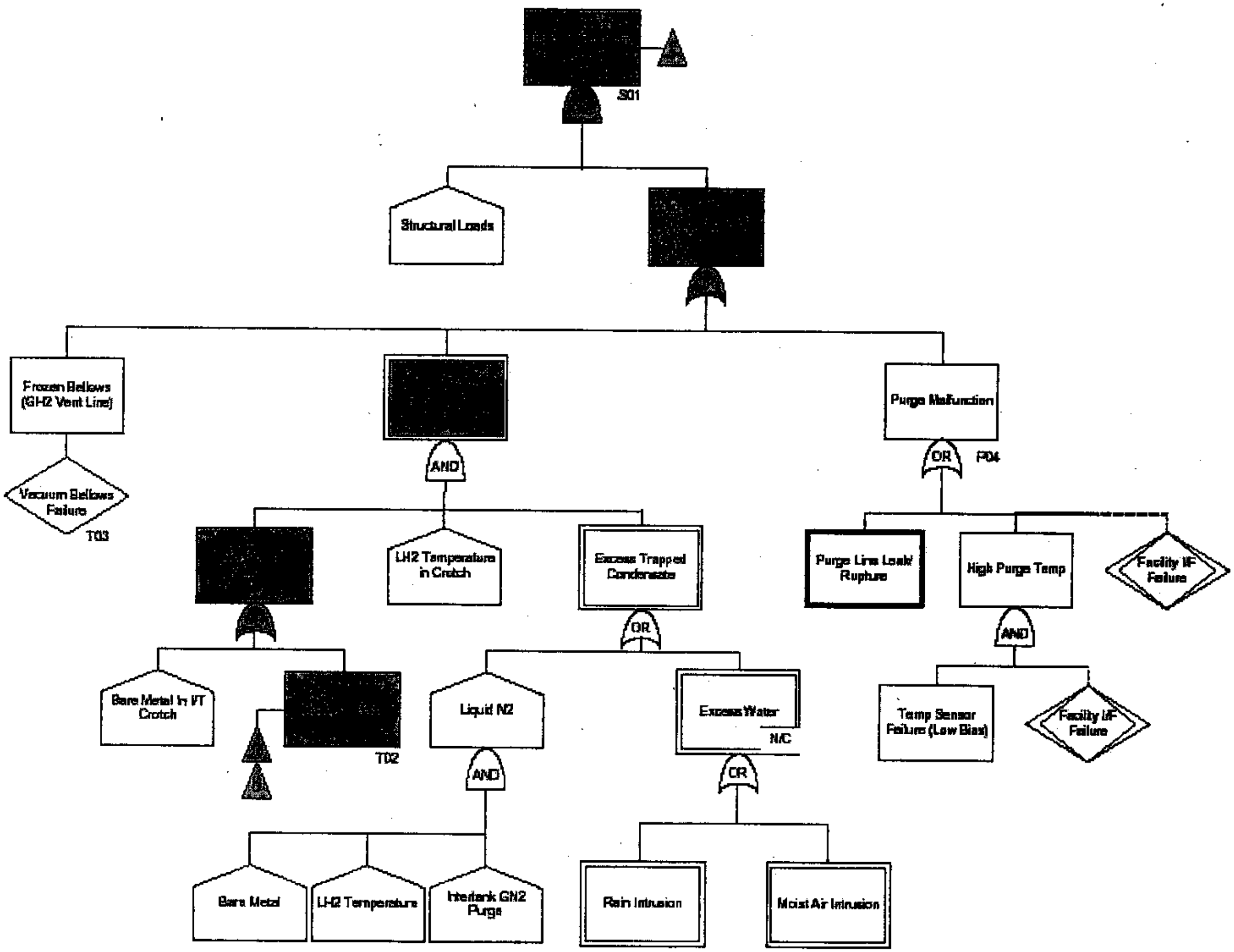
DCN 013

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT



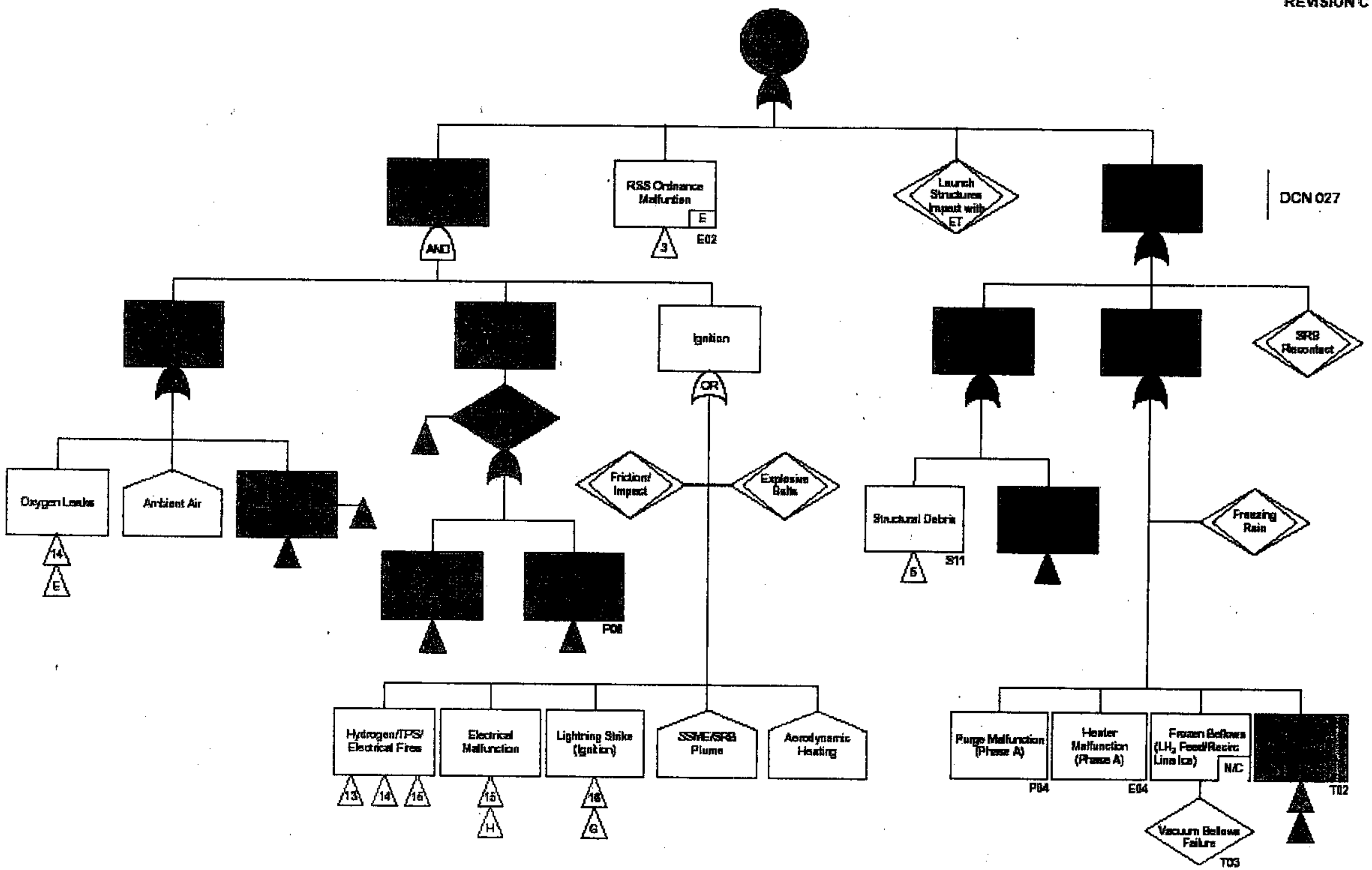
NOTE: Loss of propellant flow would most likely result in an on pad abort without structural damage to the ET. However, worst case could ultimately cause ET structural collapse (e.g. Ruptured pressurization line or feedline).

