



NSTS 60584

Orbiter Transition and Retirement Program

Orbiter Fleet Safing Document

Display Precautions and Mitigations

Baseline

6/22/10



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Orbiter Fleet Safing Document (OFSD)
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1. Introduction

With the retirement of the Space Shuttle program, plans are in place for the Shuttle fleet dispositioning as display articles. Once removed from the fleet the Orbiter vehicles must be properly prepared for final disposition for future use by NASA or another agency.

The Orbiter Fleet Safing Document (OFSD), defines the plans to "safe" the Orbiter fleet for long term storage and/or public display and to flag minor hazards and precautions which are recommended "left as is" at this time.

This document (section) does not / will not address final specific display site / Orbiter configurations beyond those dictated by the included "safing" removals.

1.1 Purpose

To define all safing mitigation steps required during the Fleet End State and Display State. All safing requirements documented in the OFSD will be incorporated into the End State Sub-system Requirements Document (ESSRD). ESSRD requirements will be worked on KSC Work Authorization Documents (WAD) during the End State flows of each Orbiter.

Upon completion of each Orbiter's End State flows, and satisfaction of all OFSD mitigation requirements summarized in Table 1, Precautionary Commodity Disposition, the Orbiter Engineering and Ground \ Operation communities are assured that all identified hazardous commodities will have been removed or identified, allowing for delivery of an Orbiter vehicle safed for controlled public display.

Controlled Public Display is defined as "Visual plus very limited controlled contact". If residual hazardous areas are accessed, the display site will be responsible for the additional safety precautions summarized in Table 2, Residual Hazardous Precautions.

2. Precautionary Commodity Disposition

Commodity	System	Planned Mitigation
Monomethyl Hydrazine (CH ₃ NHNH ₂)	OMS/RCS	<ul style="list-style-type: none"> • System drained • Contaminated components removed • System vented to atmosphere • Commodity non-detectable
Nitrogen Tetroxide (N ₂ O ₄)	OMS/RCS	<ul style="list-style-type: none"> • System drained • Contaminated components removed • System vented to atmosphere • Commodity non-detectable
Hydrazine (N ₂ H ₄)	APU	<ul style="list-style-type: none"> • Hyper system drained and removed • Commodity non-detectable
High Pressure Gas (He & GN ₂)	MPS, ECLSS, APU, PRSD, OMS/RCS	<ul style="list-style-type: none"> • Vented
CDC - confined detonating cord	PYRO	<ul style="list-style-type: none"> • Removed and/or detonated in place
XTA - expanding tube assembly	PYRO	<ul style="list-style-type: none"> • Removed
LSC - linear shaped charge		
NSI - NASA Standard Initiator		
MDF - mild detonating fuse		
SMDC - shielded MDC detonating cord		
Liquid Hydrogen (LH ₂)	MPS	<ul style="list-style-type: none"> • H₂ concentration less than .5% • System vented
	PRSD	<ul style="list-style-type: none"> • H₂ concentration less than .5% • System drained and vented
Liquid Oxygen (LO ₂)	MPS	<ul style="list-style-type: none"> • O₂ concentration less than 22% • System vented
	PRSD	<ul style="list-style-type: none"> • O₂ concentration less than 22% • System drained and vented
Ammonia (NH ₃)	ECLSS	<ul style="list-style-type: none"> • Less than 1 ppm • System drained, purged and vented
Freon 21 (CHCl ₂ F)	ECLSS	<ul style="list-style-type: none"> • Less than 5 ppm • System drained and vented
Halon	ECLSS	<ul style="list-style-type: none"> • Fire suppression bottles (Halon) removed
Hydraulic Accumulators	HYD	<ul style="list-style-type: none"> • Accumulators removed or drained/vented
WSB PGME/Water	HYD	<ul style="list-style-type: none"> • System drained and vented • WSB tank residual (2.8lbs) • Document only
Waste Water	ECLSS	<ul style="list-style-type: none"> • System drained, iodine enriched flush, dried to less than 15 mm Hg for 1 hrs min • WCS, urine filter removed

Table 1 Precautionary Commodity Disposition

Precautionary Commodity Disposition (continued)

Commodity	System	Planned Mitigation
Potable Water	ECLSS	<ul style="list-style-type: none"> • Drained & dried to less than 15 mm Hg for 1 hrs min • Microbial check valve removed
Avionics Cooling Water	ECLSS	<ul style="list-style-type: none"> • Drained & dried to less than 15 mm Hg for 1 hrs min
LCG Water	ECLSS	<ul style="list-style-type: none"> • Drained & dried to less than 15 mm Hg for 1 hrs min
Fuel Cell Water	F/C	<ul style="list-style-type: none"> • Drained and vented
APU Water & Gaseous Nitrogen (Injector Cooling System)	APU	<ul style="list-style-type: none"> • Water drained • GN2 vented
Fluorinert (FC-40)	F/C	<ul style="list-style-type: none"> • Drained and vented
Stored Mechanical Energy - T-0 & ET I/F QDs - Landing gear door opening assist bungee - Strut & Tire Press	MPS MEQ MEQ	<ul style="list-style-type: none"> • Document only • Energy removed • Vented struts & hard filled tires
APU lube oil	APU	<ul style="list-style-type: none"> • Drained and vented
LiOH	FCE	<ul style="list-style-type: none"> • Canisters removed
Batteries NiCd Lithium	DPS INSTR	<ul style="list-style-type: none"> • GPC backup battery units removed (BBU) • GPS receiver battery units removed • MEI batteries removed (OV-103/4) • WLE instrumentation batteries removed • Comsec/batteries removed
Hydraulic Fluid	HYD	<ul style="list-style-type: none"> • Significant system residual (~90 gal.) • Document only
Beryllium (Be)	STR	<ul style="list-style-type: none"> • ET doors remain installed • Star trackers remain installed • Document only
Mercury	D&C	<ul style="list-style-type: none"> • Mercury hermetically sealed in LCDs & CRTs • Document only
Radioactive Material Americium-241	ECL	<ul style="list-style-type: none"> • Tests to characterize sources and levels of radiation • Document only
TPS Silica, Manmade Vitreous Fibers (MMVF), Cerachrome	TPS	<ul style="list-style-type: none"> • Document only
Boron	STR	<ul style="list-style-type: none"> • Approx 240 struts installed during initial build. • document only
Asbestos	F/C	<ul style="list-style-type: none"> • Fuel cells remain installed (414 cu in. / 5184 grams). • Document only
Potassium Hydroxide (KOH)	F/C	<ul style="list-style-type: none"> • Fuel cells remain installed (catalytic residuals) • Document only

Table 1 (Cont) Precautionary Commodity Disposition

Precautionary Commodity Disposition (continued)

Commodity	System	Planned Mitigation
Koropon	STR	• Document only
Lead	Elect	• Document only
Cadmium	Mech Elect	• Document only

Table 1 (Cont) Precautionary Commodity Disposition

3. Residual Hazardous Precautions

Commodity	Hazard • Exposure Type	End State Configuration	Display Precautions Summary
Hydraulic Fluid	Combustible Toxic • Eye Contact • Ingestion	Contained (~90 gallons) in Closed System.	• Slippage/contact precautions, if disassembled
WSB PGME/Water	Toxic • Ingestion	2.8 lbs. in enclosed WSB tank.	• Avoid inhalation/ingestion, if disassembled
Beryllium (Be)	Toxic • Inhalation	Present in solid structural components only.	• Avoid cutting, sanding, splintering or scratching/inhalation of dust
Mercury	Toxic • Skin Contact • Eye Contact • Ingestion	Mercury hermetically sealed in LCDs & CRTs.	• Avoid contact/ingestion, if disassembled
Radioactive Material (Americium-241)	Mild Radiation • Smoke detector element contact	9 detectors @ 20 micro-curries each.	• Avoid lengthy contact if disassembled
TPS Silica, Manmade Vitreous Fibers (MMVF), Carbon Carbon RCC, Cerachrome	Respiratory irritant • Inhalation	All possible exposures require manipulation of the material.	• Avoid cutting, sanding or scratching/inhalation of fibers
Boron	Toxic • Inhalation • Splintering	Present in solid structural components only. Exposure requires manipulation of the material.	• Avoid cutting, sanding or scratching/inhalation of dust
Asbestos	Severe respiratory irritant • Inhalation	Residuals present in sealed fuel cell only. Exposure requires manipulation of the material.	• Avoid inhalation of fibers, if disassembled
Potassium Hydroxide (KOH)	Caustic • Skin/Eye Contact	Residuals present in sealed fuel cell only. Forms non-hazardous Potassium Carbonate when exposed to air.	• Avoid contact • Placard signs to be placed at F/C location cautioning not to contact power head section
Koropon Paint	Toxic • Inhalation	Paint on orbiter aluminum skin - remains in place. Cured Koropon is not an exposure issue unless sanded to dust.	• Avoid sanding or scratching/inhalation of dust
Lead	Toxic • Ingestion	Present in solder only. Exposure requires disassembly of electronic equipment.	• Avoid ingestion, if disassembled

Table 2 Residual Hazardous Precautions

Residual Hazardous Precautions (continued)

Commodity	Hazard • Exposure Type	End State Configuration	Display Precautions Summary
Quick Disconnects (QD) / stored energy	Physical • Stored Energy • Pinch Points	Some stored energy remains in Quick Disconnects (QD), if manipulated. GSE covers will be used for high energy MPS (PD1, PD2 & PD3) QD's.	<ul style="list-style-type: none"> Avoid contact/manipulation
Cadmium	Toxic • Inhalation	Present in connector bayonet pins and springs only. Covered by insulation and closeout panels. Exposure requires contact and manipulation of the material.	<ul style="list-style-type: none"> Avoid contact Placard signs to be placed at locations cautioning to avoid contact

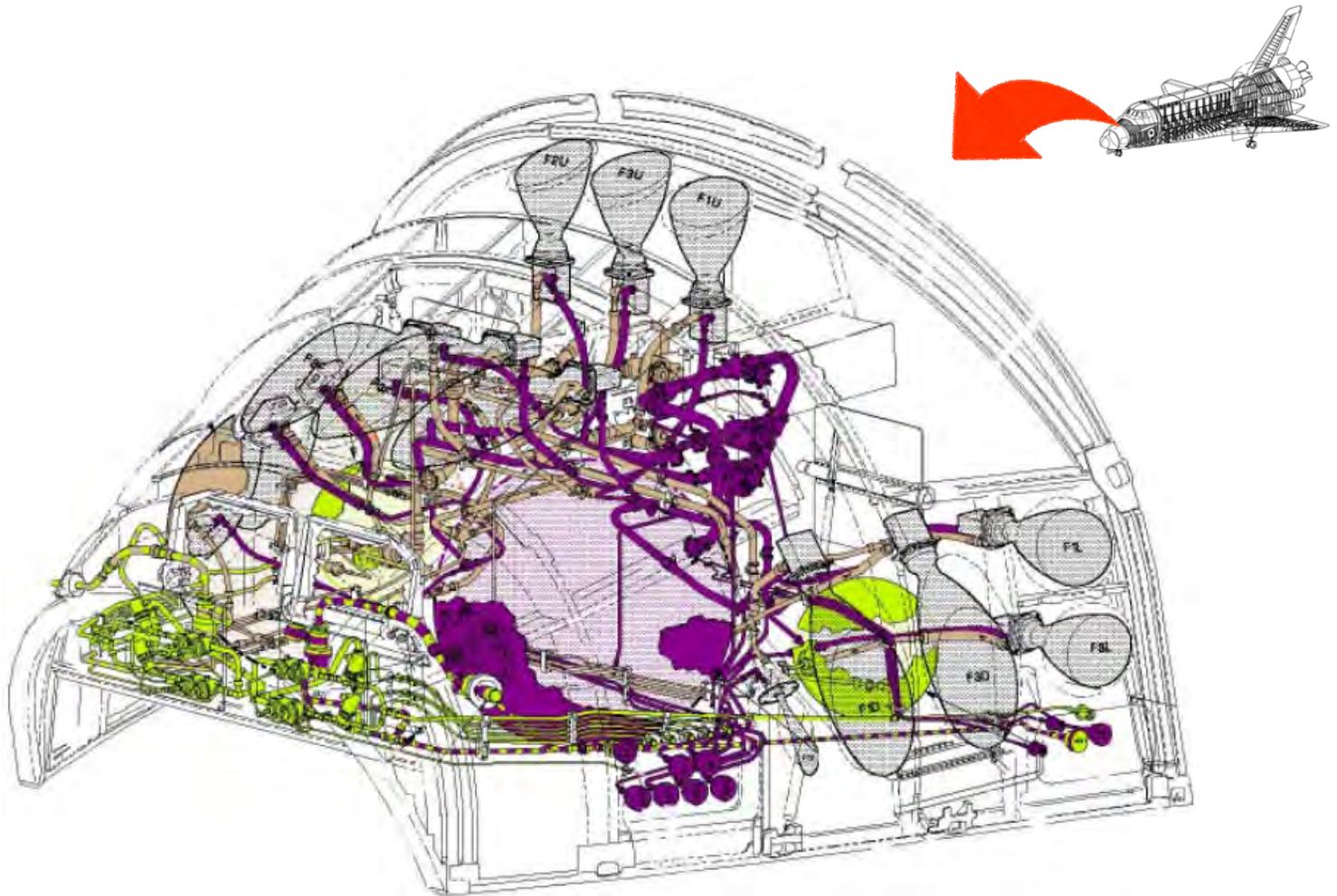
Table 2 (Cont) Residual Hazardous Precautions

4. Orbiter Hazard Commodity Locations

4.1 Monomethyl Hydrazine and Nitrogen Tetroxide

Forward Reaction Control System (FRCS).

- Fuel (CH_3NHNH_2), oxidizer (N_2O_4), and pressurization (He).



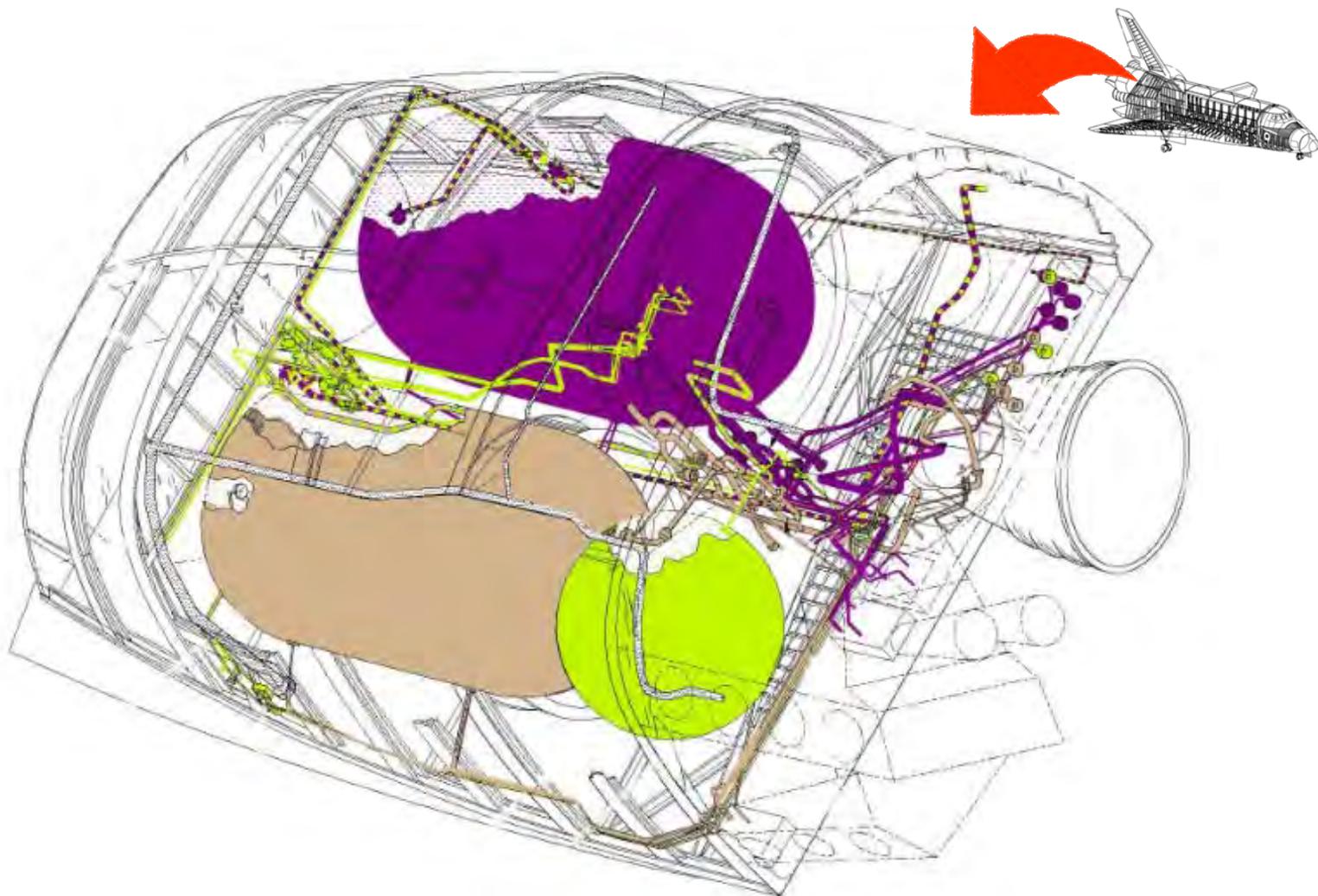
Legend	
CH_3NHNH_2 – purple	
N_2O_4 – brown	
He – green	

Forward RCS

Monomethyl Hydrazine and Nitrogen Tetroxide (continued)

Orbital Maneuvering System (OMS) – left.

