

CRITICAL ITEMS LIST (CIL)

SYSTEM:	Pressure Vessels	FUNCTIONAL CRIT:	1
SUBSYSTEM:	LH2 Tank	PHASE(S):	a, b
REV & DATE:	J, 12-19-97	HAZARD REF:	S.02, S.06, S.08
DCN & DATE:			
ANALYSTS:	M. Quiggle/R.Lauto		

FAILURE MODE: Leakage

FAILURE EFFECT: a,b) loss of mission and vehicle/crew due to fire/explosion.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S):
 A: Structural Failure of Plates
 B: Structural Failure of Forgings
 C: Structural Failure of Extrusions
 D: Structural Failure of Welds

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: Contains the LH2 fuel for the SSME's.

<u>FMEA ITEM CODE(S)</u>	<u>PART NO.</u>	<u>PART NAME</u>	<u>QTY</u>	<u>EFFECTIVITY</u>
6.2.1.1	80904000000-020	LH2 Tank Complete	1	LVT-54 thru 88

REMARKS: Retention rationale for FMEA Item Codes 6.2.1.1 and 6.2.1.2 is the same.

CRITICAL ITEMS LIST (CIL)

SYSTEM:	Pressure Vessels	FUNCTIONAL CRIT:	1
SUBSYSTEM:	LH2 Tank	PHASE(S):	a, b, c
REV & DATE:	J, 12-19-97	HAZARD REF:	S.02, S.08
DCN & DATE:			
ANALYSTS:	M. Quiggle/R. Lauta		

FAILURE MODE: Burst

FAILURE EFFECT: a,b) loss of mission and vehicle/crew due to structural failure or fire/explosion.
 c) loss of mission and vehicle/crew due to Orbiter/ET collision.
 loss of life due to ET impacting outside designated footprint.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S): A: Structural Failure of Plates
 B: Structural Failure of Forgings
 C: Structural Failure of Extrusions
 D: Structural Failure of Welds

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: Contains the LH2 fuel for the SSME's.

<u>FMEA ITEM CODE(S)</u>	<u>PART NO.</u>	<u>PART NAME</u>	<u>QTY</u>	<u>EFFECTIVITY</u>
6.2.1.2	B0904000000-C20	LH2 Tank Complete	1	LWT-54 thru 88

REMARKS: Retention Rationale for FMEA Item Codes 6.2.1.1 and 6.2.1.2 is the same.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE:

RATIONALE FOR RETENTION

DESIGN:

The Liquid Hydrogen (LH2) tank is a thin-wall fusion welded aluminum semi-monocoque shell and is designed as a safe life structure. Structural integrity is assured by the fracture control plan (MNC-ET-SE13). Materials and processes are selected in accordance with MNC-ET-SE16, which assures repetitive conformance of composition and properties. The LH2 tank is designed to a required yield safety factor of 1.10 for all loads and ultimate safety factor of 1.25 for well-defined loads (i.e. thrust, inertia from thrust, dead weight, and ullage pressure) and 1.40 for other loads (i.e. thermal, aerodynamic, and dynamic transients). However, from External Tank (ET)/Orbiter separation through Main Engine Cut-Off (MECO) +225 seconds, the assembly is designed to a required ultimate safety factor of 1.00 for all loads. Tank strength analysis is based on minimum drawing thicknesses. (Reference ET Stress Report 826-2188).

A: The twelve forward dome gores and twelve aft dome gores are stretch-formed per STP1002 to the required 0.75 height-to-radius ellipsoidal shape. Heat treatment to 2219-T87 condition is followed by chem-milling per STP5014 on both sides to the required thicknesses. Three forward dome gores have locally thickened skin pads for the attachment of either exterior support brackets for the Gaseous Hydrogen (GH2) pressurization line, an exterior support bracket for the vent/relief duct, or interior support brackets for the sensor mast. Cutouts are provided in an aft dome gore for the feedline fitting and the recirculation fitting. Primary and secondary weld lands are configured to minimize discontinuity stresses. The dome gores are edge trimmed during assembly.

The electrical fitting is 13.0 inches in diameter and is machined from 2219-T87 aluminum plate. The fitting contains external mounting provisions for the electrical feedthru of the internal cabling on the sensor mast. The electrical fitting is edge trimmed during assembly. Threaded inserts and bolts are installed in the electrical fitting per STP2024 and STP2014 respectively.

The vent valve fitting is 15.0 inches in diameter and is machined from 2219-T87 aluminum plate. The vent valve fitting provides the external mounting surface for the vent/relief valve. The vent valve fitting is edge trimmed during assembly. Threaded inserts and bolts are installed in the vent valve fitting per STP2024 and STP2014 respectively.

The forward dome and aft dome manhole fittings are 45.0 inches in diameter and are machined from 2219-T87 aluminum plate. The manhole fittings provide a 36.0 inch clear access to the tank interior. The manhole fittings are edge trimmed during assembly. Threaded inserts and bolts are installed in the manhole fittings per STP2024 and STP2014 respectively.