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT

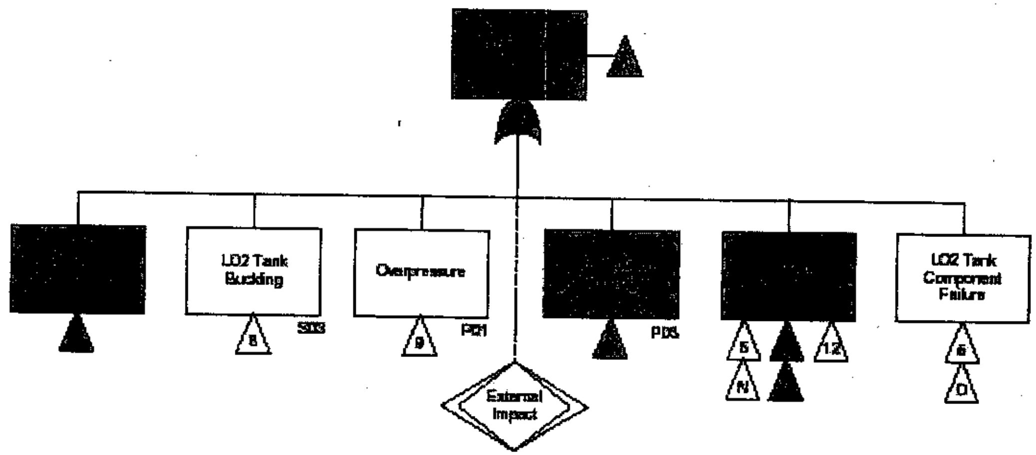


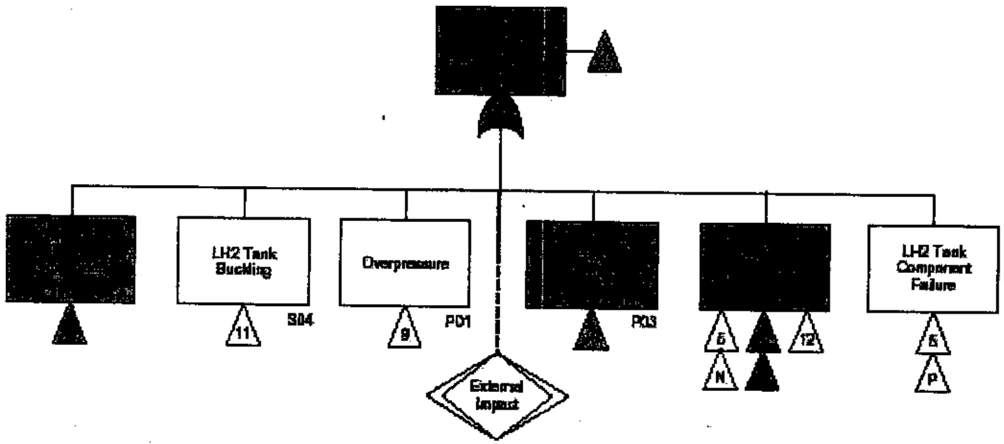
SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT

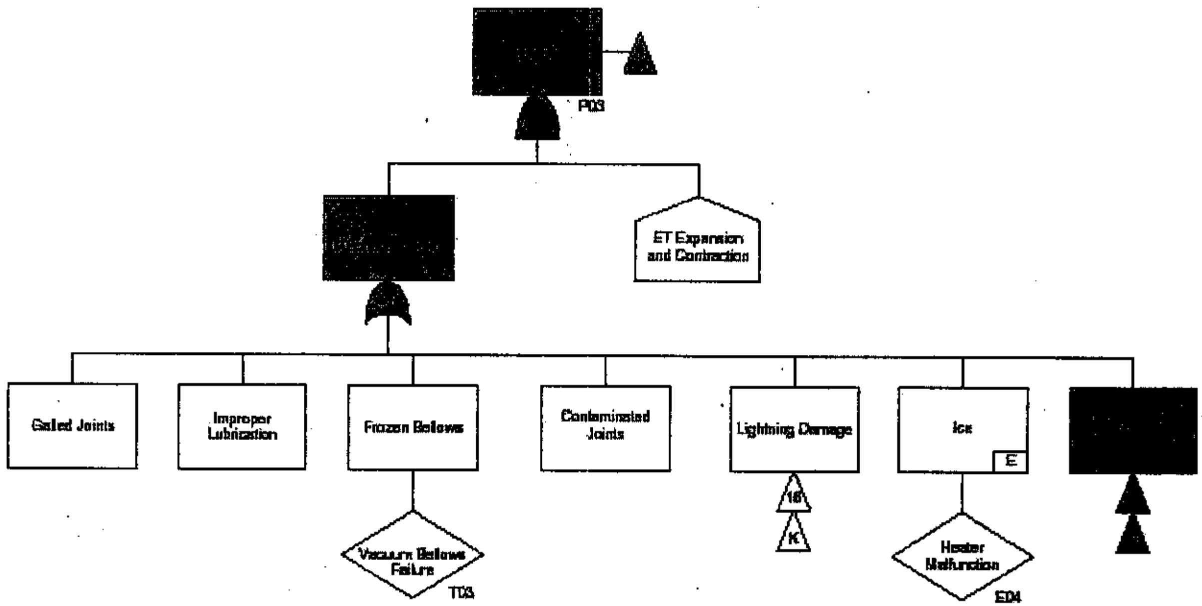
DCN 027

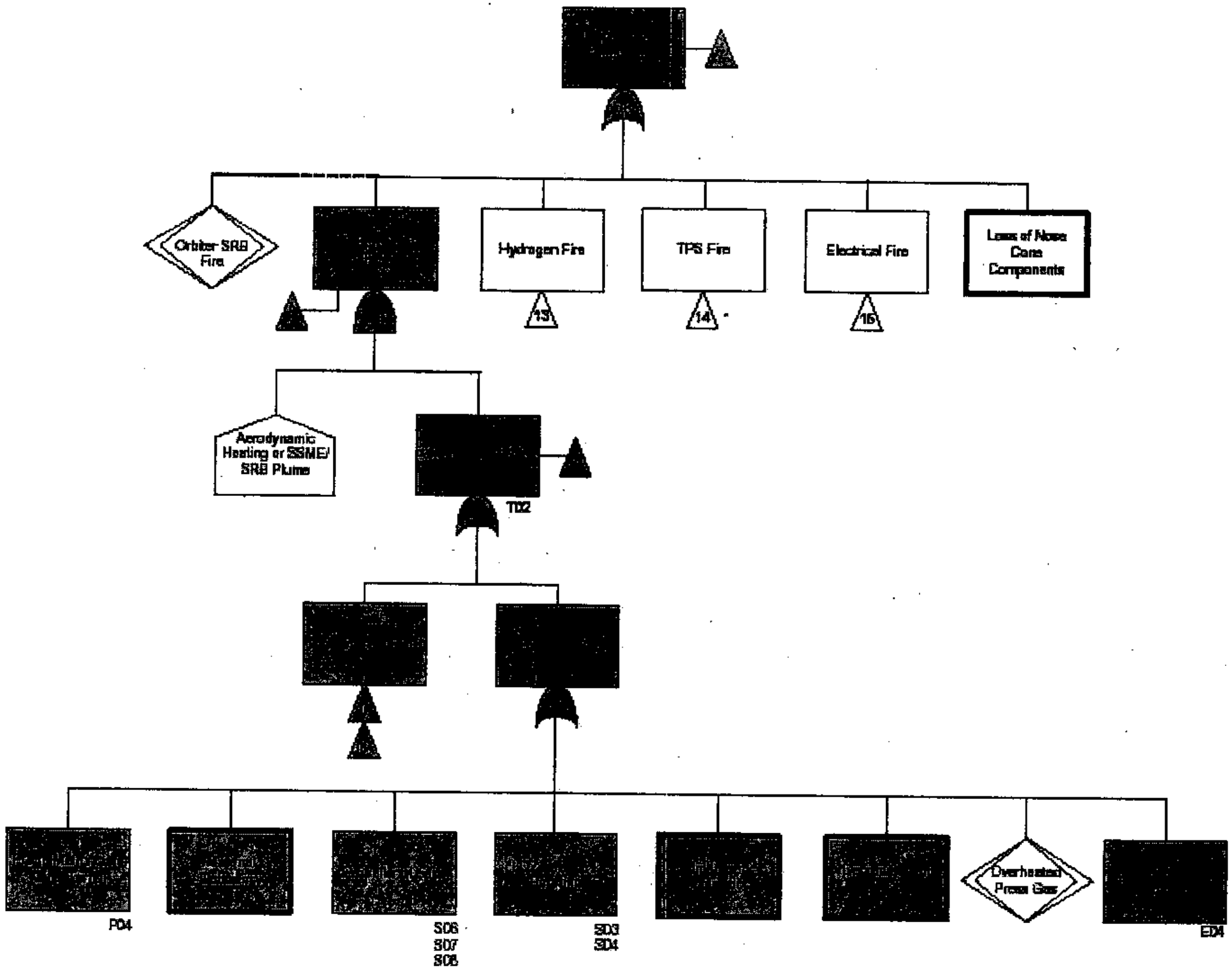


SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT

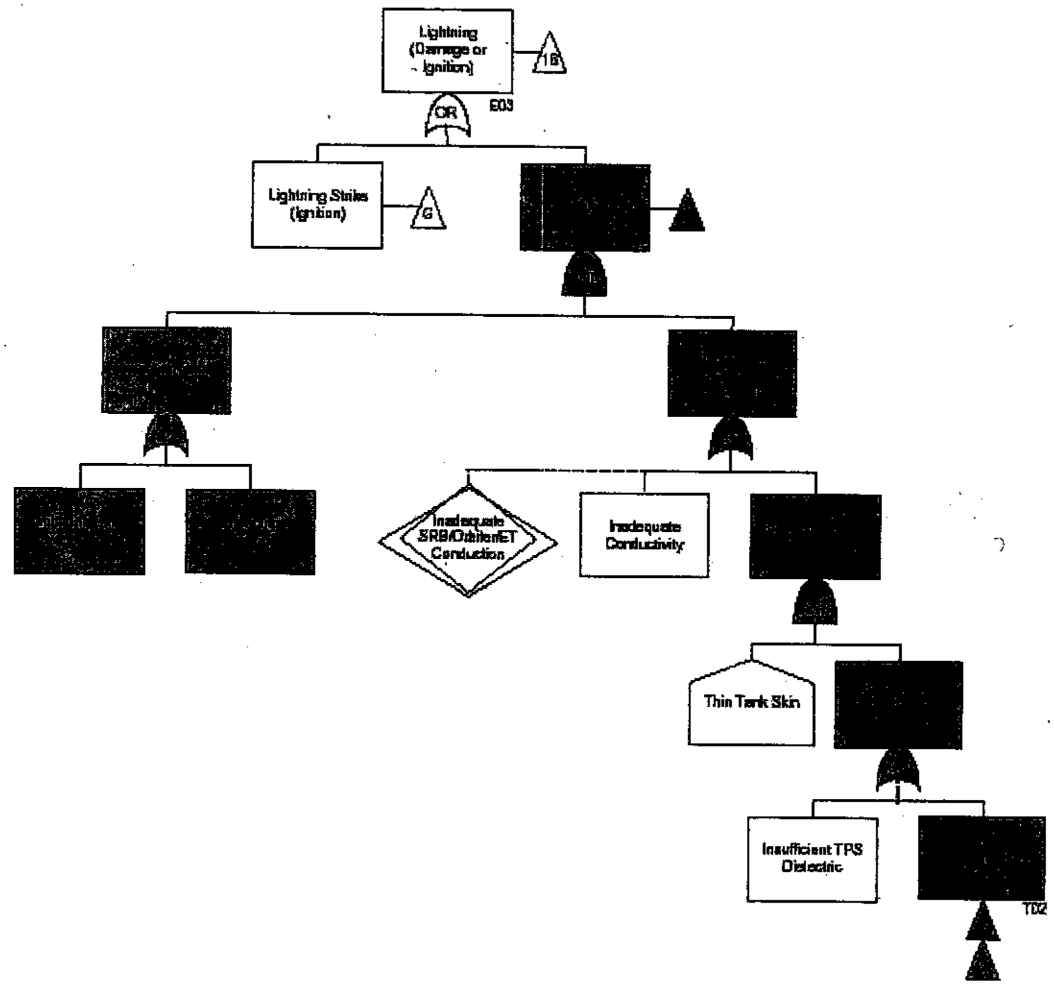



LH2 Tank Buckling
11
S04
Overpressure
9
P01
External Impact
P03
5
12
N
LH2 Tank Component Failure
5
P