- Fuel (CH_3NHNH_2), Oxidizer (N_2O_4), and pressurization (He).



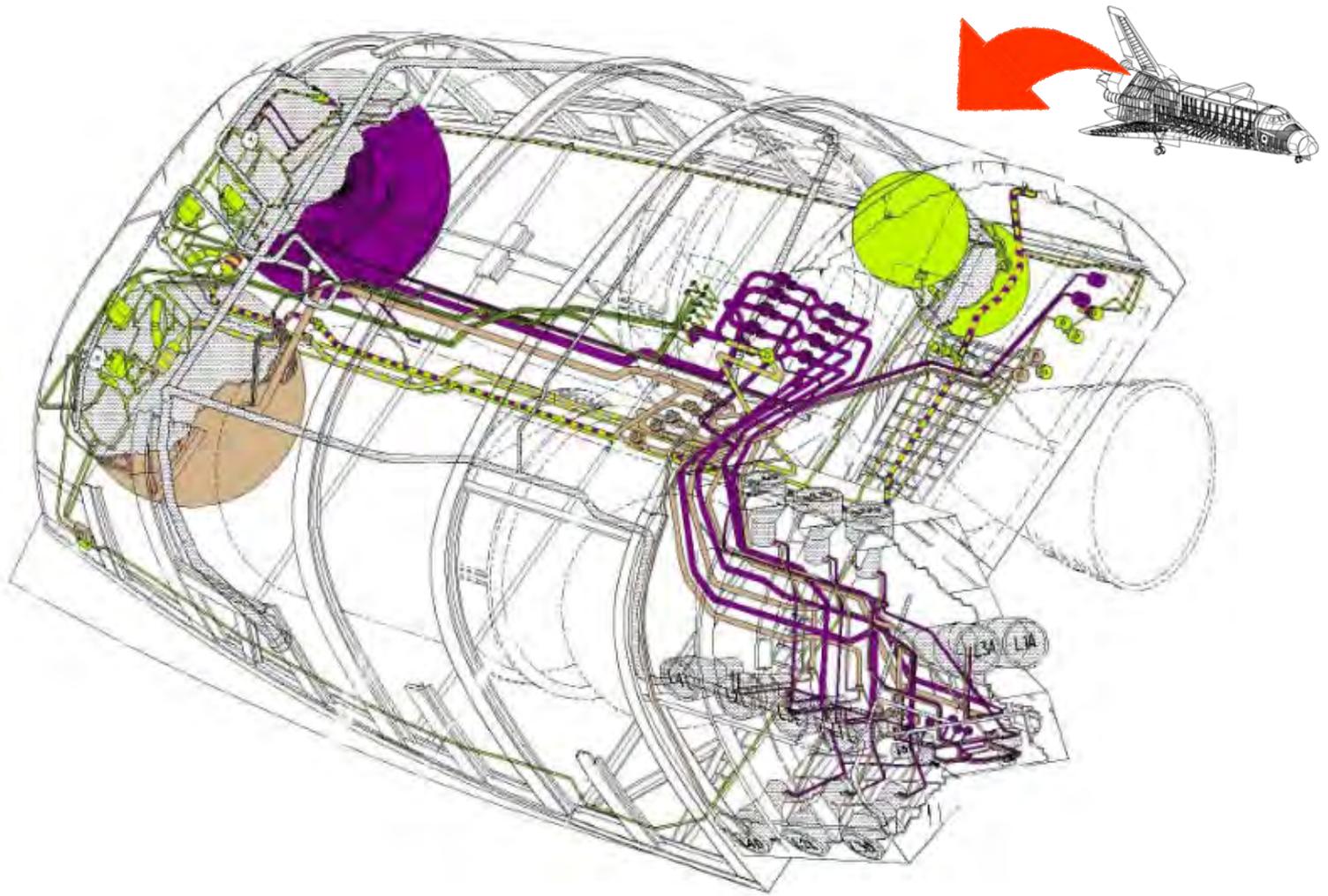
Legend	
CH_3NHNH_2 – purple	
N_2O_4 – brown	
He - green	

OMS

Monomethyl Hydrazine and Nitrogen Tetroxide (continued)

Reaction Control System (RCS) – Aft, left.

- Fuel (CH_3NHNH_2), Oxidizer (N_2O_4), and pressurization (He).

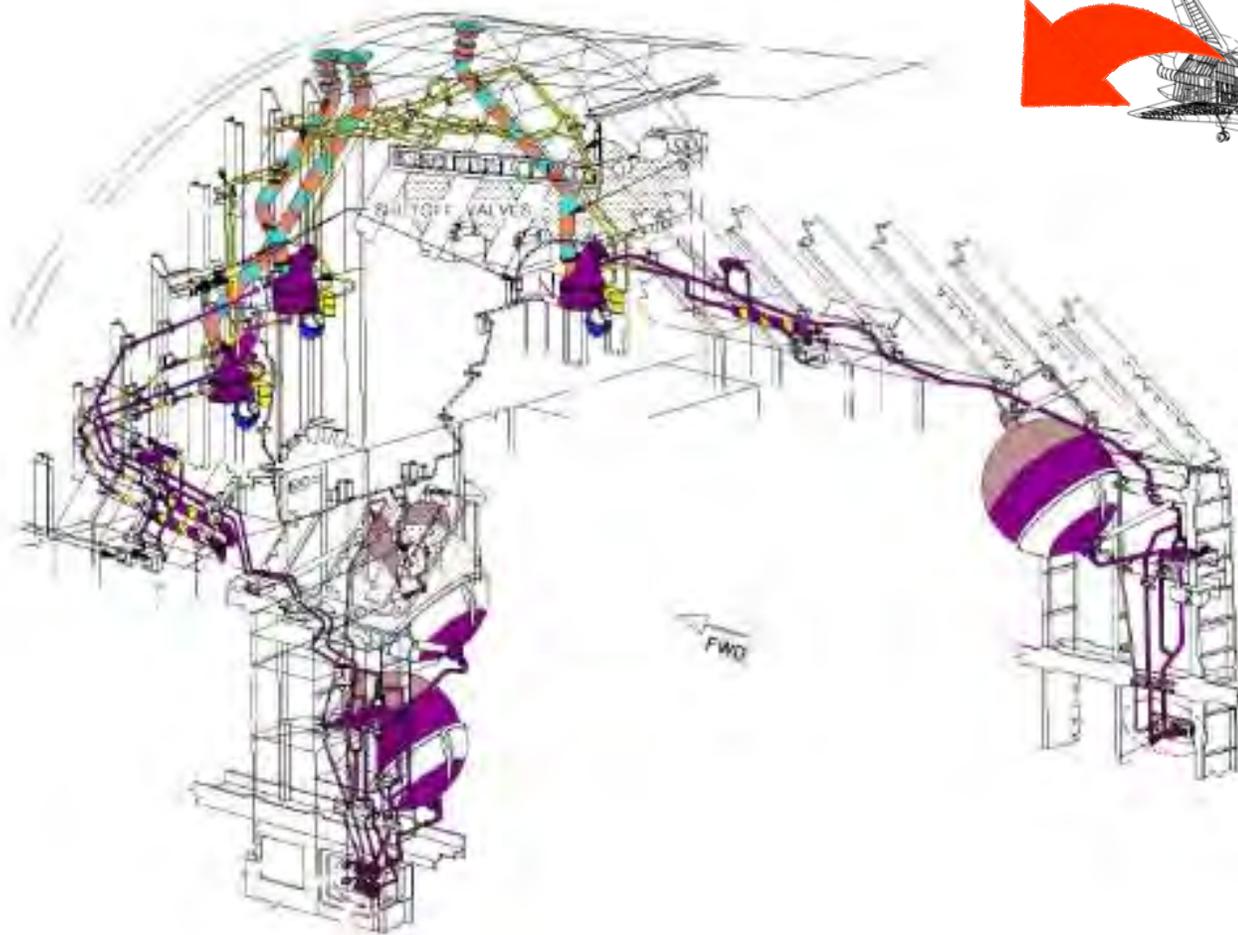


Legend	
CH_3NHNH_2 – purple	
N_2O_4 – brown	
He – green	

Aft RCS

4.2 Hydrazine Auxiliary Power Unit (APU)

- Fuel (Hydrazine), catalytic bed (aluminum oxide and iridium) and pressurization (GN_2).

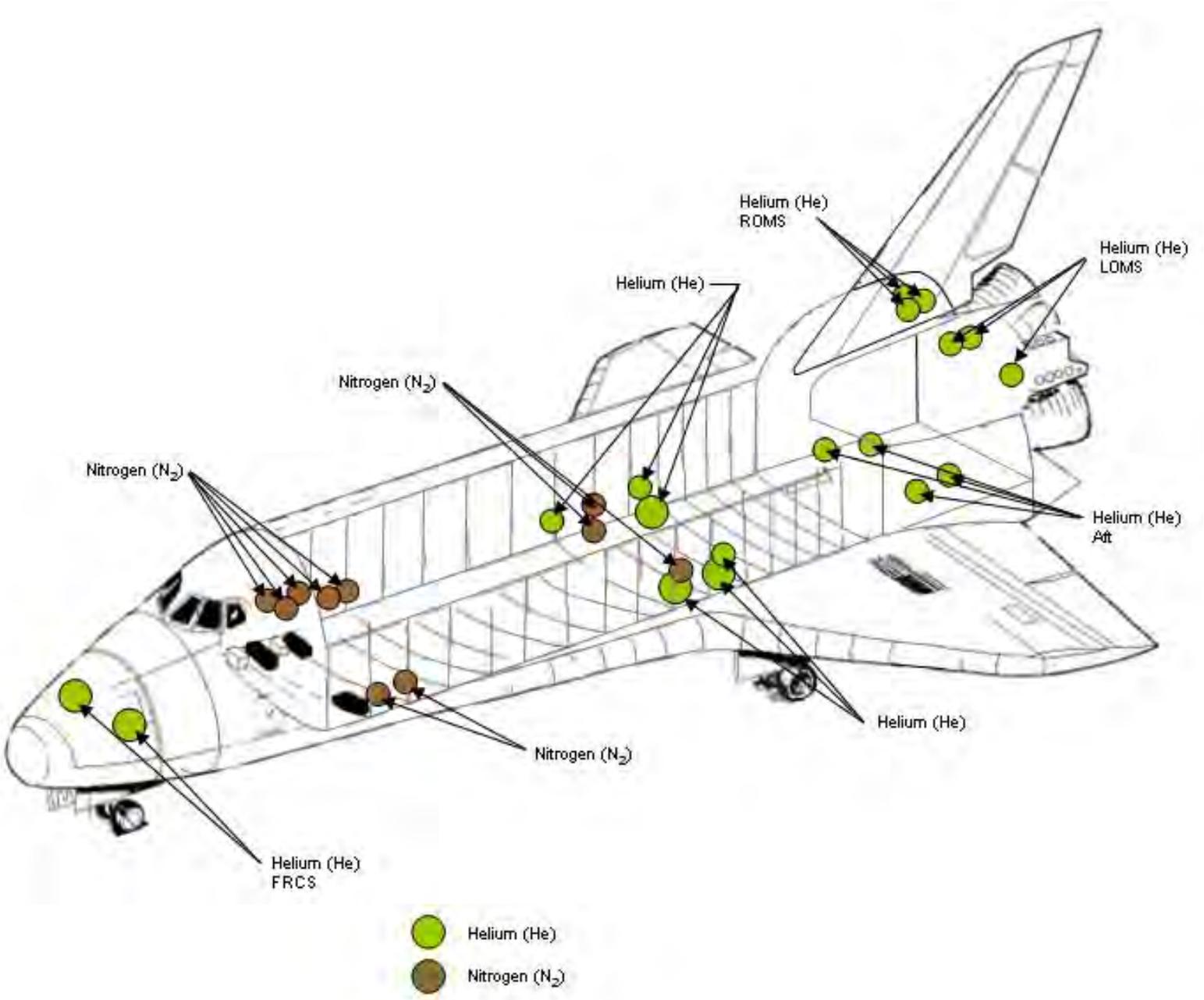


Legend	
N_2H_4 – purple	
GN_2 – brown	
APU exhaust duct	

APU System

4.3 High Pressure Gas Systems

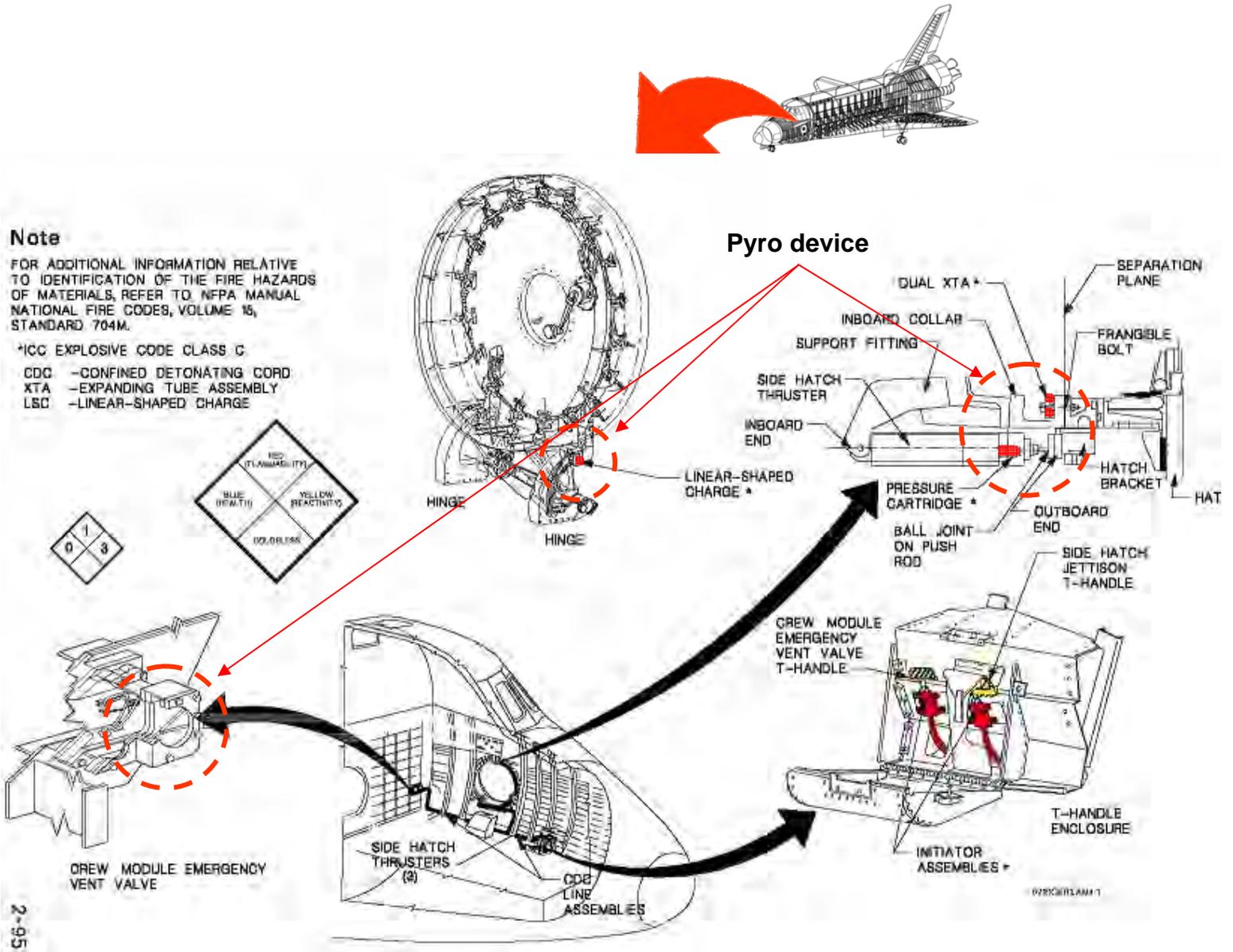
- Helium and Gaseous Nitrogen.