The forward dome and aft dome spherical dome caps are 140.0 inches in diameter and are spin-formed per STP1005. Heat treatment to 2219-T87 condition is followed by chem-milling per STP5014 on both sides to the required thicknesses. Cutouts are provided in the forward dome and aft dome caps for the vent, electrical, and manhole fittings and the siphon and manhole fittings respectively. The forward dome cap has locally thickened skin pads for the attachment of exterior support brackets for the GH2 pressurization line, an exterior support bracket for the vent/relief duct, and interior support brackets for the sensor mast. Primary and secondary weld lands are configured to minimize discontinuity stresses. The forward dome and aft dome caps are edge trimmed during assembly.

The forward and aft dome manhole covers are machined from 2219-T87 aluminum plate. The manhole covers provide a closure for and a sealing surface with the manhole fittings. The manhole covers and the manhole fittings have index pins that preclude the possibility of interchanging the Liquid Oxygen (LO2) and LH2 manhole covers. The forward dome manhole cover contains external mounting provisions for the GH2 pressurization line and the GH2 diffuser. Threaded inserts and bolts are installed in the manhole covers per STP2024 and STP2014 respectively.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE: 001, 6-15-98

RATIONALE FOR RETENTION

DESIGN: (cont)

Each of the four barrels is composed of eight 2219-T87 aluminum panels. The panels are machined on numerically controlled mills and longitudinal stiffeners are incorporated as an integral part of each panel. Four panels from Barrel No. 2 and six panels from Barrel No. 1 are brake-formed per STP1002 to the required radius of 165.5 inches. One panel from each of the four barrels has bosses machined into the longitudinal stiffeners for external mounting provisions of the Gaseous Oxygen (GO2) and GH2 pressurization lines and electrical cable tray. Two panels from Barrel No. 4 have bosses machined into the longitudinal stiffeners for internal mounting provisions of station 1129.9 frame stabilizers. One panel from Barrel No. 2 has bosses machined into the longitudinal stiffeners per mounting provisions of the intermediate frames. Eight panels from Barrel No. 1 have bosses machined into the longitudinal stiffeners for mounting provisions of the station 1973.5 frame and of the station 1871 frame stabilizers. One panel from Barrel No. 1 has bosses to provide an external mounting surface for a LO2 feedline support bracket. Primary and secondary weld lands are configured to minimize discontinuity stresses. The barrel panels are edge trimmed during assembly. Threaded inserts and bolts are installed in the required barrel panels per STP2024 and STP2014 respectively.

The siphon support fitting is 56.0 inches in diameter and is machined from 2219-T87 aluminum plate. The siphon support fitting provides the internal mounting surface for the LH2 feedline siphon support. The siphon support fitting provides a 36.0 inch clear access to the LH2 feedline screen. The siphon support fitting is edge trimmed during assembly. Threaded inserts and bolts are installed in the siphon support fitting per STP2024 and STP2014 respectively.

B: The two longerons are machined from aluminum forgings heat-treated to 2219-T6 condition. Each longeron is approximately 177.5 inches long and 32.5 inches wide and is an integral part of Barrel No. 1. The forward end of each longeron contains exterior mounting provisions for the Orbiter thrust struts. One longeron contains exterior mounting provisions for the electrical feedthru of the internal LH2 sensor cabling. The longerons are edge trimmed during assembly. Threaded inserts and bolts are installed in the longerons per STP2024 and STP2014 respectively.

The feedline fitting is machined from a 2219-T6 aluminum forging and has a 16.60 inch inside diameter. The feedline fitting provides both an internal and external mounting surface for the feedline. The feedline fitting is edge trimmed during assembly. Threaded inserts and bolts are installed in the feedline fitting per STP2024 and STP2014 respectively.

The recirculation fitting is machined from a 2219-T6 aluminum forging and has a 3.95 inch inside diameter. The recirculation fitting carries warm LH2 from the Space Shuttle Main Engines (SSME's) back to the ET during propellant loading and hold. The recirculation fitting is edge trimmed during assembly. Threaded inserts and bolts are installed in the recirculation fitting per STP2024 and STP2014 respectively.

C: The forward dome ring is made up of four extrusions formed per STP1002 to the required radius of 165.5 inches. For LWT-54 thru 85, there are three 2L2019 extrusions and one 2L2039 extrusion. For LWT-86 thru 88, there are three 2L2094 extrusions and one 2L2093 extrusion. Heat-treatment to 2219-T8511 condition is followed by machining. It forms a portion of the LH2 tank wall, the outer chord for the station 1129.9 frame, and the interface flange to mate the LH2 tank/intertank. The 2L2039 and 2L2093 extrusion provide an exterior mounting surface for the ET/Orbiter forward attach fittings and a LO2 feedline support bracket. Threaded inserts and bolts are installed in the 2L2039 and 2L2093 extrusion per STP2024 and STP2014 respectively.