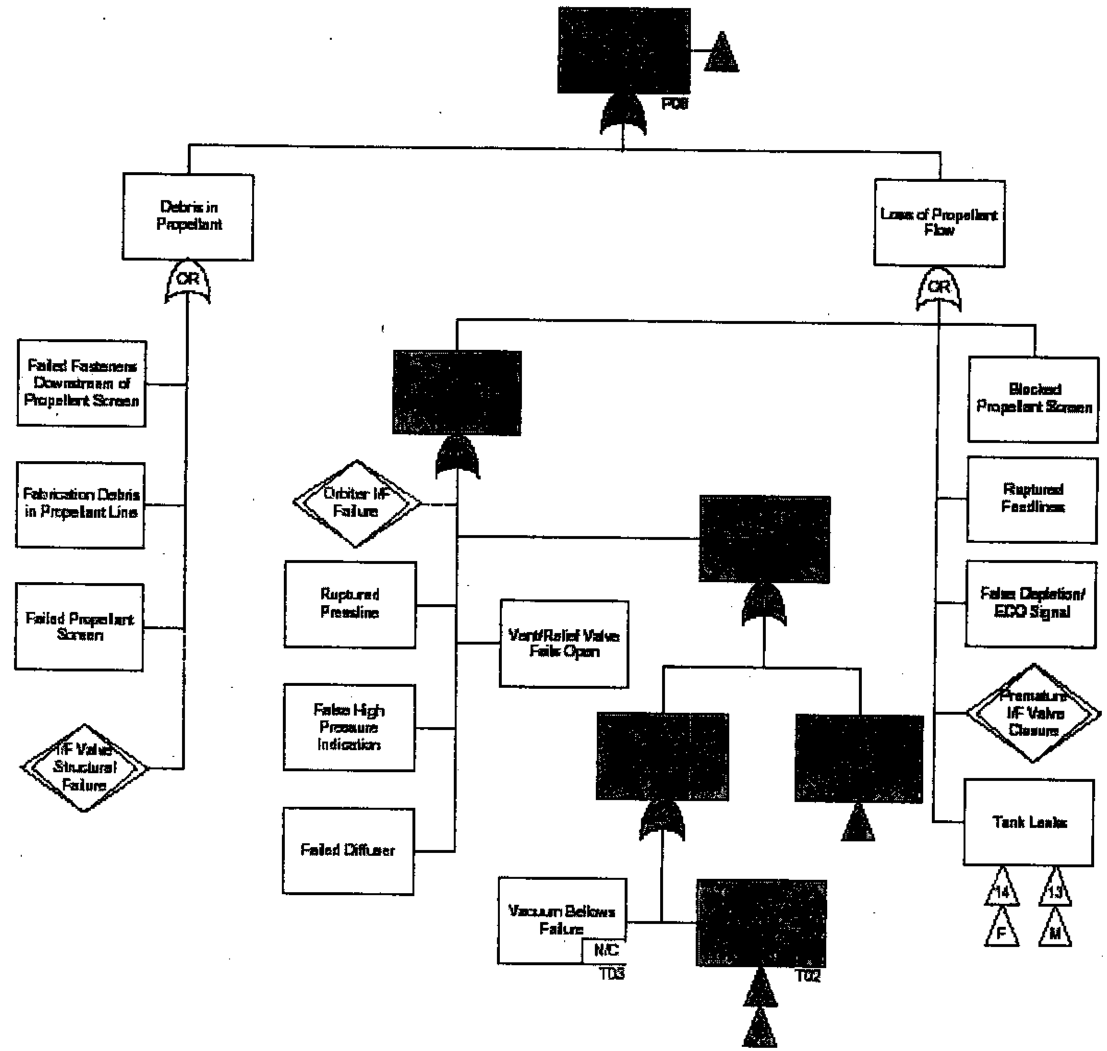

P03
ET Expansion and Contraction
Galled Joints
Improper Lubrication
Frozen Bellows
Contaminated Joints
Lightning Damage
Ice
E
Vacuum Bellows Failure
T03
16
K
Heater Malfunction
E04