High Pressure Gas Systems

4.4 Pyrotechnics

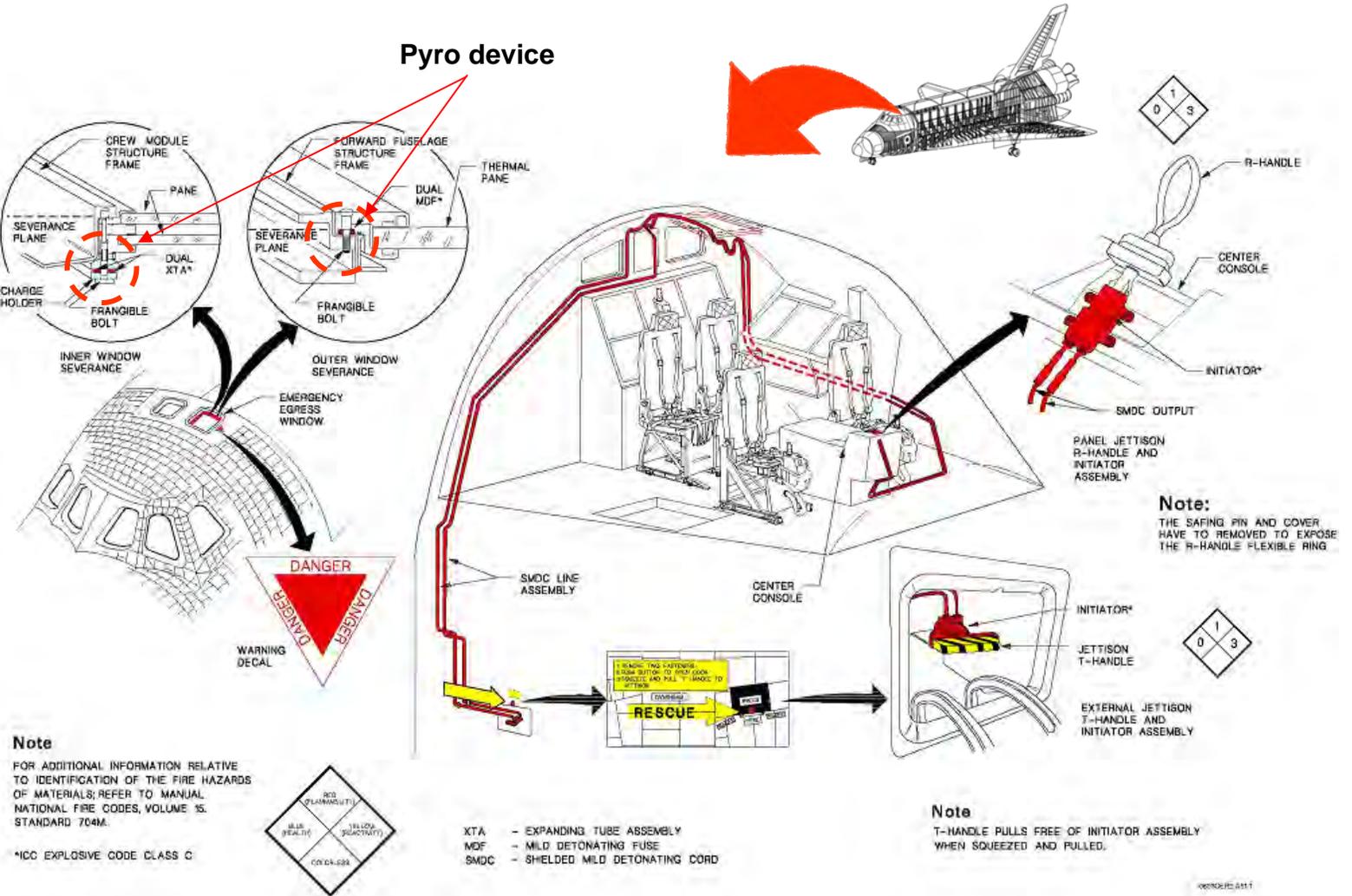
- Side hatch emergency escape system.



Side Hatch Escape System

Pyrotechnics (continued)

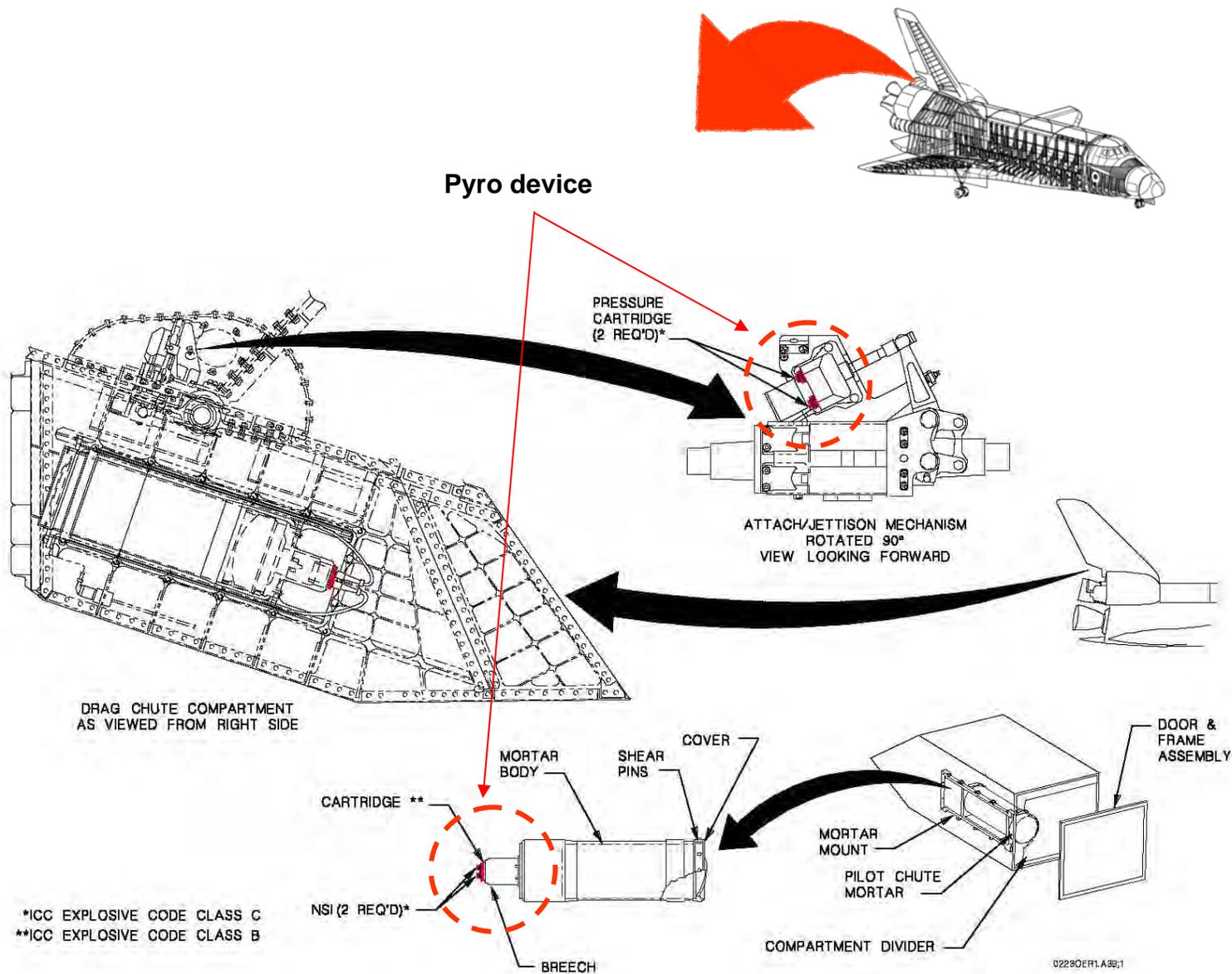
- Overhead window jettison system.



Overhead Window Escape System

Pyrotechnics (continued)

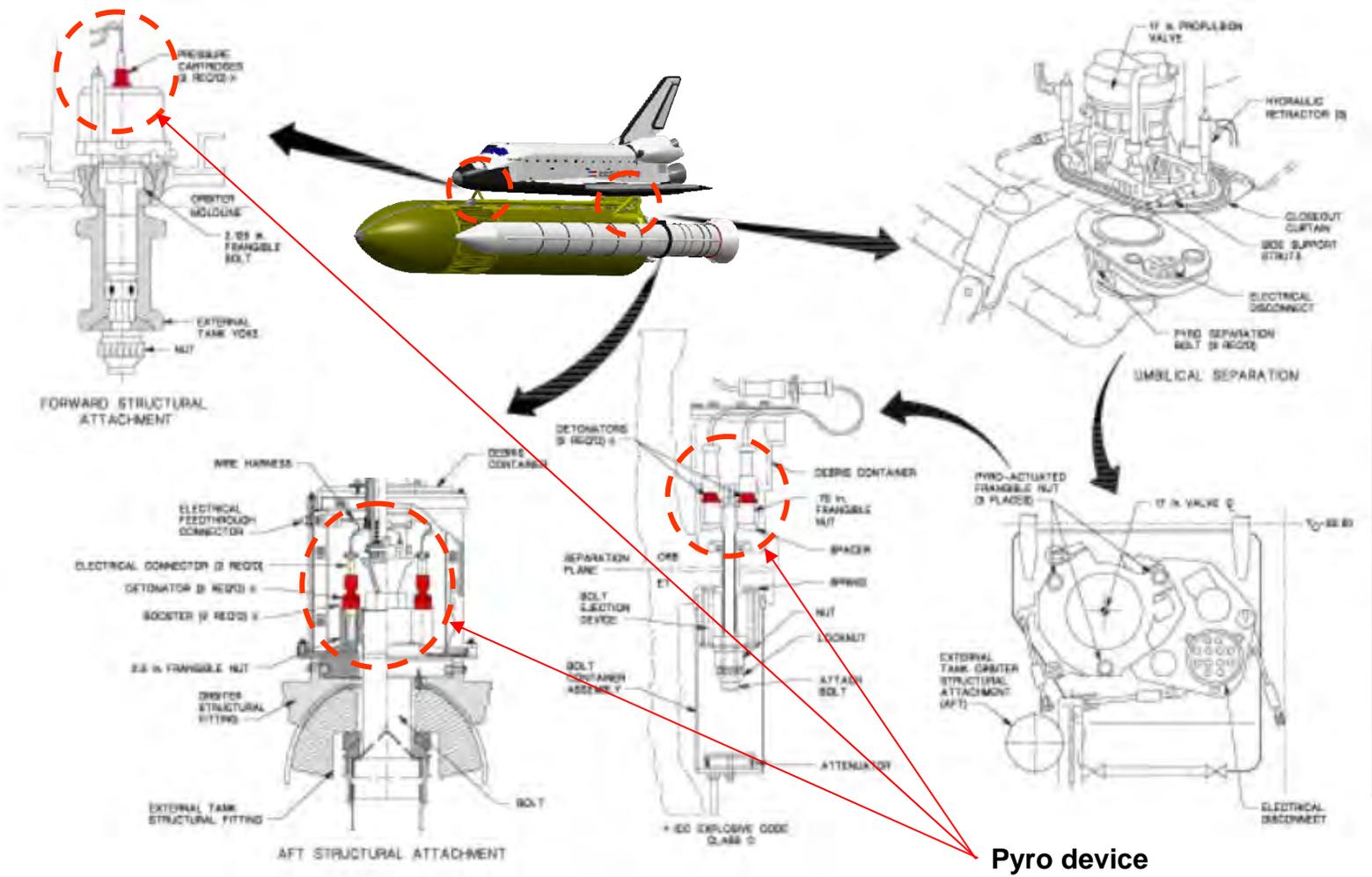
- Orbiter drag chute deployment pyrotechnic system. Archive.



Orbiter Drag Chute System Pyrotechnics

Pyrotechnics (continued)

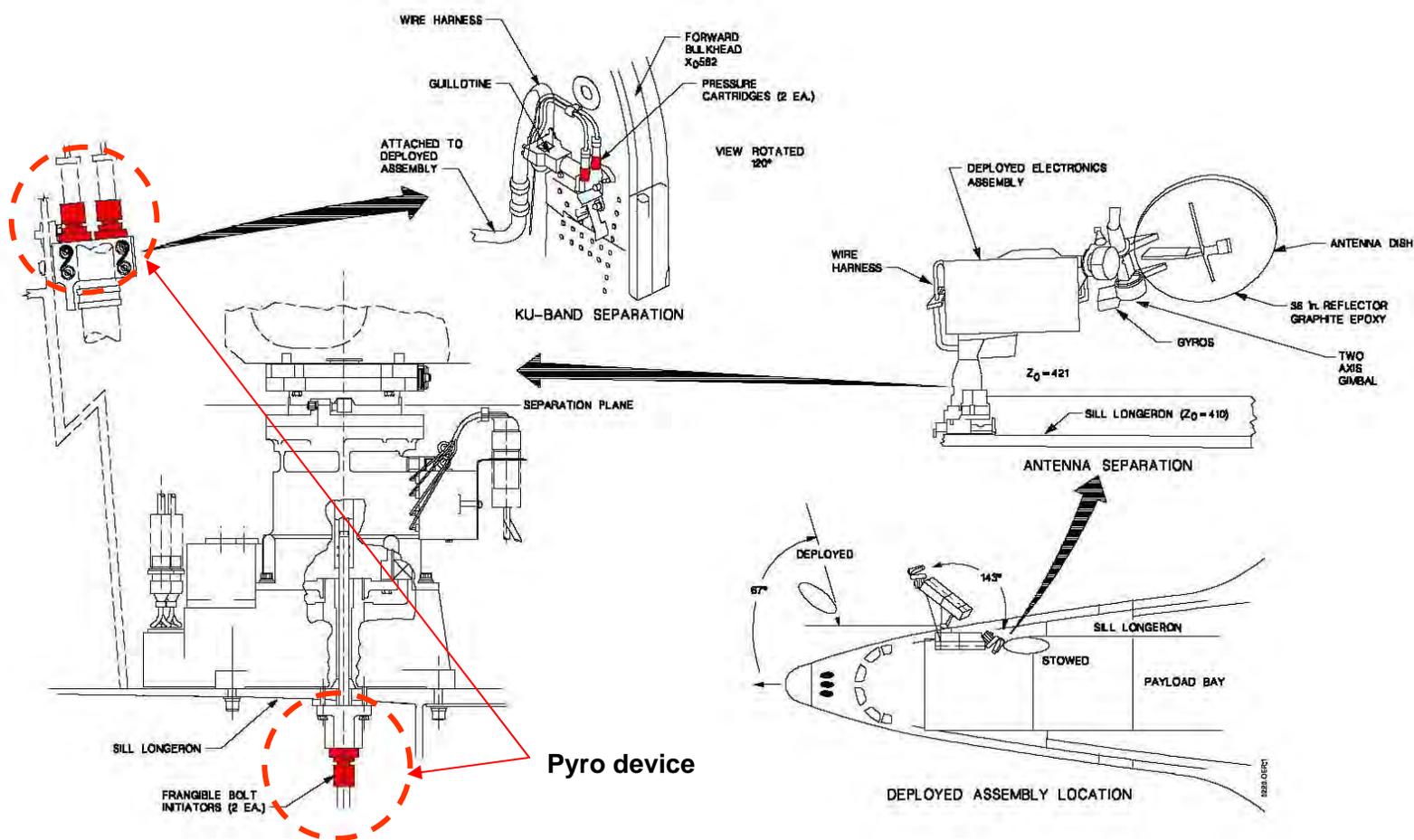
- Orbiter / External Tank (ET) separation pyrotechnic system.



Orbiter ET Separation System Pyrotechnics

Pyrotechnics (continued)

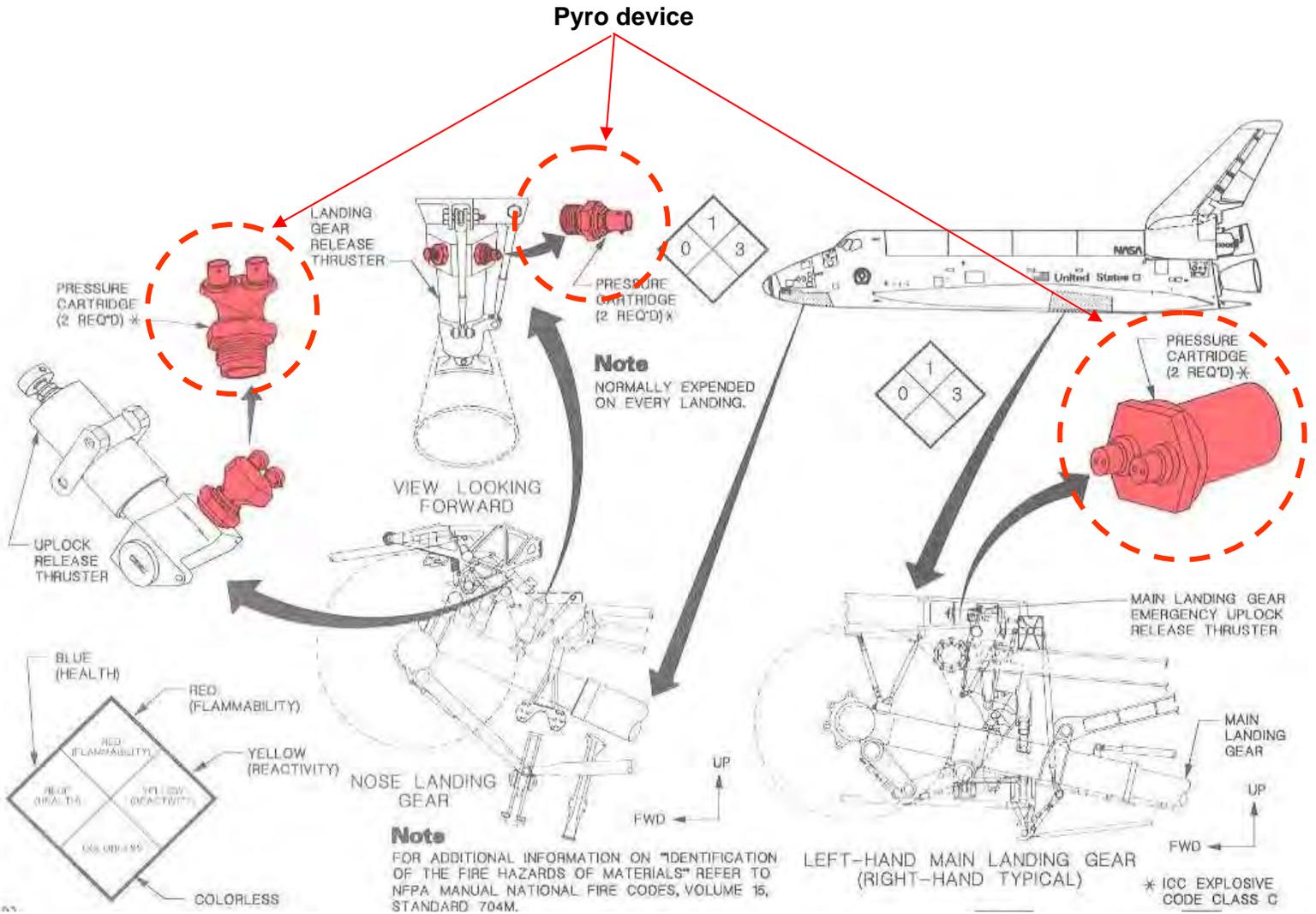
- Orbiter Ku-band antenna pyrotechnic release system.