Rings No. 2 and No. 3 are each made up of four extrusions formed per STP1002 to the required radius of 165.5 inches. For LWT-54 thru 85, there are three 2L2007 extrusions and one 2L2006 extrusion. For LWT-86 thru 88, there are three 2L2096 extrusions and one 2L2095 extrusion. Heat-treatment to 2219-T8511 condition is followed by machining. The rings form a portion of the LH2 tank wall. Ring No. 3 forms the outer chord for the station 1377.35 frame and Ring No. 2 forms the outer chord for the 1623.80 frame. The 2L2006 and 2L2095 extrusions provide an exterior mounting surface for a LO2 feedline support bracket. Threaded inserts and bolts are installed in the 2L2006 and 2L2095 extrusions per STP2024 and STP2014 respectively.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LK2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCM & DATE: 001, 6-15-06

RATIONALE FOR RETENTION

DESIGN: (cont)

Ring No. 1 is made up of four extrusions formed per STP1002 to the required radius of 165.5 inches. For LMT-54 thru 84, there are two 2L2037 extrusions and two 2L2038 extrusions. For LMT-85 thru 88, there are two 2L2040 extrusions and two 2L2081 extrusions. Heat-treatment to 2219-T8511 condition is followed by machining. It forms a portion of the LK2 tank wall and the outer chord for the station 1871 frame. 2L2038 and 2L2081 extrusions provide an exterior mounting surface for a L02 feedline support bracket. Threaded inserts and bolts are installed in the 2L2038 and 2L2081 extrusion per STP2024 and STP2014 respectively.

The aft dome ring is made up of four extrusions formed per STP1002 to the required radius of 165.5 inches. For LMT-54 thru 85, there are two 2L2016 extrusions and two 2L2017 extrusions. For LMT-86 thru 88, there are two 2L2082 extrusions and two 2L2083 extrusions. Heat-treatment to 2219-T8511 condition is followed by machining. It forms a portion of the LK2 tank wall, the outer chord for the station 2058 frame, and provides an exterior mounting surface for the ET/Orbiter aft attach fittings, the ET/Solid Rocket Booster (SRB) aft attach fittings, the G02 pressurization line, and transportation fittings. Threaded inserts and bolts are installed per STP2024 and STP2014 respectively.

D: The LK2 tank welds are designed to a safe life criterion. This assures that failure will not occur from flaw propagation in the expected operating environment during the required life of the vehicle. The welds are designed to three criteria: 1) leak-burst fracture stress, 2) allowable weld grades, and 3) allowable ultimate strength.

- 1) The leak-burst fracture stress is the stress level above which a flaw reaches critical flaw size prior to stable growth through the weld thickness. Below this stress level, the flaw would propagate in a stable manner through the weld thickness and leak LK2/GK2 prior to catastrophic failure. An objective was to design all welds to leak before burst. All welds met this objective except the HT1-2 and -4 welds, which are classified as burst welds.
- 2) The allowable weld grades limit the allowable flaw size to one-half of the critical flaw size for a given weld stress, weld land thickness, and operating temperature.
- 3) The ultimate strength analysis establishes the limitations of combined peaking and mismatch weld land misalignments, so that required weld grades and required ultimate safety factors are maintained.

Four types of welding are utilized on the LK2 tank: Tungsten Inert Gas (TIG) butt welds, TIG fillet welds, Variable Polarity Plasma Arc (VPPA) butt welds, and TIG spot welds. The requirements for these welds are controlled by STP5501, STP5501, STP5506, and STP5503 respectively.

TEST:

The LK2 Tank Complete is certified. Reference NCS NMC-ET-TM08-L-5147.

Verification:

The structural integrity of the Lightweight Tank (LWT) LK2 tank was verified by: 1) similarity to the Standard Weight Tank (SWT) LK2 tank, 2) limit load test on LWT tank at regions with major design modifications, and 3) structural analysis. This approach is a direct result of the Structural Test Article (STA) and limit load verification test programs having successfully verified the structural integrity of the LK2 tank as a pressure vessel and having successfully validated the structural analysis techniques.

The STA and limit load test programs: 1) verified the structural integrity of the LK2 tank as a pressure vessel for the critical design loads and internal pressure loads, 2) verified the validity of the assumptions, methods, and computer modeling techniques utilized for the structural analysis, and 3) provided a database relative to weight optimization and upgraded vehicle performance.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
PNEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
OCN & DATE:

RATIONALE FOR RETENTION

TEST: (cont)

A-D: "Structural Strength and LH2 Tank Nodal Survey STA Major Ground Tests" (Reference ET Test Report MMC-ET-TM03, Vol III).