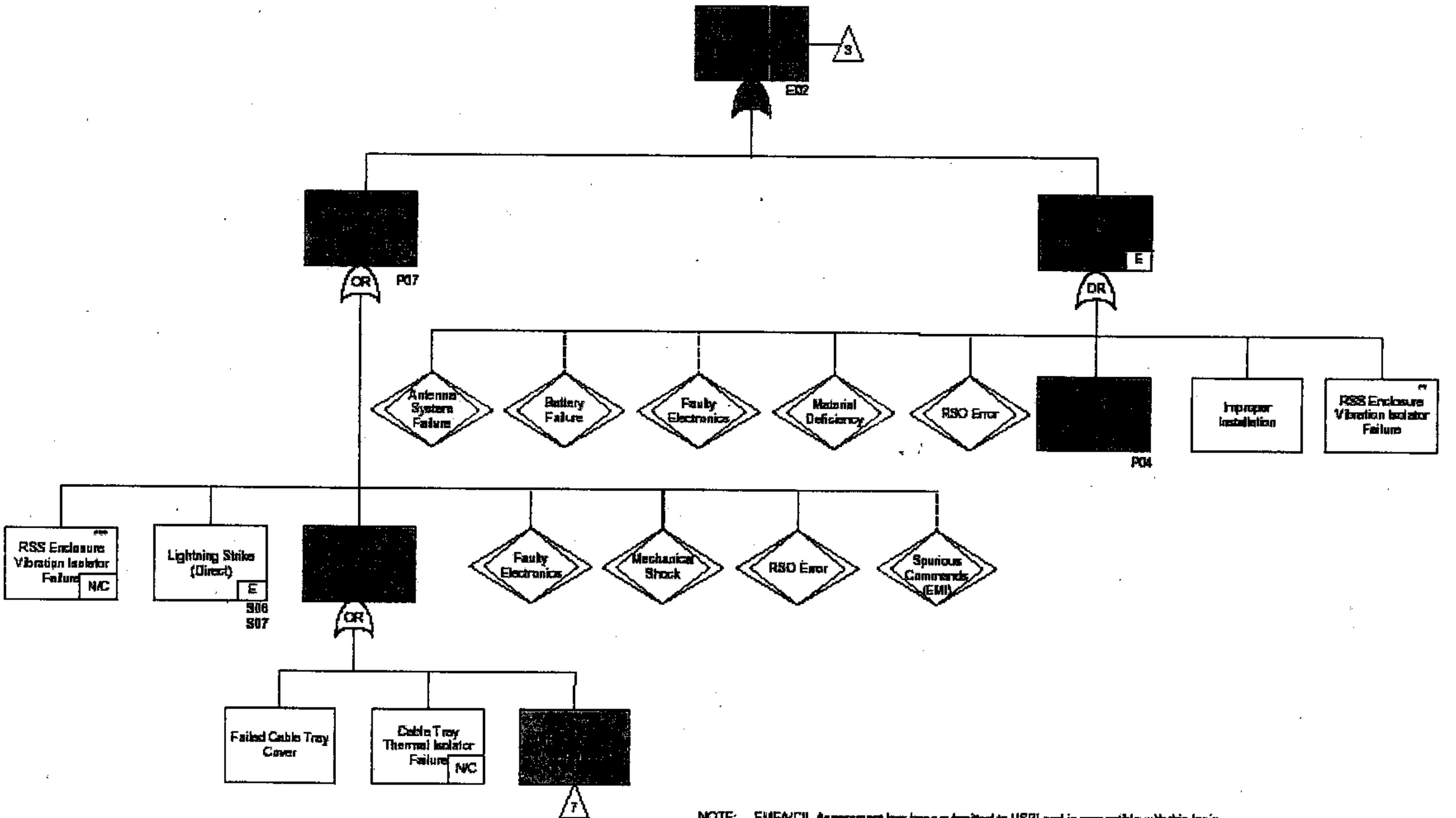


*Note - This hazardous event can only occur during Phase A and could manifest itself during Phase B.


Lightning (Damage or Ignition)
1B
OR
E03
Lightning Strike (Ignition)
G
Inadequate SRB/Orbiter/ET Conduction
Inadequate Conductivity
Thin Tank Skin
Insufficient TPS Dielectric
T02

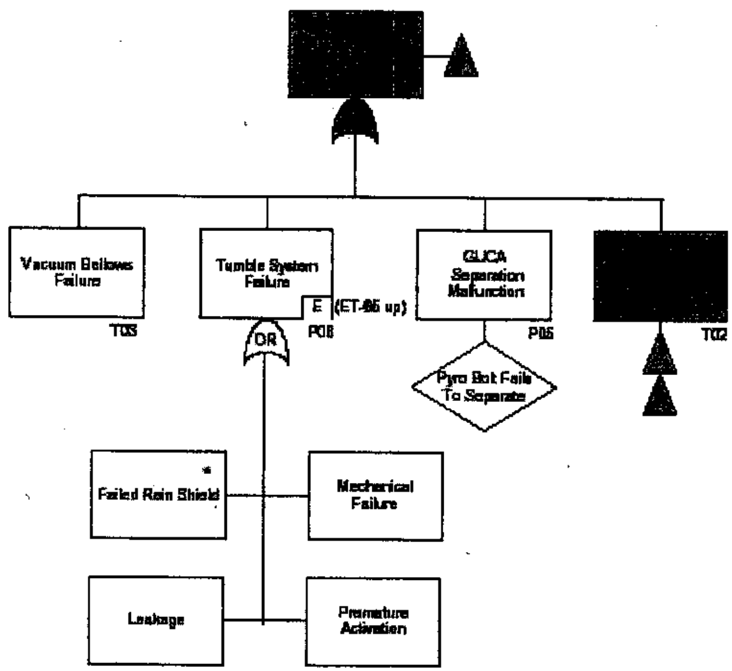
SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT





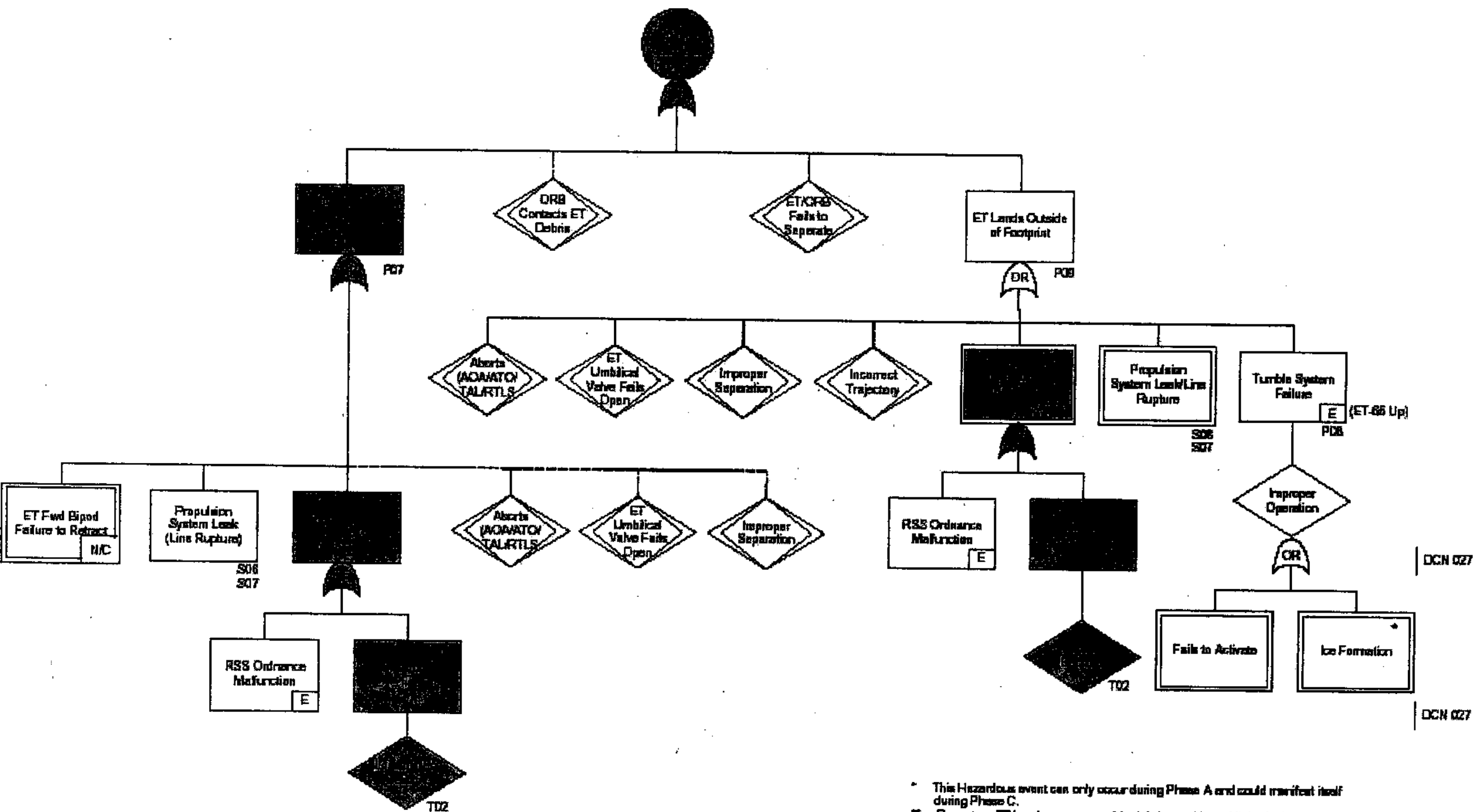
NOTE: FMEA/CIL Assessment has been submitted to USBI and is compatible with this logic.
* NOTE: This hazardous event can only occur during Phase A and could manifest itself during Phase B.
** NOTE: RSS Enclosure vibration isolator failure could also result in faulty electronics or battery failure.
*** NOTE: RSS Enclosure vibration isolator failure resulting in inadvertent ordinance detonation was determined to be non credible by USBI.

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT



*Note - This hazardous event can only occur during Phase A and would manifest itself in Phase B or C.

SPACE SHUTTLE EXTERNAL TANK HAZARD ANALYSIS REPORT



- * This Hazardous event can only occur during Phase A and could manifest itself during Phase C.
- ** Premature ET break-up may result in debris reaching orbital velocity and impacting orbiter or other space vehicle.