Ku-band Antenna Release System Pyrotechnics

Pyrotechnics (continued)

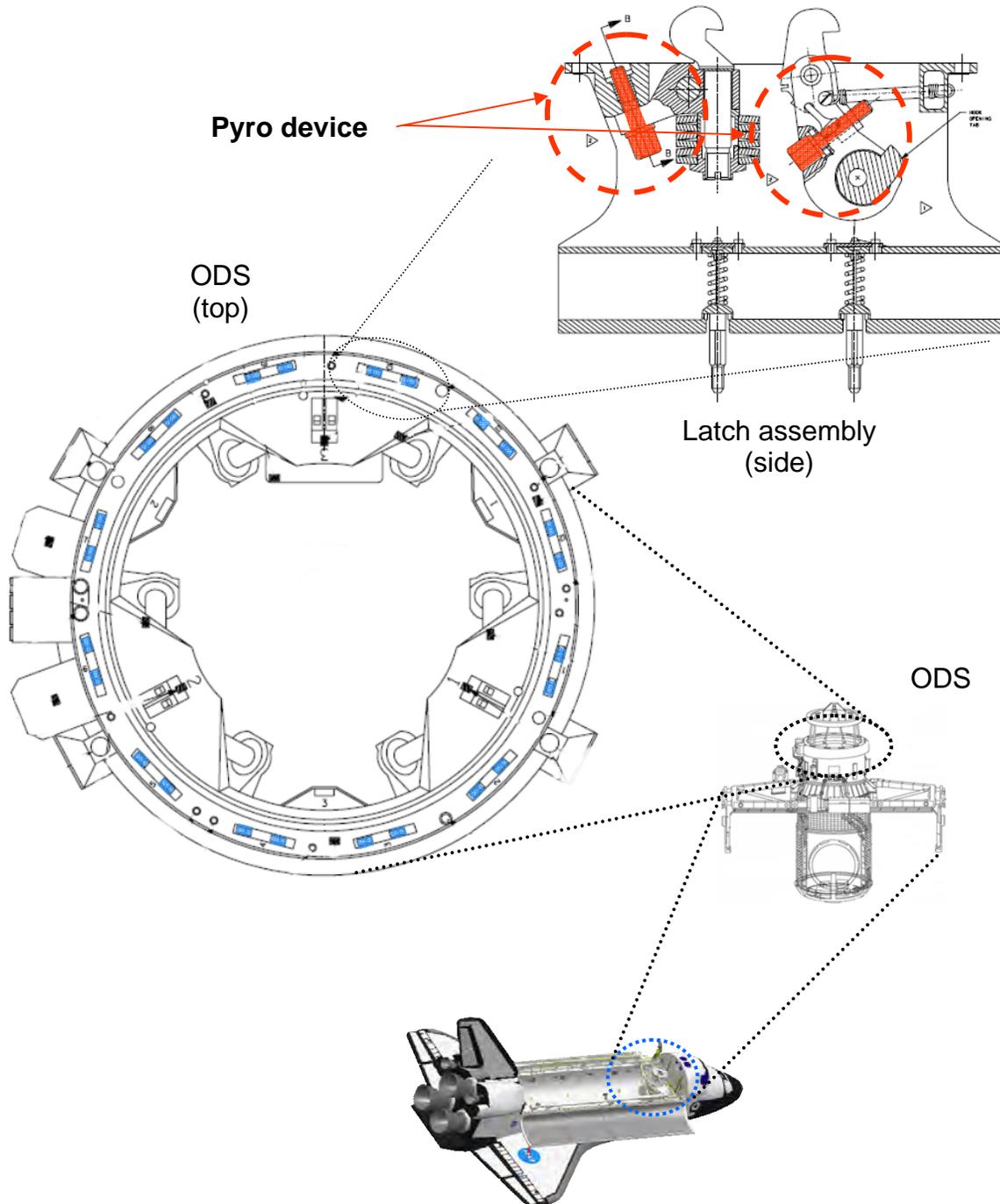
- Nose Landing Gear (NLG) and Main Landing Gear (MLG) pyrotechnic release system.



Landing Gear Release System Pyrotechnics

Pyrotechnics (continued)

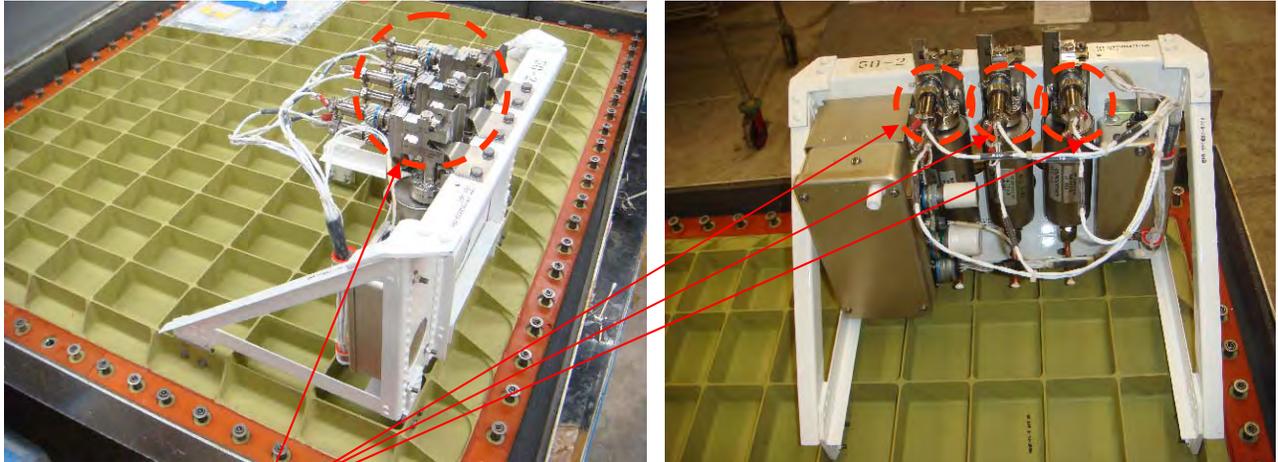
- Orbiter Docking System (ODS) pyrotechnic system. Each latch has one pyro bolt. (24 latches and 24 pyro bolts total).



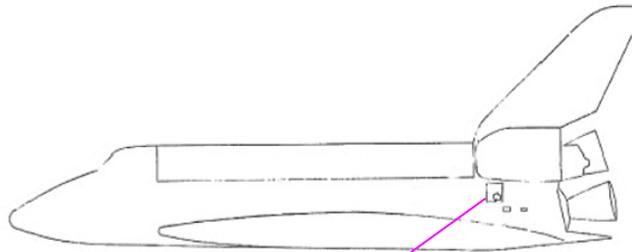
ODS Pyrotechnics

Pyrotechnics (continued)

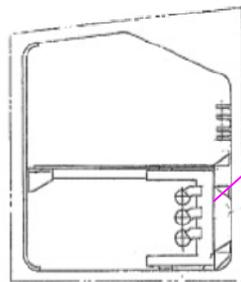
- Orbiter Gas Sampler Pyrotechnic System (6 pressure cartridges per Door).



Pyro device



Gas Sampler



RH Door View
Looking Outboard



LH Door View
Looking Outboard

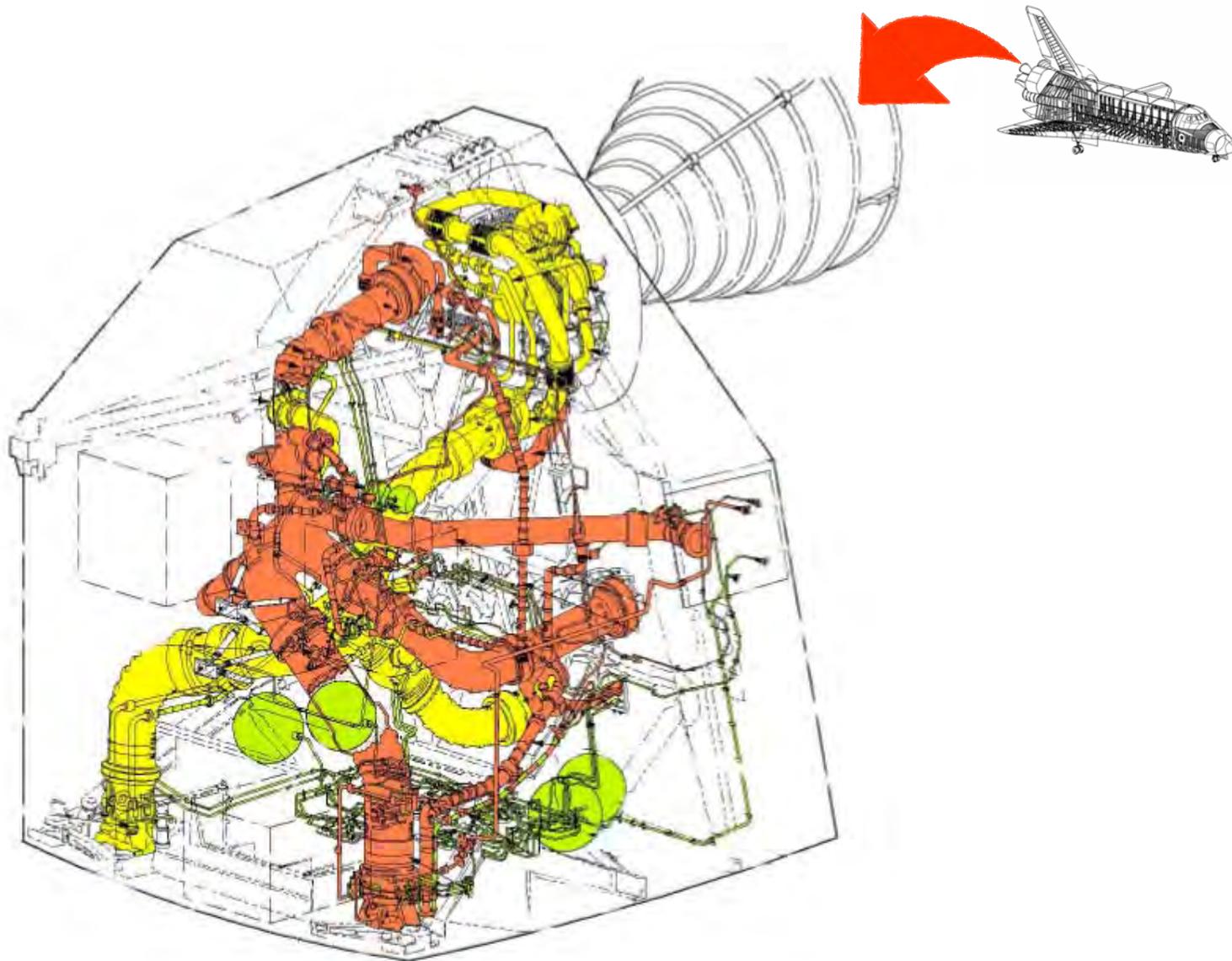
Aft Fuselage Gas Sampler System

4.5 Main Propulsion System (MPS) Cryogenics Liquid Hydrogen

Standard post-flight deservicing/safing. No post flight residuals.

4.6 Main Propulsion System (MPS) Cryogenics Liquid Oxygen

Standard post-flight deservicing/safing. No post flight residuals.



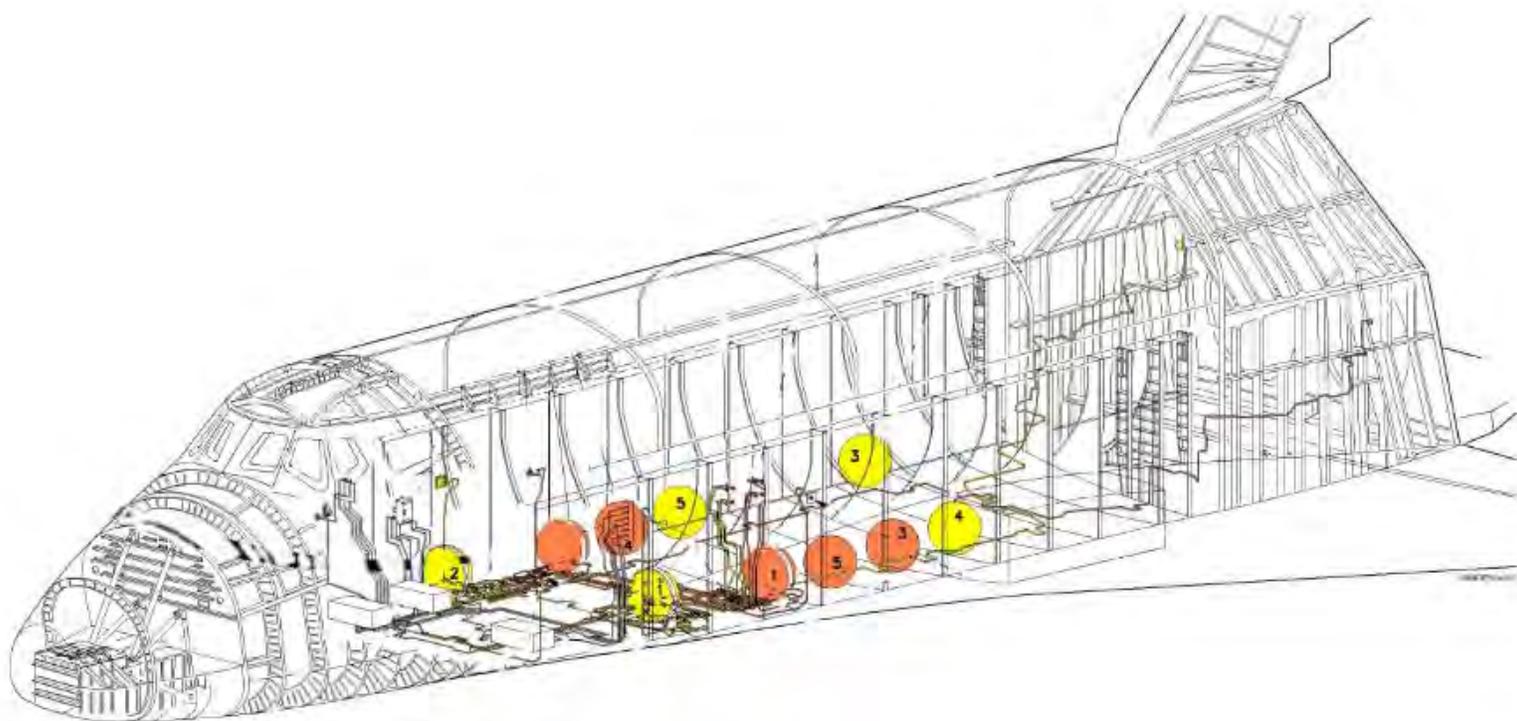
Legend	
LH ₂ – orange	
LO ₂ – yellow	
He - green	

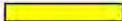
MPS System

4.7 PRSD Cryogenics

Standard post-flight deservicing/safing. No post flight residuals.

- LH₂.
- LO₂.



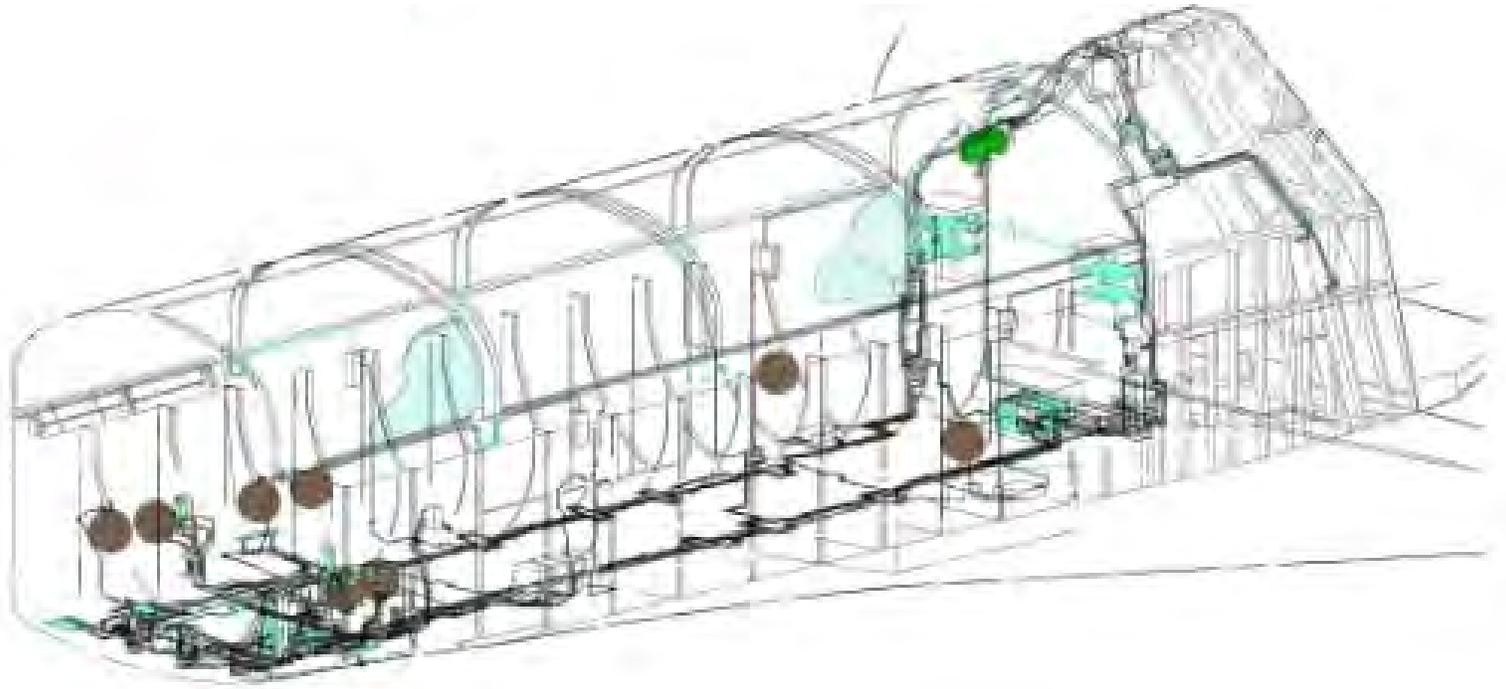
Legend	
LH ₂ - orange	
LO ₂ - yellow	

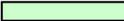
PRSD Tanks

4.8 Ammonia / Freon 21

Active Thermal Cooling System (ATCS).