The SUT LH2 tank STA consisted of four components: LH2 tank, intertank, LO2 tank simulator, and lower load ring. The SUT LH2 tank was structurally tested in compliance with the Test Requirements Document, MMC-ET-TM07. Volume III of MMC-ET-TM03 describes the various tests performed and is augmented by Supplement A. Tests were conducted at both -423° F and room temperature. The tests conducted at room temperature necessitated the modification of test load and internal pressure load requirements to compensate for the difference in material properties exhibited at the required flight temperature and room temperature.

A-D: "Limit Load Verification Test - LWT LH2 Tank" (Ref. Document No. 826-2271).

The LWT LH2 tank (limit load verification article) consisted of the LWT-2 LH2 tank. The LH2 tank was structurally tested in compliance with ETO-3512-009. Areas which sustained major redesign with respect to the SUT LH2 tank were tested to limit flight load. These areas included the station 1871 and the station 2058 frames. The tests were conducted at room temperature, which necessitated the reduction of test load and internal pressure load requirements to compensate for the difference in material properties exhibited at -423° F and room temperature.

Development:

A: "Evaluation of Cleaning and Conversion Coating of Z219-T87" (Ref. Document No. 826-2130).

This program was undertaken to establish process parameters and acceptance criteria for the chem-film process.

The effects of forming techniques, soiling, aging, cleaning solutions, and high temperature Thermal Protection System (TPS) curing on the corrosion resistance and adhesion properties of the chem-film, Spray On Foam Insulation (SOFI) primer, and the SOFI/Super-Light Ablator (SLA) composites were evaluated. The results of this program were incorporated into STP3001 and STP5009.

D: "Evaluation of Z219 Welds" (Ref. Document No. 826-2023).

This program was undertaken to establish design allowables for Z219 TIG welds in Z219-T87 sheet/plate.

The effects of weld repairing and other manufacturing discrepancies were evaluated. This was accomplished by using B-repair-welded, mismatch, and peaking specimens. Automatic and manual repair methods were evaluated. The effects of mismatch and peaking on tensile strength were evaluated and acceptance criteria and weld allowables were established. The results of this program were incorporated into STP5501 and Engineering drawing 8090000060.

D: "Fracture Mechanics Data on Z219-T87 Aluminum for the Space Shuttle External Tank" (Ref. Document No. 826-2027).

This program was undertaken to establish fracture mechanics data for Z219-T87 aluminum base-metal, as-welded, and repair-welded material.

Fracture toughness, proof cycle flaw growth, and simulated service useful life tests were conducted in this evaluation. The results of this program were incorporated into STP5501 and Engineering drawing 8090000060.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
PHEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE:

RATIONALE FOR RETENTION

TEST: (cont)

- D: "Variable Polarity Plasma Arc Welding Process: Design Allowables Program for Weldment Strengths" (Ref. Document No. 826-2306).

This program was undertaken to establish design allowables for 2219 VPPA welds in 2219-T87 sheet/plate.

The effect of weld repairing and other manufacturing discrepancies were evaluated. This was accomplished by using 3-repair-welded, mismatch, and peaking specimens. Manual repair methods were evaluated. The effects of mismatch and peaking on tensile strength were evaluated and acceptance criteria and weld allowables were established. The results of this program were incorporated into STP5506 and Engineering drawing 80900000060.

- D: "Variable Polarity Plasma Arc Welding: Fracture Mechanics Data for 2219-T87 Aluminum Welds" (Ref. Document No. 826-2375).

This program was undertaken to establish fracture mechanics data for 2219-T87 as-welded material.

Fracture toughness tests were conducted in this evaluation. The results of this program were incorporated into STP5506 and Engineering drawing 80900000060.

- D: "Investigation into Effect of Peaking and Mismatch Misalignments on 2219 Aluminum TIG and VPPA Strength Properties" (Ref. Document No. 826-2312).

This program was undertaken to extend the limits of the established peaking and mismatch weld land misalignments as established by the "Evaluation of 2219 Welds" (Ref. Document No. 826-2023) and "Variable Polarity Plasma Arc Welding Process: Design Allowables Program for Weldment Strengths" (Ref. Document No. 826-2306). The results of this program were incorporated into STP5501, STP5506, and Engineering drawing 80900000060.

Acceptance:

MAF:

- A-D: Perform LH2 tank proof test to verify structural integrity and ultimate cycle life (MHC-ET-TM04k).

The required proof stress is equal to the flight limit stress multiplied by the proof factor at the proof test temperature. This proof factor is equal to the fracture toughness of the material at the proof test temperature divided by the fracture toughness of the material at the use temperature times the proof factor at the use temperature.

The result of enveloping the required proof stresses establishes that the proof stress requirements are dictated by a required pressure at station 2173.275 and the application of externally applied mechanical loads at the Aft ET/Orbiter and Aft ET/SRB attachment fittings. Gaseous Nitrogen (GN2) is used to pressurize the tank and hydraulic jacks provide the mechanical loads. The proof pressure requirements do not result in detrimental yielding of the LH2 tank.

Test covers for the forward dome manhole cover and the aft dome manhole covers are substituted for the flight covers for the proof test. The test covers have the same elastic properties and the same equivalent stiffness as the flight covers. The flight covers are proof tested separately to facilitate manufacturing.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
PHEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE:

RATIONALE FOR RETENTION

TEST: (cont)

- A: A forward dome gore (Ref. Engineering drawing 80914160982) is inadequately proofed in the vicinity of the sensor mast pad region since the mechanical loads are not applied. Four forward dome gores (Ref. Engineering drawings 80914160983 and 80914160986) are inadequately proofed in the vicinity of the $\pm Y$ at station 1129.9 due to the difference in the LH2 tank support configuration for proof test and flight. The forward dome cap (Ref. Engineering drawing 80914150993) is inadequately proofed in the vicinity of the electrical fitting, the sensor mast pad region, and the GN2 vent/relief duct pad region since the mechanical loads are not applied. One panel from each of the four barrels (Ref. Engineering drawings 80914200998, 80914400986, 80914600975, and 80914800995) is inadequately proofed in the vicinity of the cable tray support regions since the mechanical loads are not applied. Two panels from Barrel No. 1 (Ref. Engineering drawing 80914800993) are inadequately proofed in the vicinity of the longerons at station 1271 due to the difference in LH2 tank support configuration for proof test and flight. An aft dome gore (Ref. Engineering drawing 80914980993) is inadequately proofed in the vicinity of the LH2 feedline and recirculation fittings since the mechanical loads are not applied. The aft dome cap (Ref. Engineering drawing 80914950994) is inadequately proofed in the vicinity of the siphon support fitting, since the mechanical loads are not applied. To assure structural integrity, a NDE (penetrant examination) is performed on these plates.
- D: Inadequately proofed and manual welds that form a part of the pressure vessel wall are identified in the "Weld Acceptance Manual" (80900000060). Welds are considered inadequately proofed when the temperature adjusted load during proof testing is less than the load during flight multiplied by the required proof factor specified in the EIS. Structural integrity of these welds is assured by an additional NDE (radiographic examination) after proof testing for LWT-54 thru 88 (80900000060).
- D: Structural integrity of the bracket fillet welds (MFL) is assured by radiographic, visual and penetrant examinations following welding. Structural integrity of the clip welds (MFC and MAC) is assured by visual and penetrant examination following welding (STP5501 and 5503).
- D: Perform the LH2 leak test to verify structural integrity (MHC-ET-TM04k).
- The LH2 tank is pressurized with GN2 to 6.0 psi after completion of the proof test. A Leak test fluid is applied to the fusion butt welds to detect leaks. The system is controlled by STP3503. No leaks are permitted.

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE: 001, 6-15-98

RATIONALE FOR RETENTION

INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

A: Verify material selection and verification controls (MNC-ET-SE16, QQ-A-250/30 and STK1701).

A: Verify heat-treatment of the following parts to Z219-T87 (MIL-H-6088).

<u>Forward Dome Gores</u> 80914160981 80914160982 80914160983 80914160984 80914160986	<u>Aft Dome Gores</u> 80914980991 80914980993 80914980994 80914980996 80914980997	<u>Forward Dome Cap</u> 80914150993 <u>Aft Dome Cap</u> 80914950991
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A: Verify cleaning of the following parts (STP5008 and Engineering drawing).

Diffuser Mounting Plate
80921021047

A-C: Verify ultrasonic examination of the following parts (MIL-I-8950, Class B).

<u>Forward Dome Ring</u> 80914140997 (2L2019 and 2L2039 Only)	<u>Aft Dome Ring</u> 80914960998 (2L2016 and 2L2017 Only)	<u>Barrel No. 1 Panels</u> 80914800964 80914800965
<u>Barrel No. 2 Panel</u> 80914600963	<u>Barrel No. 3 Panel</u> 80914600963	<u>Barrel No. 4 Panel</u> 80914600963
<u>Ring No. 1 Segment</u> 80914700993 (2L2037 and 2L2038 Only)	<u>Ring No. 2 Segment</u> 80914500961 (2L2006 and 2L2007 Only)	<u>Ring No. 3 Segment</u> 80914500961 (2L2006 and 2L2007 Only)
<u>Lonsgran</u> 82614300026		

A-C: Inspect dimensions of the following parts (Engineering drawing).