- Coolant (NH₃ and Freon) and pressurization (GN₂).

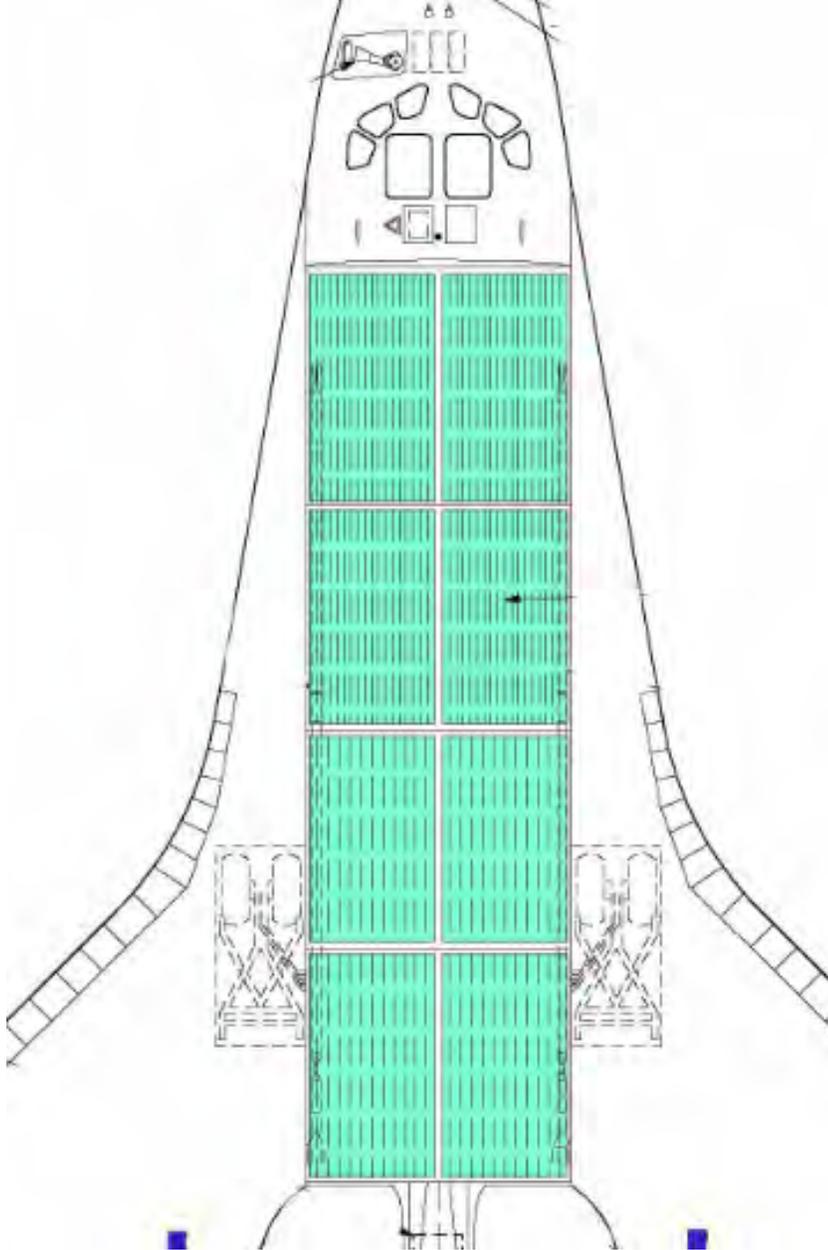


Legend	
NH ₃ – green	
N ₂ – brown	
Freon	

Freon Delivery System

Ammonia / Freon 21 (continued)

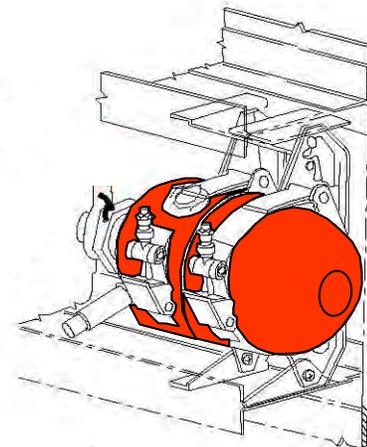
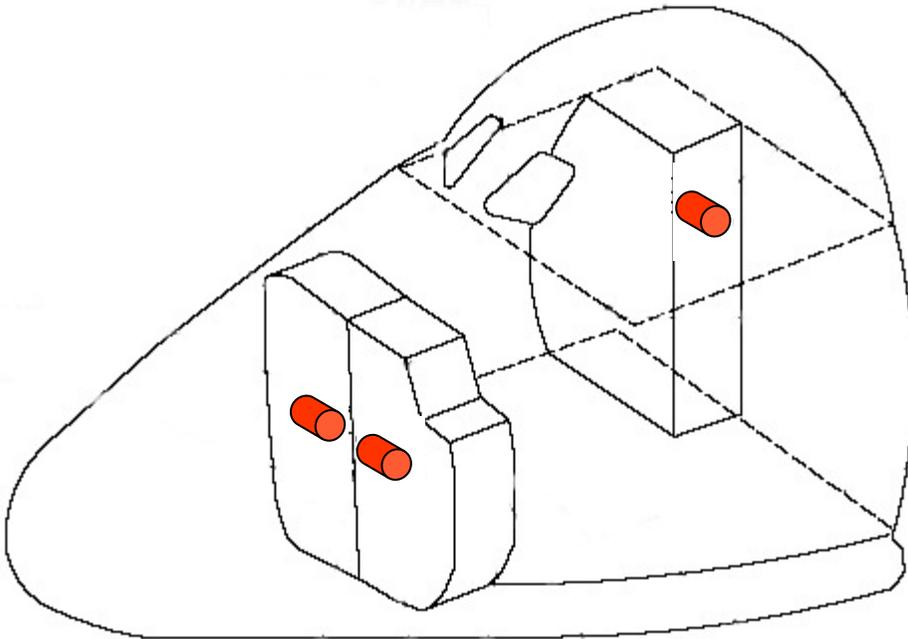
- Orbiter Radiator panels.



Radiator Panels

4.9 Halon

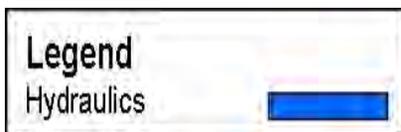
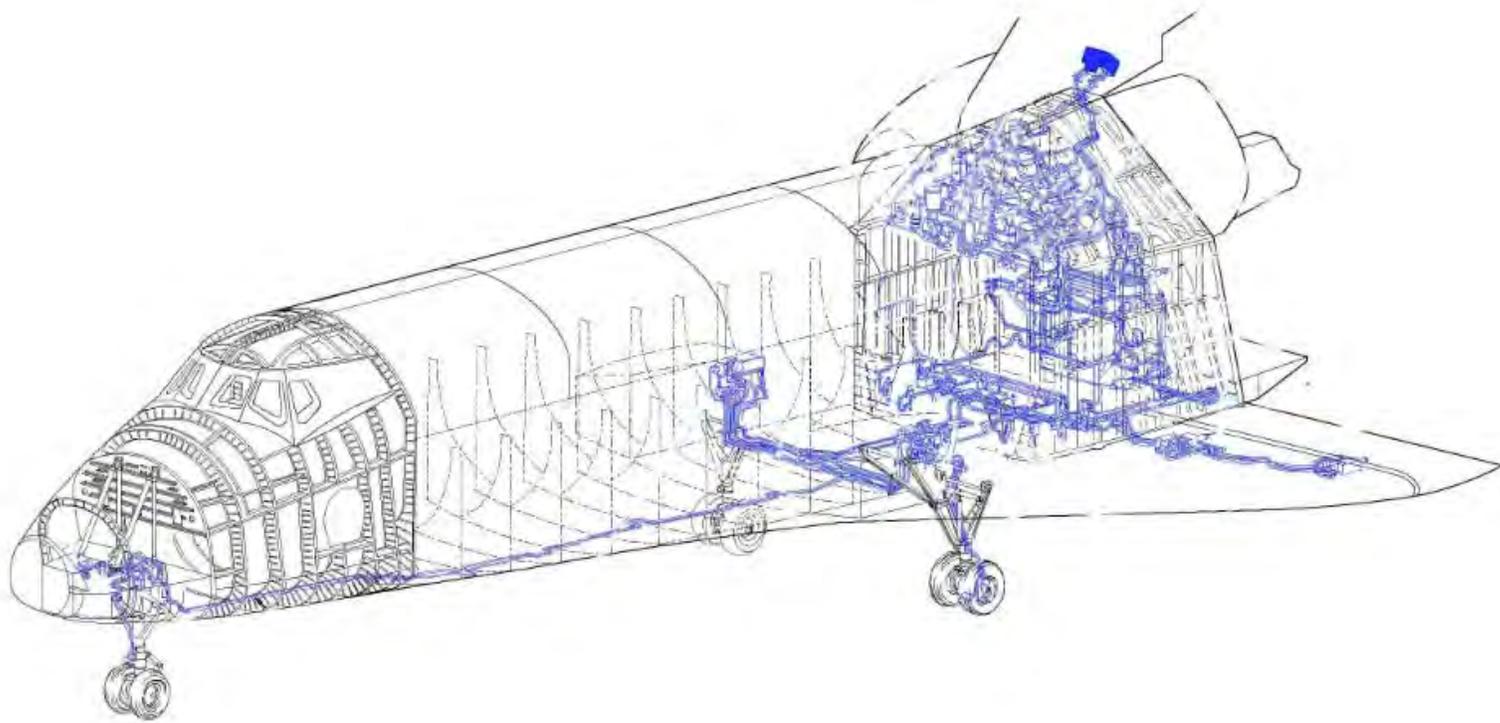
- Halon fire suppression in the crew cabin avionics bays.



Avionics Bays Fire Suppression System

4.10 Hydraulic fluid

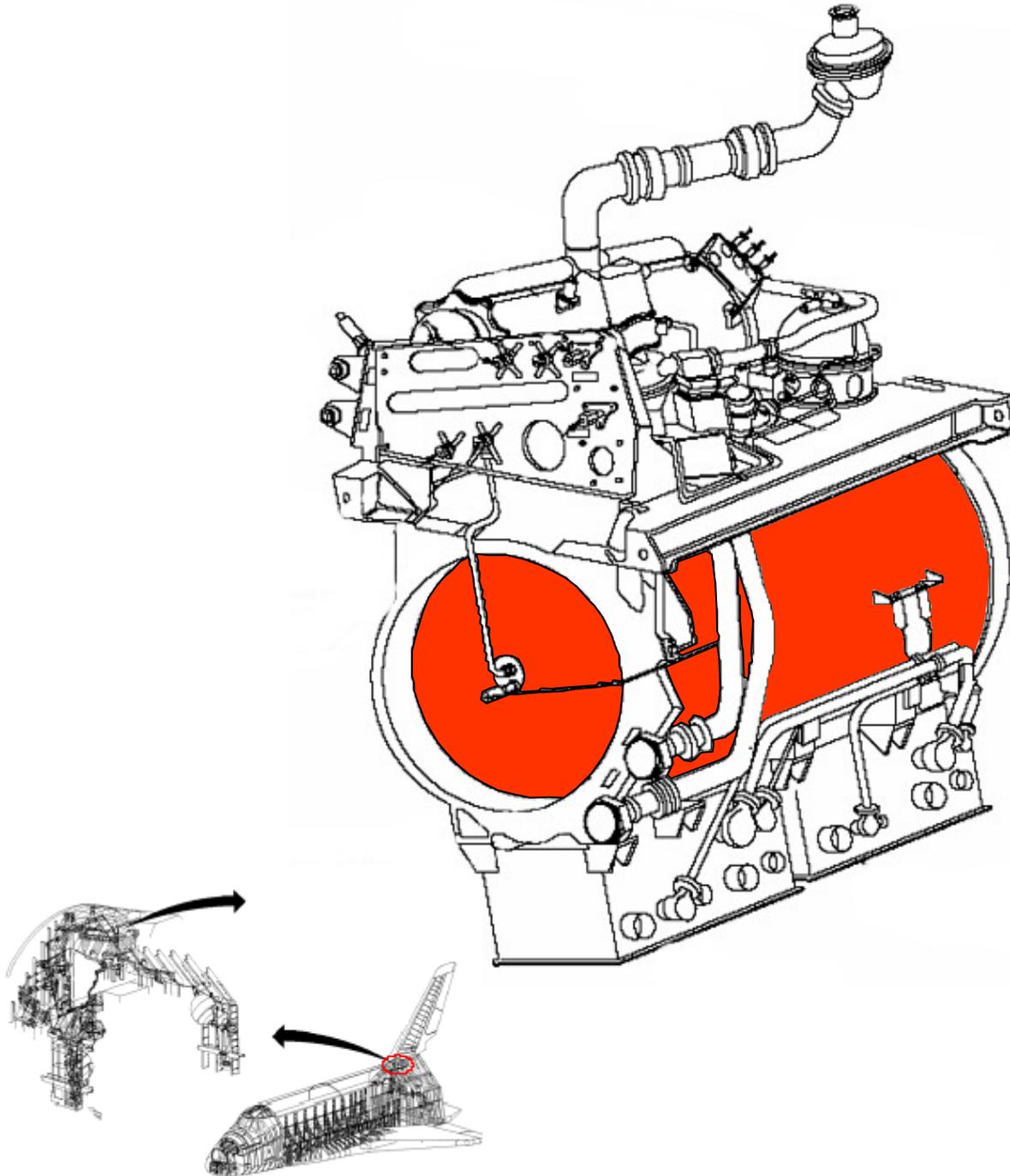
Possible 50 – 60 gallons residual. Hazardous considered fluid / condition may exist due to possible leakage on display site floor – this condition is acceptable with in-place containment processes.



Hydraulic System

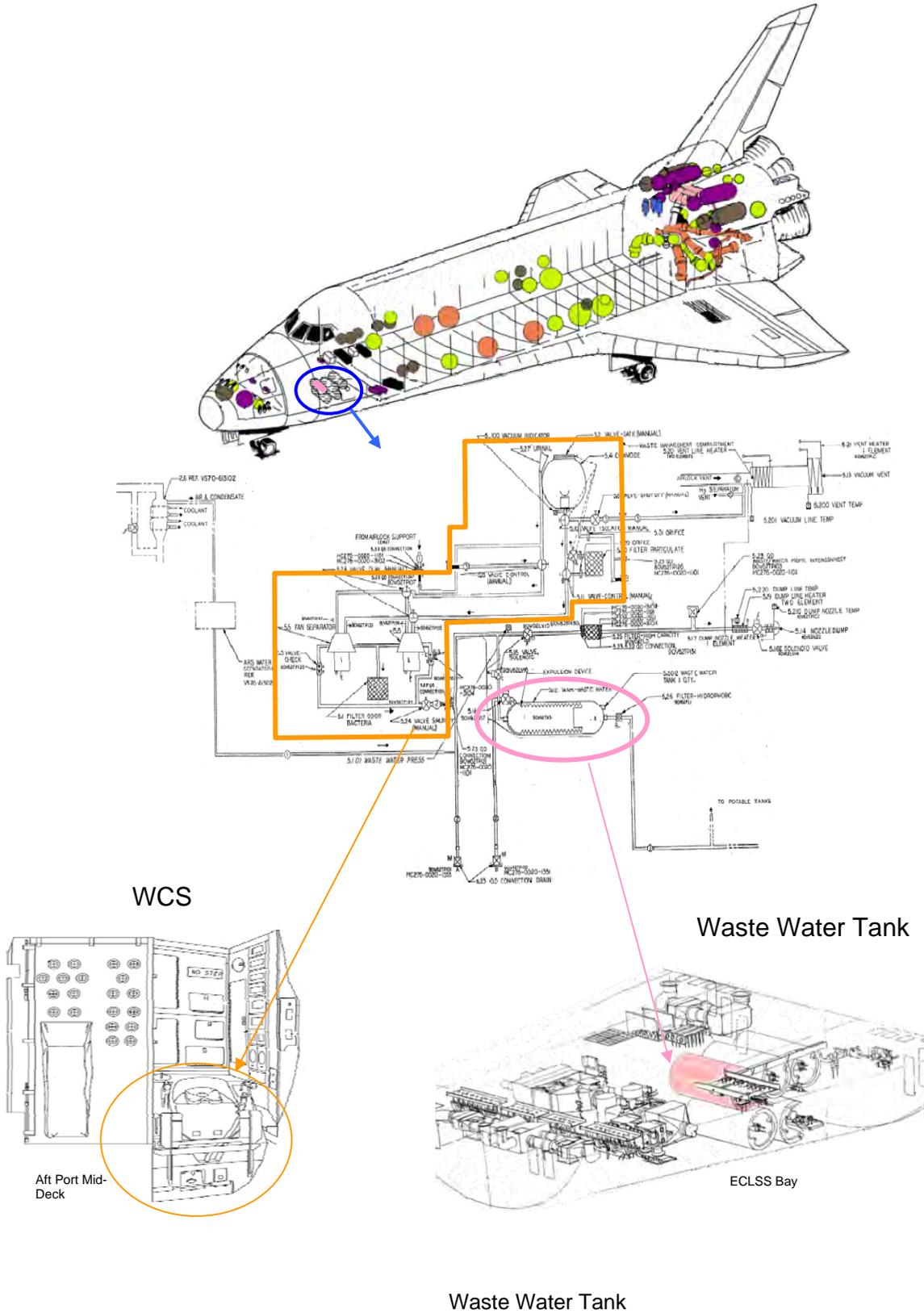
4.11 PGME

- Water Spray Boiler (WSB) / PGME coolant tank.