<u>Forward Dome Gores</u> 80914160981 80914160982 80914160983 80914160984 80914160986	<u>Aft Dome Gores</u> 80914980991 80914980993 80914980994 80914980996 80914980997	<u>Barrel No. 1 Panels</u> 80914800991 80914800992 80914800993 80914800994 80914800995
<u>Barrel No. 2 Panels</u> 80914600971 80914600972 80914600973 80914600974 80914600975	<u>Barrel No. 4 Panels</u> 80914200983 80914200996 80914200997 80914200998 80914400982	<u>Barrel No. 3 Panels</u> 80914400981 80914400982 80914400984 80914400985 80914400986
<u>Ring No. 1 Segment</u> 80914700993 (LWT-54 thru 84) 80914700994 (LWT-85 thru 88)	<u>Ring No. 2 Segment</u> 80914500961	<u>Ring No. 3 Segment</u> 80914500961
<u>Aft Dome Cap</u> 80914950991	<u>Forward Dome Cap</u> 80914150993	<u>Lonsgran</u> 80914800987

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
CON & DATE: 001, 6-15-98

RATIONALE FOR RETENTION

INSPECTION: (cont)

<u>Recirculation Fitting</u> 80914940988	<u>Feedline Fitting</u> 80914940988	<u>Forward Dome Ring</u> 80914140997
<u>Electrical Fitting</u> 80914130996	<u>Siphon Support Fitting</u> 80914930988	<u>Forward Dome Manhole Fitting</u> 80914150948
<u>Aft Dome Manhole Fitting</u> 80914950994	<u>Vent Valve Fitting</u> 80914130996	<u>Diffuser Mounting Plate</u> 80921021047
<u>Aft Dome Ring</u> 80914960998	<u>Feedthru Plate</u> 80934003726 80931003717	

A-C: Inspect penetrant examination of the following parts (STP2501, Type 1, Method A).

<u>Forward Dome Cap</u> 80914150995	<u>Aft Dome Cap</u> 80914950991	<u>Longeron</u> 80914800987
<u>Aft Dome Ring</u> 80914960998	<u>Forward Dome Ring</u> 80914140997	<u>Ring No. 3 Segment</u> 80914500961
<u>Ring No. 2 Segment</u> 80914500961	<u>Ring No. 1 Segment</u> 80914700993 (LWT-54 thru 84) 80914700994 (LWT-85 thru 88)	<u>Feedline Fitting</u> 80914940988
<u>Recirculation Fitting</u> 80914940988	<u>Electrical Fitting</u> 80914130996	<u>Feedthru Plate</u> 80931003717 80934003726
<u>Forward Dome Manhole Fitting</u> 80914150948	<u>Aft Dome Gore</u> 80914980993	<u>Forward Dome Gores</u> 80914160981 80914160982 80914160983 80914160984 80914160986
<u>Siphon Support Fitting</u> 80914930988	<u>Aft Dome Manhole Fitting</u> 80914950994	
<u>Diffuser Mounting Plate</u> 80921021047	<u>Vent Valve Fitting</u> 80914130996	

A-C: Inspect hole dimensions for inserts on the following parts (STP2024 and Engineering drawing).

<u>Longeron</u> 80914800987	<u>Forward Dome Ring</u> 80914140997	<u>Ring No. 3 Segment</u> 80914500961
<u>Ring No. 2 Segment</u> 80914500961	<u>Ring No. 1 Segment</u> 80914700993 (LWT-54 thru 84) 80914700994 (LWT-85 thru 88)	<u>Barrel No. 4 Panels</u> 80914200997 80914200998
<u>Barrel No. 3 Panel</u> 80914600986	<u>Barrel No. 2 Panel</u> 80914600975	<u>Barrel No. 1 Panels</u> 80914800991 80914800992 80914800993 80914800994 80914800995
<u>Feedthru Plate</u> 80931003717	<u>Recirculation Fitting</u> 80914940988	
<u>Diffuser Mounting Plate</u> 80921021047		

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LN2 Tank
PNEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE: 001, 6-15-98

RATIONALE FOR RETENTION

INSPECTION: (cont)

A-C: Inspect part number applied to the following parts (Engineering drawing).

<u>Forward Dome Gores</u>	<u>Aft Dome Gores</u>	<u>Barrel No. 4 Panels</u>
80914160981	80914980991	80914200983
80914160982	80914980993	80914200996
80914160983	80914980994	80914200997
80914160984	80914980996	80914200998
80914160986	80914980997	80914400982

<u>Barrel No. 3 Panels</u>	<u>Barrel No. 2 Panels</u>	<u>Barrel No. 1 Panels</u>
80914400981	80914600971	80914800991
80914400982	80914600972	80914800992
80914400984	80914600973	80914800993
80914400985	80914600974	80914800994
80914400986	80914600975	80914800995

B: Verify material selection and verification controls (MMC-ET-SE16, STN-0-250 and STMS163).

B: Verify cold cycle stress relief on the following part (Engineering drawing).

Feedline Fitting
80914940986

B: Verify heat-treatment of the following part to 2219-T6 (MIL-H-6088).

Longeron
80914800987

C: Verify material selection and verification controls (MMC-ET-SE16 and STK3120, Class 1).

C: Verify heat-treatment of the following parts to 2219-T8511 (MIL-H-6088).

<u>Forward Dome Ring Segment</u>	<u>Aft Dome Ring Segment</u>	<u>Ring No. 3 Segment</u>
80914140997	80914960998	80914500961

<u>Ring No. 2 Segment</u>	<u>Ring No. 1 Segment</u>
80914500961	80914700993 (LM7-54 thru 84)
	80914700994 (LM7-85 thru 88)

A: Verify chemical film applied to the following parts (STP3001, Class 1A and Engineering drawing).

<u>Feedthru Plates</u>	<u>Diffuser Mounting Plate</u>
80934003726	80921021047
80931003717	

A: Verify epoxy primer applied to the following parts (STP3003, Type 1 and Engineering drawing).

<u>Feedthru Plates</u>	<u>Diffuser Mounting Plate</u>
80934003726	80921021047
80931003717	

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE:

RATIONALE FOR RETENTION

INSPECTION: (cont)

Lockheed Martin Procurement Quality Representative:

A: Witness Proof Test of the following parts (Engineering drawing).

Feedthru Plates
80934003726
80931003717

MAF Quality Inspection:

A: Verify material selection and verification controls (MNC-ET-SE16, GR-A-250/30 and STA1701).

Forward Dome Manhole Cover
80914081488

Aft Dome Manhole Cover
80911001444

A: Inspect dimensions of the following parts (Engineering drawing).

Electrical fitting
80914110990

Forward Dome Manhole Fitting
80914110990

Vent Valve Fitting
80914110990

Siphon Support Fitting
80914910990

Aft Dome Manhole Fitting
80914910990

Feedline Fitting
80914961960

Aft Dome Manhole Cover
80911001444

Forward Dome Manhole Cover
80914081488

A: Verify cleaning of the following parts (STP5008 and Engineering drawing).

Forward Dome Manhole Cover
80914081488

Aft Dome Manhole Cover
80911001444

Feedthru Plates
80934003709
80931003779

A: Verify epoxy primer applied to the following parts (STP3003, Type 1 and Engineering drawing).

Forward Dome Manhole Cover
80914081488

Aft Dome Manhole Cover
80911001444

A: Inspect weld land widths of the following assemblies (Engineering drawing).

Forward Dome Assembly
80914100995
80914120900
80914140975
80914140985
80914140995
80914160925
80914160935
80914160945
80914170910
80914170925

Aft Dome Assembly
80914900980
80914920900
80914941979
80914970940
80914970955
80914980935
80914980945
80914980955

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LX2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE:

RATIONALE FOR RETENTION

INSPECTION: (cont)

A-C: Inspect hole dimensions for inserts on the following parts (STP2024 and Engineering drawing).

<u>Forward Dome Manhole Cover</u> 80914081438	<u>Aft Dome Ring</u> 80914961960	<u>Aft Dome Manhole Fitting</u> 80914910990
<u>Feedline Fitting</u> 80914961960	<u>Forward Dome Manhole Fitting</u> 80914110990	<u>Aft Dome Manhole Cover</u> 80911001444
<u>Electrical Fitting</u> 80914110990	<u>Vent Valve Fitting</u> 80914110990	<u>Siphon Support Fitting</u> 80914910990 80914951969

A-C: Inspect installation of bolts in the following parts and assemblies (STP2014 and Engineering drawing).

<u>Aft Dome Manhole Fitting</u> 80911001449	<u>Forward Dome Manhole Cover</u> 80924061009	<u>Forward Dome Manhole Fitting</u> 80914081490
<u>Forward Dome Ring</u> 80911051109 80914151910 80911001459	<u>Siphon Support Fitting</u> 80911001449 80914951969	<u>Feedthru Plates</u> 80931003779 80931003810
<u>Electrical Fitting</u> 80931003759 (LWT-54 thru 58) 80931003810 (LWT-59 thru 88)	<u>Diffuser Mounting Plate</u> 80921021009	<u>Recirculation Fitting</u> 80921011009
<u>Vent Valve Fitting</u> 80921021309	<u>Barrel No. 4 Assembly</u> 80914001950 80914041409	<u>Barrel No. 3 Assembly</u> 80914041409
<u>Barrel No. 2 Assembly</u> 80914601970 80914041409	<u>Barrel No. 1 Assembly</u> 80914091989 80914801900 80914041409 80914041459	<u>Feedline Fitting</u> 80921011009 80924901916
<u>Ring No. 3 Assembly</u> 80911001459	<u>Ring No. 2 Assembly</u> 80914041459	<u>Ring No. 1 Assembly</u> 80914041459 80914701990
<u>Aft Dome Ring Assembly</u> 80914041409 80911031149 80911031169 80911051120 80911051124	<u>Longeron</u> 80914091979 80914091989 80934003719	

A-D: Inspect Proof Test and Leak Test (MHC-ET-TM(4k)).

A-D: Verify cleaning and chemical film applied to the following assembly (STP5009 and Engineering drawing).

LX2 Tank Assembly
80914015920
80914005940

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCN & DATE:

RATIONALE FOR RETENTION

INSPECTION: (cont)

A-D: Verify chemical film applied to the following parts (STP3001, Class 1A and Engineering drawing).