Water Spray Boiler

4.12 Waste Water



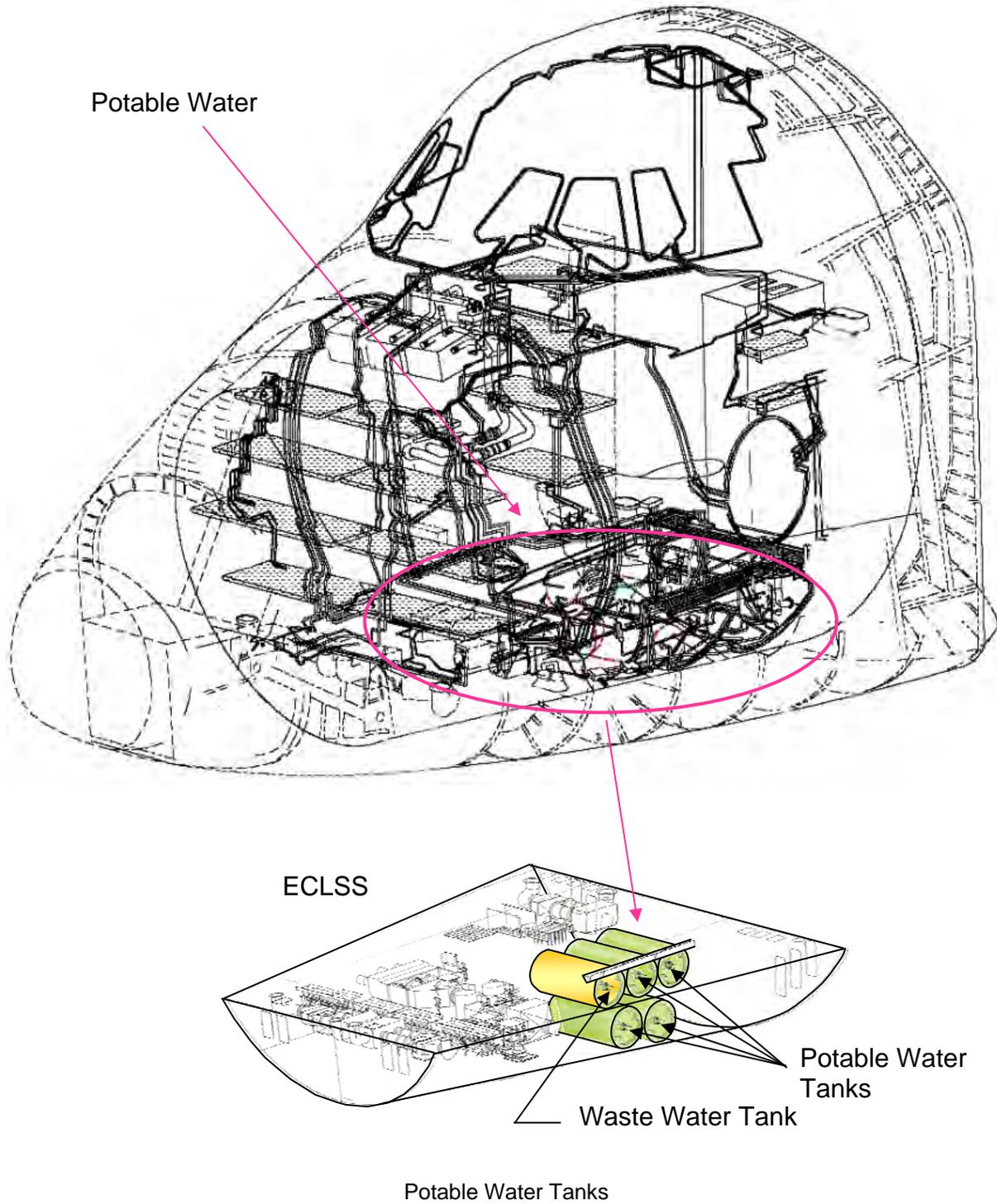
Aft Port Mid-Deck

Waste Water Tank

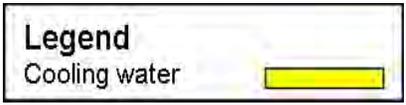
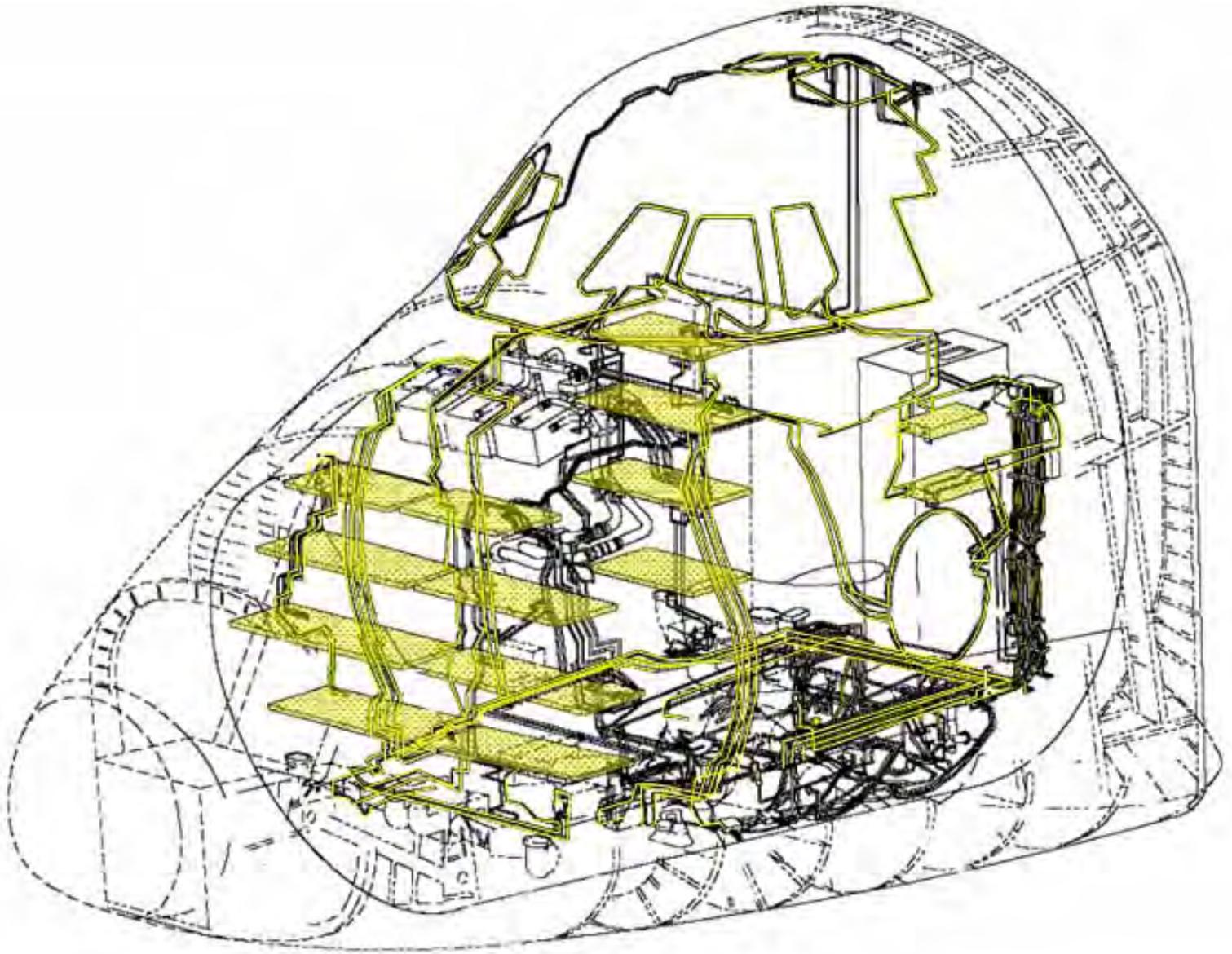
ECLSS Bay