<u>Forward Dome Manhole Cover</u> 80914081488	<u>Forward Dome Manhole Fitting</u> 80914110990	<u>Aft Dome Manhole Cover</u> 80911001444
<u>Forward Dome Ring</u> 80914100900	<u>Electrical Fitting</u> 80914110990	<u>Aft Dome Ring</u> 80914900900
<u>Vent Valve Fitting</u> 80914110990	<u>Aft Dome Manhole Fitting</u> 80914910990	<u>Siphon Support Fitting</u> 80914910990 80914951969
<u>Feedline Fitting</u> 80914961960	<u>LH2/Intertank Flange</u> 80914005940 (LWT-54 thru 63) 80911000000 (LWT-64 thru 88) 80914101900	

A-D: Verify epoxy primer applied to the following parts and assembly (STP3004 and Engineering drawing).

<u>LH2 Tank Assembly</u> 80914005940	<u>Aft Dome Ring</u> 80911018900 (LWT-54 thru 63) 80911000000 (LWT-64 thru 88) 80914004000
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A, C: Inspect penetrant examination of the following parts (STP2501, Type 1, Method A).

<u>Aft Dome Manhole Cover</u> 80911001444	<u>Forward Dome Ring</u> 80914101900	<u>Forward Dome Manhole Cover</u> 80914081488
<u>Barrel No. 1 Panels</u> 80914800993 80914800995	<u>Barrel No. 2 Panel</u> 80914600975	<u>Barrel No. 3 Panel</u> 80914400986
<u>Barrel No. 4 Panel</u> 80914200998		

A, C: Inspect orientation of welded parts in the following assemblies (Engineering drawing).

<u>Barrel No. 4 Assembly</u> 80914200990	<u>Barrel No. 3 Assembly</u> 80914400980	<u>Forward Dome Assembly</u> 80914100900
<u>Barrel No. 2 Assembly</u> 80914600970	<u>Barrel No. 1 Assembly</u> 80914800900	<u>Aft Dome Assembly</u> 80914900900
<u>LH2 Tank Assembly</u> 80914000000 80914000960		

A, C: Inspect axis orientation markings and/or direction orientation markings applied to the following assemblies (Engineering drawing).

<u>Forward Dome Assembly</u> 80914120900	<u>Aft Dome Assembly</u> 80914920900	<u>Ring No. 3 Assembly</u> 80914300975
<u>Ring No. 2 Assembly</u> 80914500955	<u>Ring No. 1 Assembly</u> 80914700995	

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Pressure Vessels
SUBSYSTEM: LH2 Tank
FMEA ITEM CODE(S): 6.2.1.1, 6.2.1.2

REV & DATE: J, 12-19-97
DCH & DATE:

RATIONALE FOR RETENTION

INSPECTION: (cont)

A, C: Verify zinc chromate paste applied to the following assemblies (Engineering drawing).

Ring No. 3 Assembly
80911001459

Ring No. 2 Assembly
80914041459

Ring No. 1 Assembly
80914041459

Forward Dome Ring Assembly
80911051109
80911001459

Barrel No. 4 Assembly
80914041409

Barrel No. 3 Assembly
80914041409

Barrel No. 2 Assembly
80914041409

Barrel No. 1 Assembly
80914041409
80914041459

Aft Dome Ring Assembly
80911051120
80911051124
80911051149
80911031169
80914041409

D: Inspect the 2319 aluminum weld wire/rod (MMS-Y-469) for conformance to material specification and packaging (MMC-ET-SE16 and STM-Y-469).

D: Inspect post proof inspection (Engineering drawing).

LH2 Post Proof Inspection
80914004000

C: Reinspect pre-proof radiographs of welds reclassified from adequately proofed to inadequately proofed (UCN J31121; LWT-54 thru 64).

D: Inspect the dimensions and conformance to weld grade of the following assemblies (Engineering drawing).

(Reference the following STPs for welding and acceptance requirements: STP5501 for TIG weld, STP5503 for TIG spot weld, and STP5506 for VPPA weld).

Forward Dome Assembly
80914100900
80914100995
80914101900
80914120900
80914130930
80914140975
80914140985
80914140995
80914150940
80914150925
80914160935
80914160945
80914170910
80914170925

Aft Dome Assembly
80914900900
80914900980
80914920900
80914930935
80914940945
80914950955
80914960980
80914960985
80914960990
80914970940
80914970955
80914980935
80914980945
80914980955

Barrel No. 4 Assembly
80914200990

Barrel No. 3 Assembly
80914400980

Barrel No. 2 Assembly
80914600970

Barrel No. 1 Assembly
80914800900

Ring No. 3 Assembly
80914300975

Ring No. 2 Assembly
80914500935

Ring No. 1 Assembly
80914700995

LH2 Tank Assembly
80914090960
80914000000

FAILURE HISTORY:

Current data on test failures, unexplained anomalies and other failures experienced during ground processing activity can be found in the PRACA data base.