Waste Water Tank

4.13 Potable Water

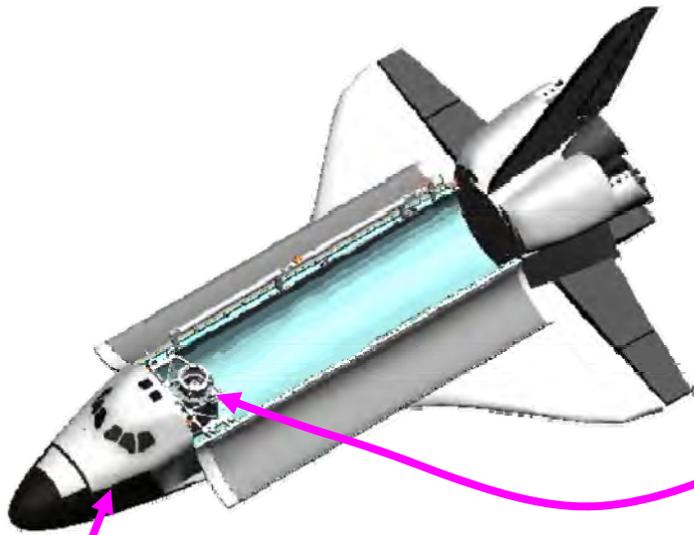


4.14 Avionics Cooling Water



Avionics Cooling Water Loop

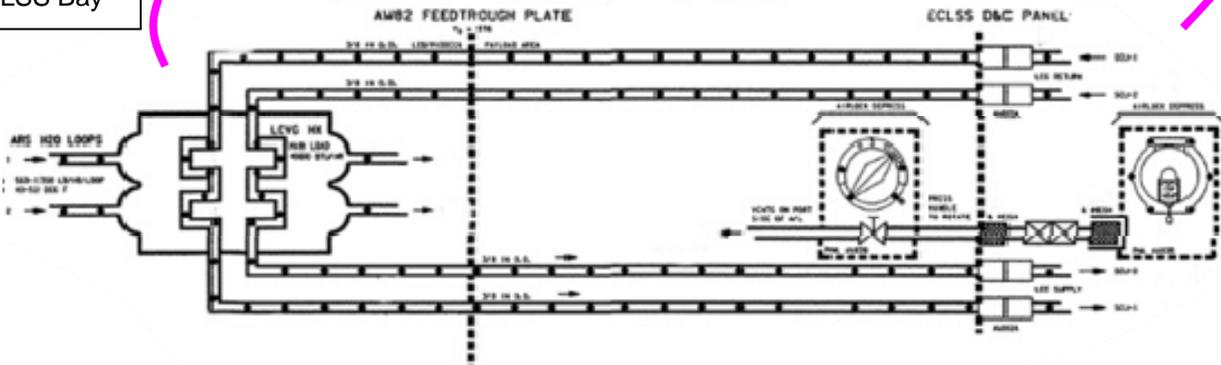
4.15 LCG Water



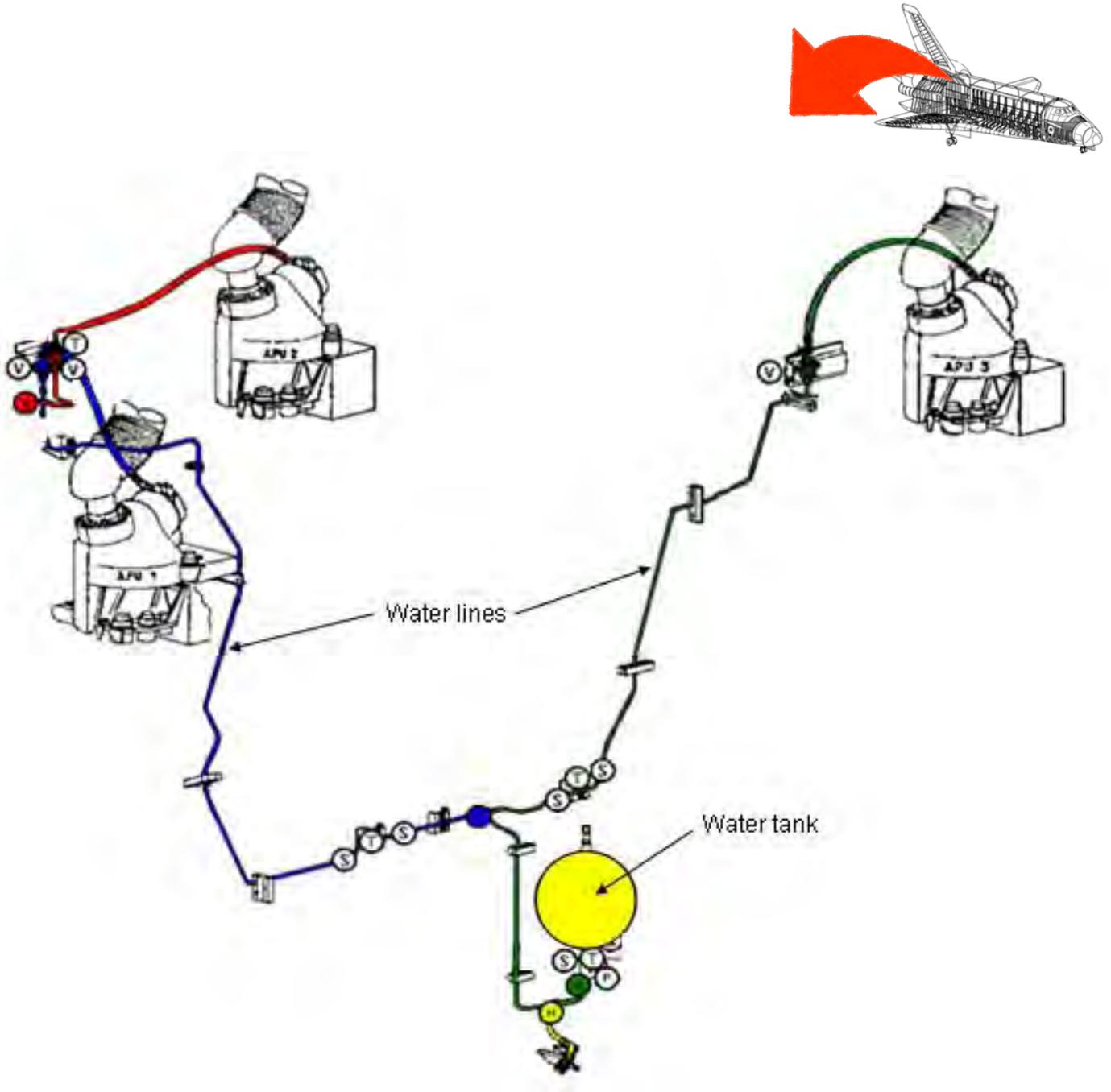
Airlock Interior



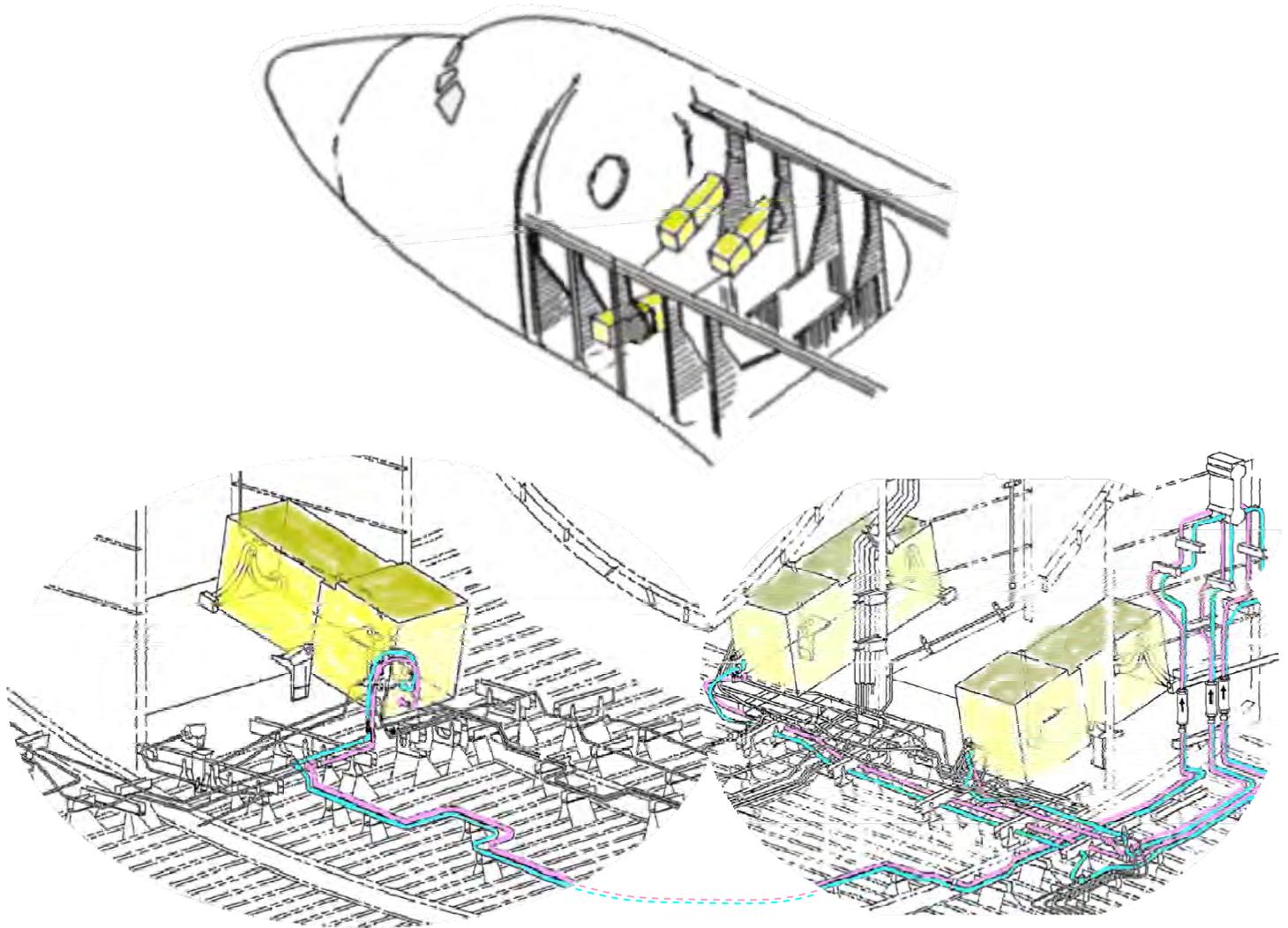
ECLSS Bay



4.16 APU Water & Gaseous Nitrogen (Injector Cooling System)



4.17 Fluorinert FC-40



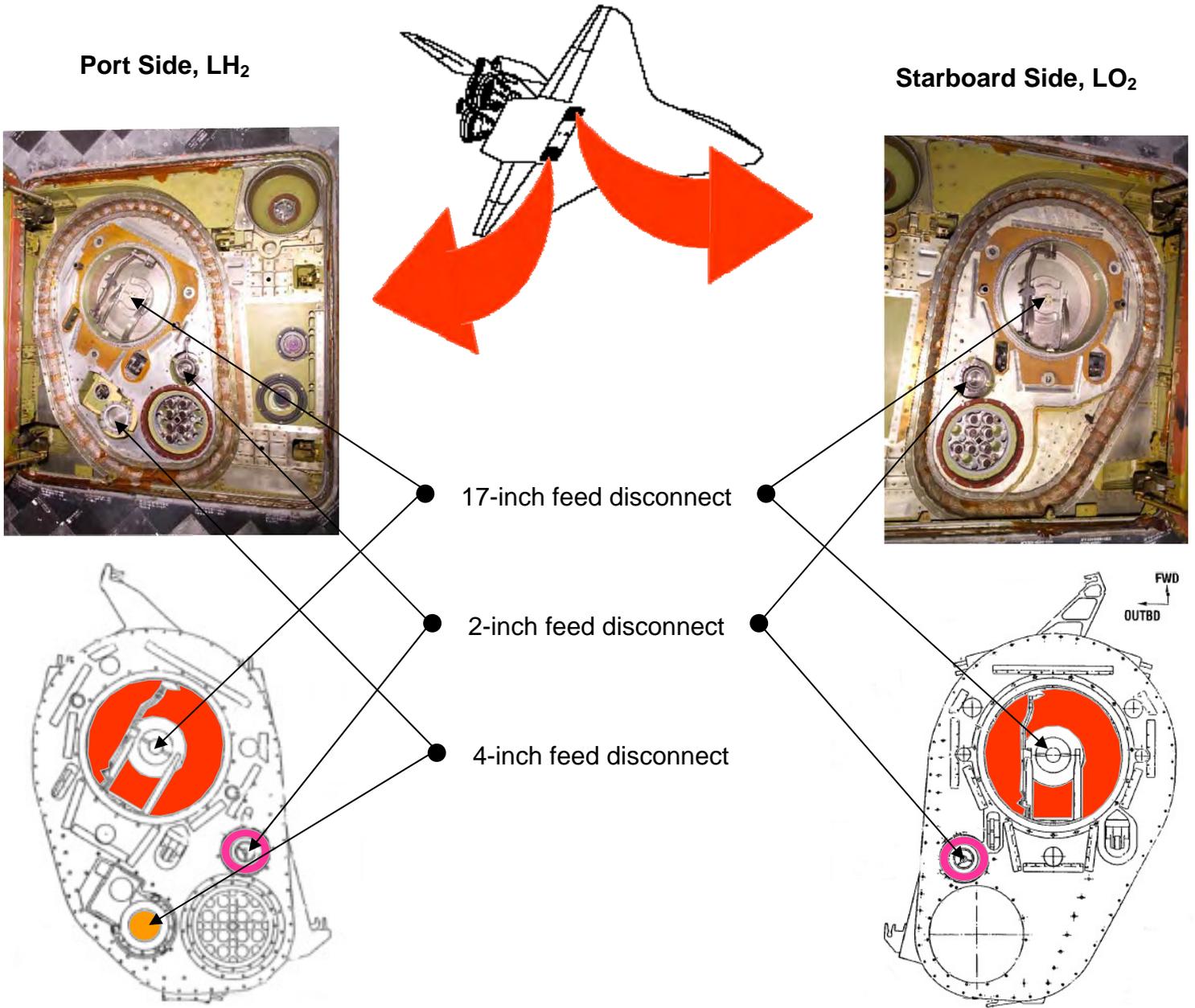
Legend	
Fuel cells	
Freon	
Freon	

FC-40

4.18 Stored Mechanical Energy

Standard post-flight safing.

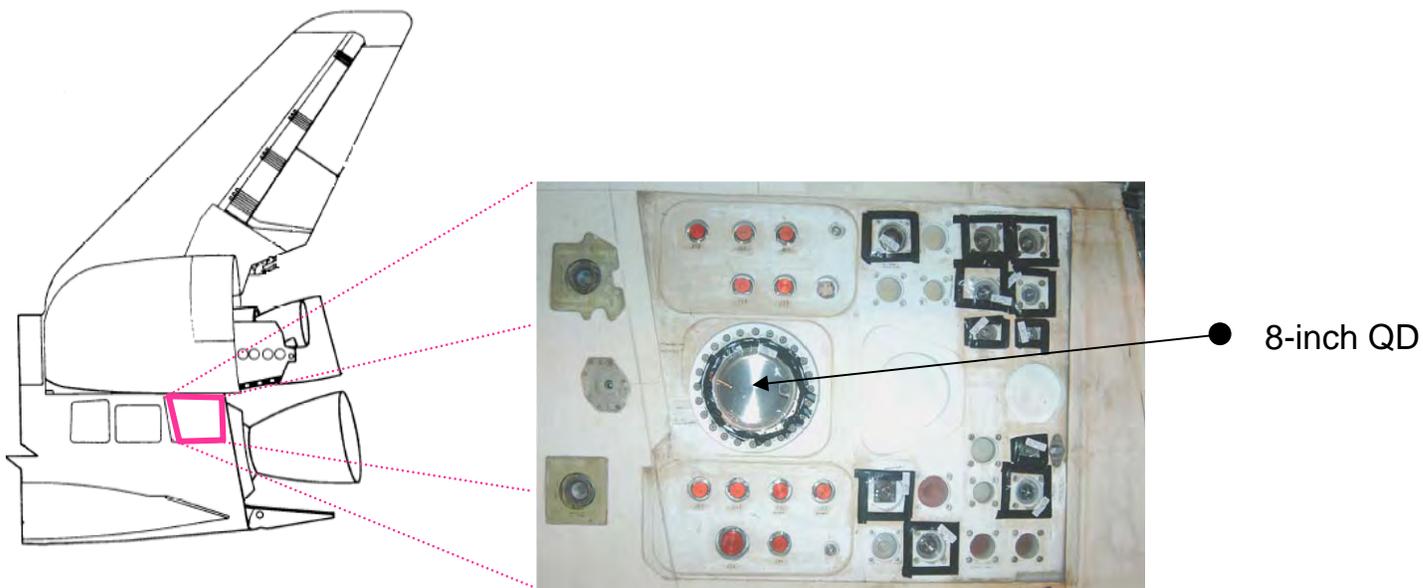
- ET/Orbiter 17-inch Disconnects.



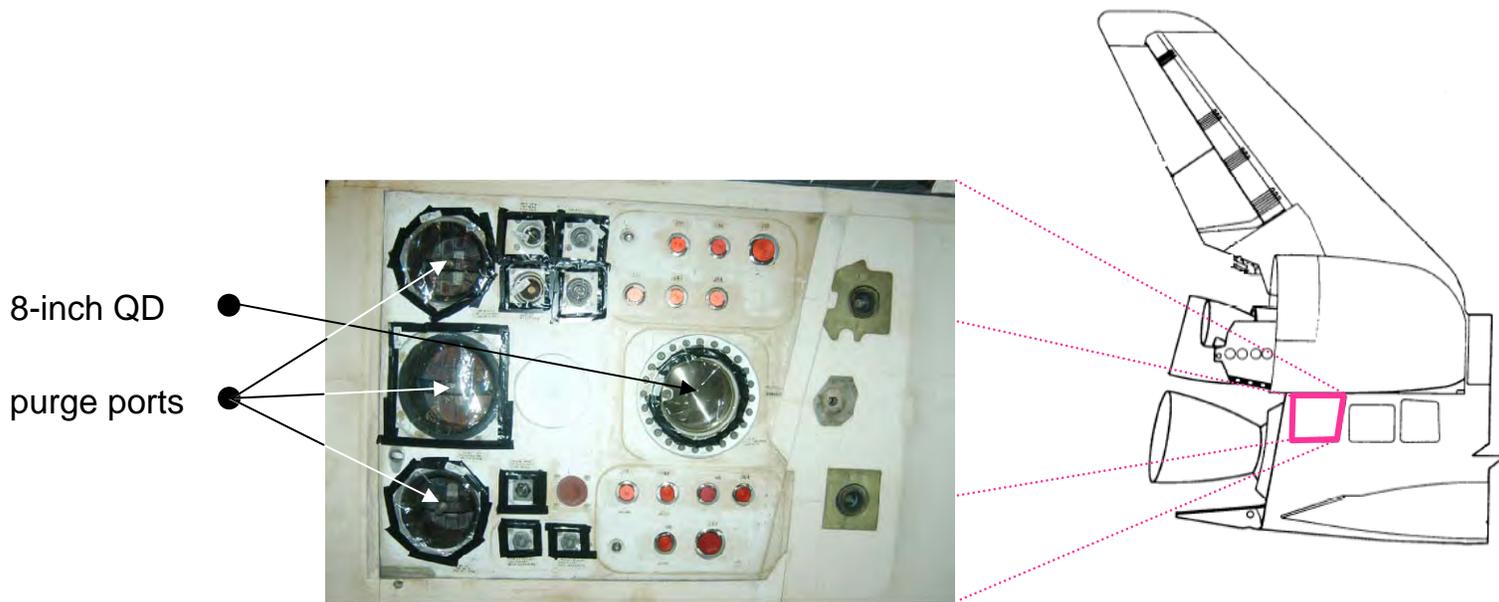
Orb/ET 17-inch QD

Stored Mechanical Energy (continued)

- T-0 Umbilical.



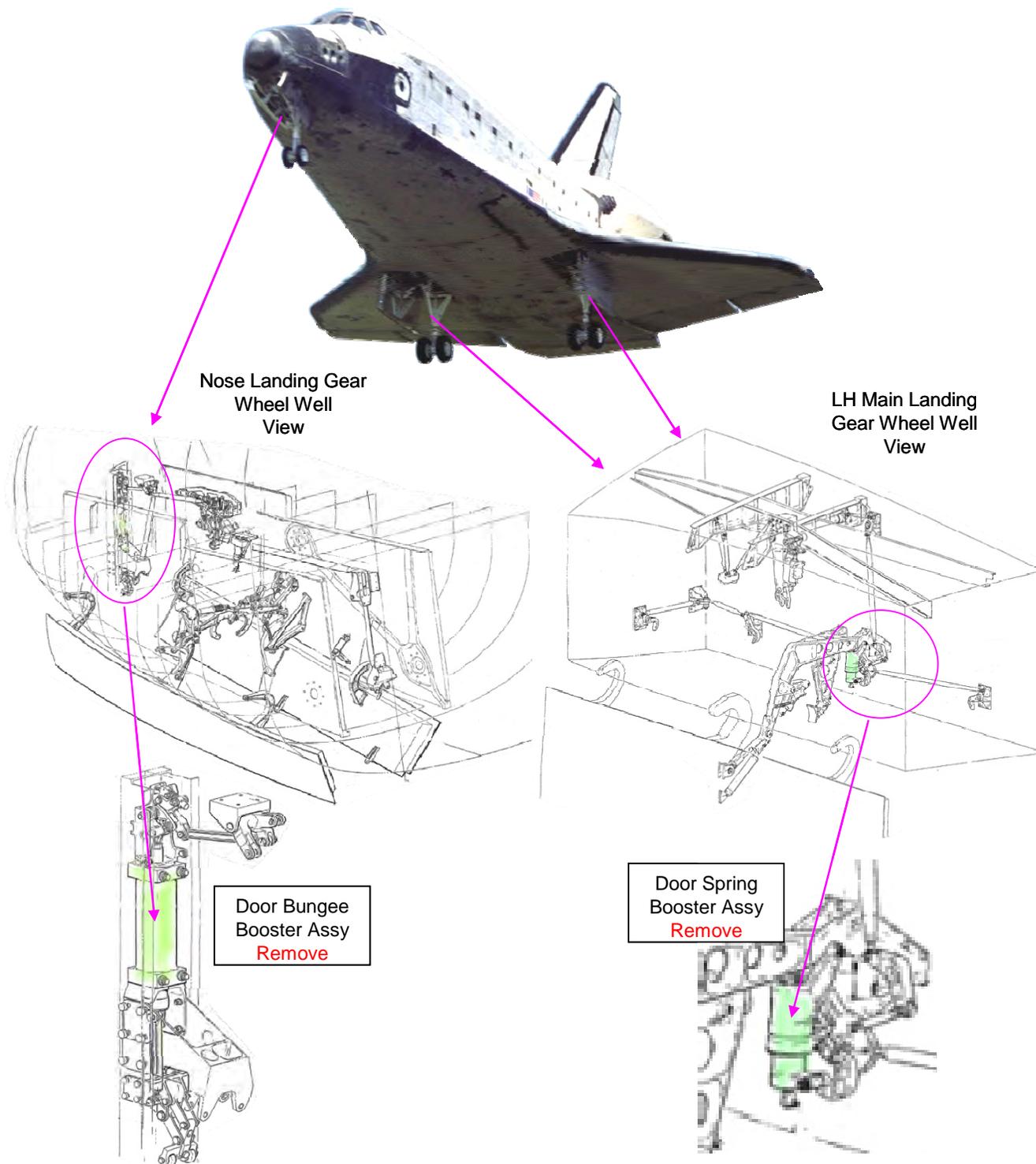
Port Side T-0 Umbilical



Starboard Side T-0 Umbilical

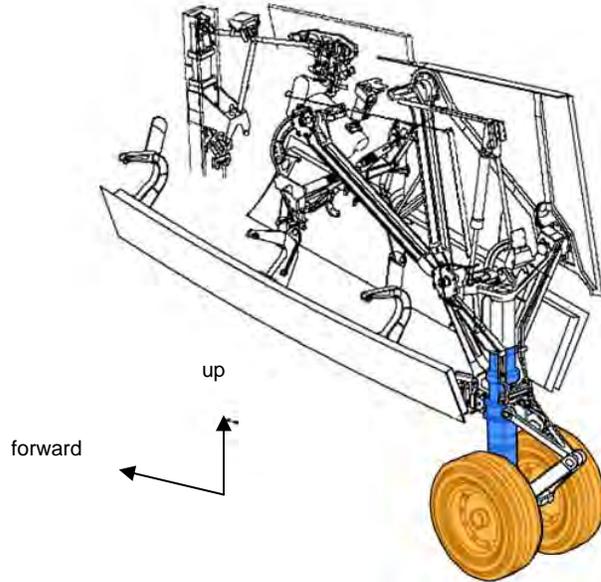
Stored Mechanical Energy (continued)

- Nose (NLG) and Main (MLG) landing gear door opening assist bungee will be removed, door overcenter and gear downlock bungees will remain installed.

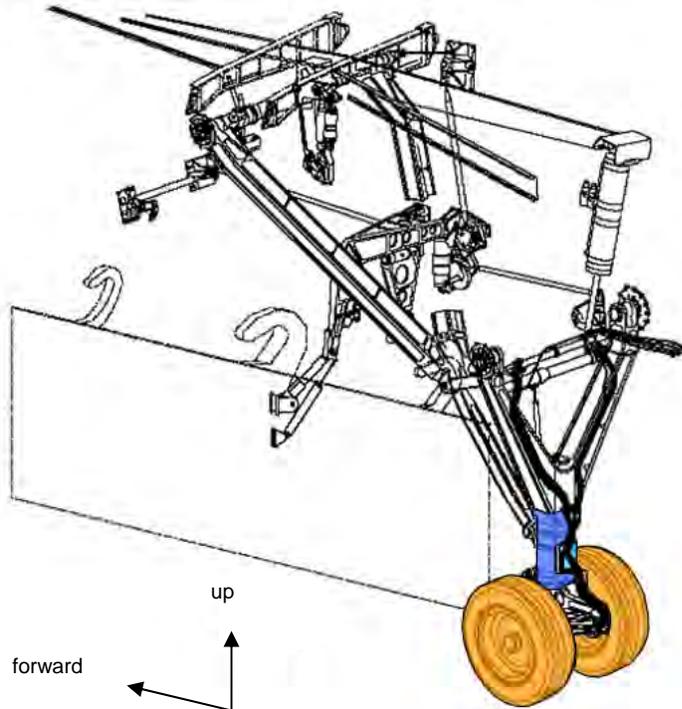


Stored Mechanical Energy (continued)

- Nose (NLG) and Main (MLG) landing gear tires and struts.

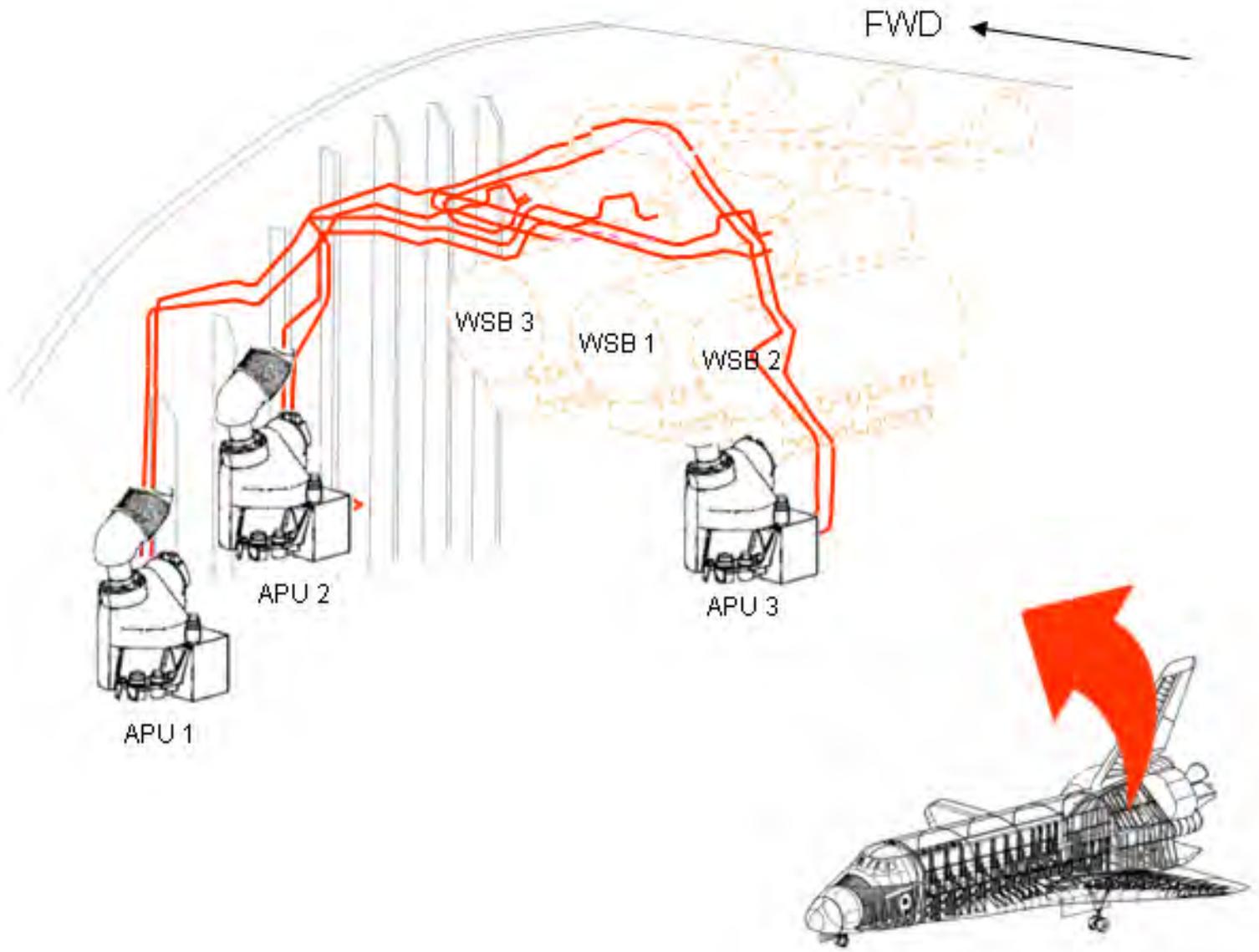


NLG Chassis Assembly



MLG Chassis Assembly

4.19 APU Lube Oil

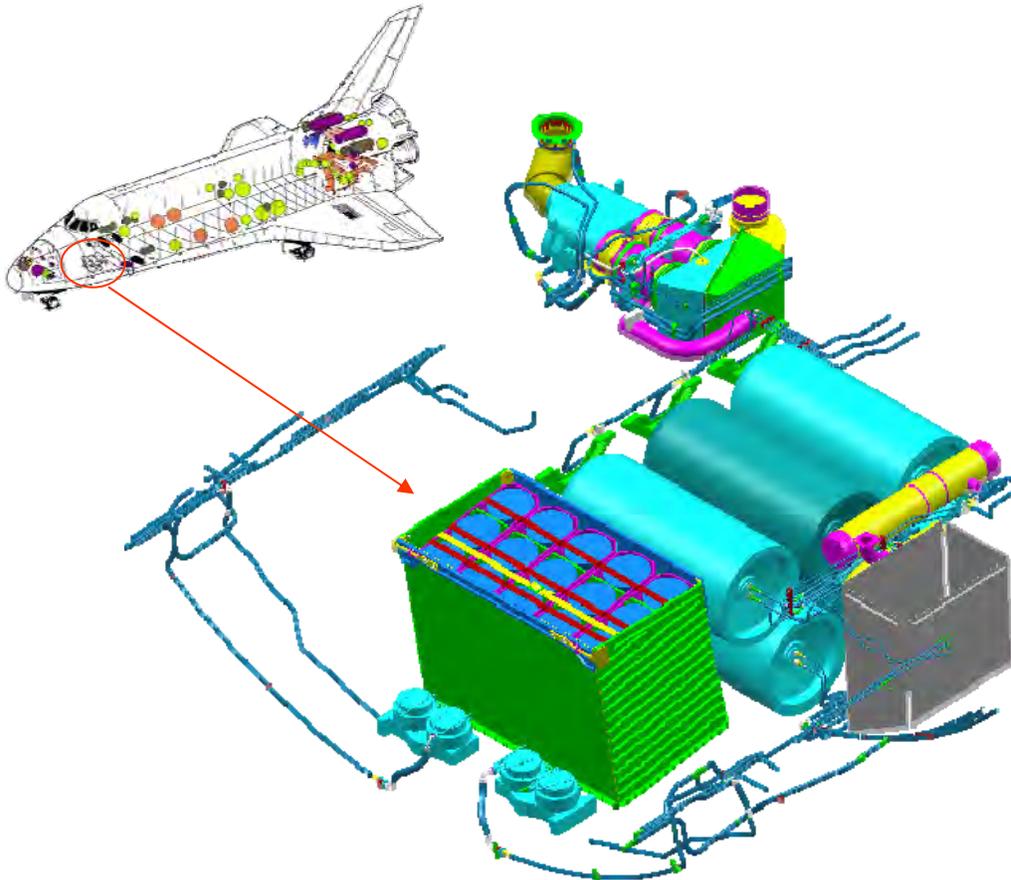


APU Lube Oil System

4.20 LiOH Canisters



LiOH canister

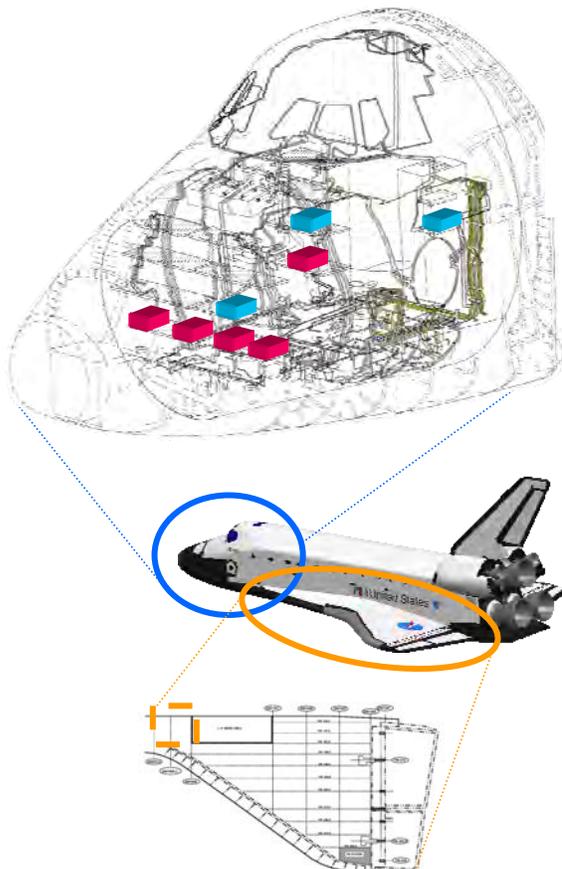


LiOH Canister Location

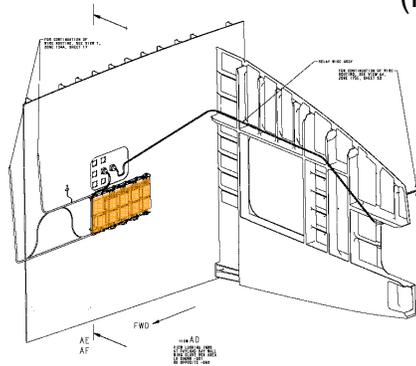
4.21 Batteries

General Purpose Computer (GPC), Global Positioning System (GPS) and Wing Leading Edge (WLE).

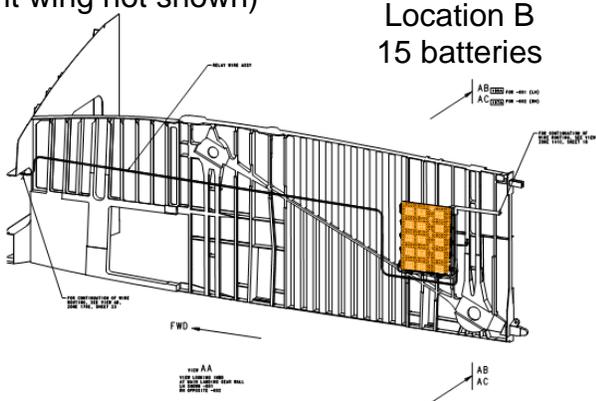
GPC (5) & GPS (3)



Location A
9 batteries



Left Wing WLE location (24)
(Right wing not shown)

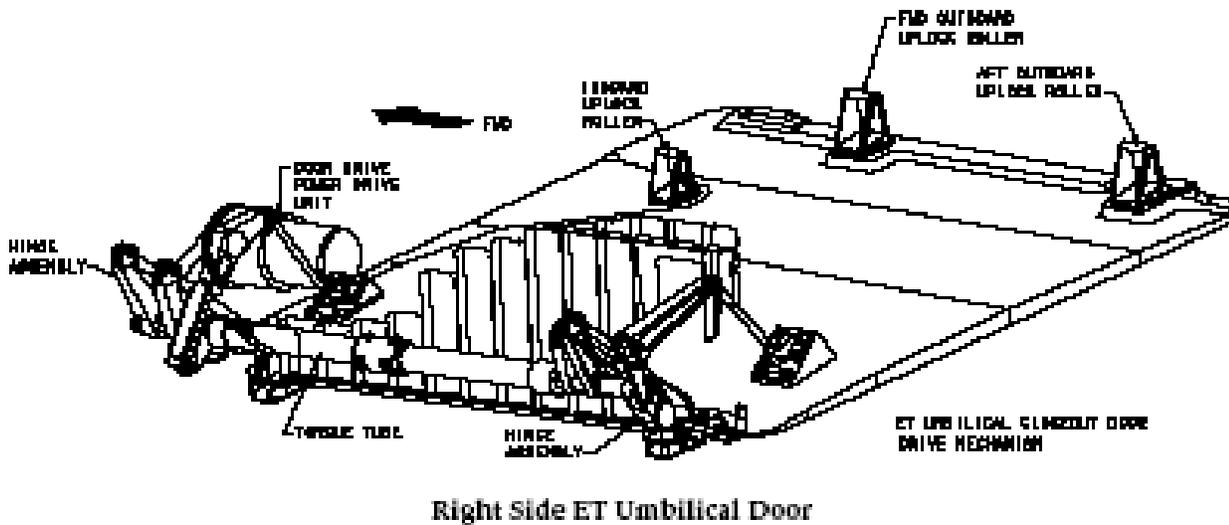
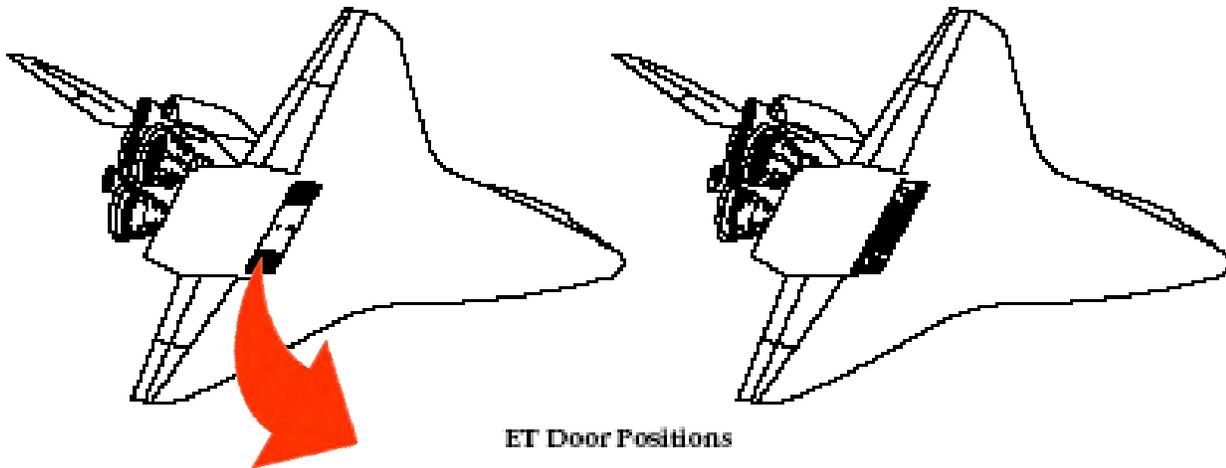


Location B
15 batteries

Battery Locations

4.22 Beryllium

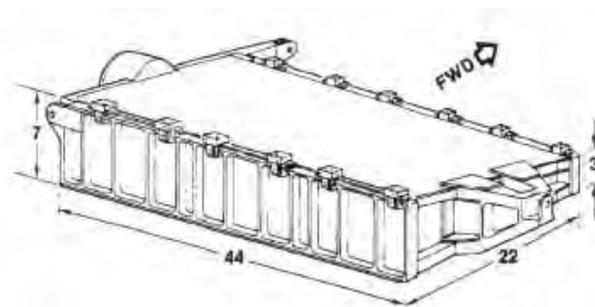
Remains installed on Orbiter. Hazardous condition exists only for breathing if any ET door structure disturbances (scratch, ding, nick, scuff or opening, break, crack, hole) occur. Display acceptable.



ET Doors

Beryllium (continued)

Remains installed on Orbiter. Two units are located just forward and to the left of the commander's plus X window, outside of the pressurized crew compartment. Hazardous condition exists only for breathing if any Star Tracker mounting tray structure disturbances (scratch, ding, nick, scuff or opening, break, crack, hole) occur. Display acceptable.



Star Tracker

4.23 Mercury

Mercury hermetically sealed in LCDs & CRTs.



Crew Compartment / MEDS

4.24 Radioactive Material

Potential RAM exists in components such as switches, circuit breakers, and meters due to unique circumstances.

- Gauges or Meters with radioluminescent indicator marks, dial pointers, or alphanumeric, where the Radium paint utilized is enclosed within a sealed glass housing.
- Components with radioluminescent parts or markings, such as switches and circuit breakers, where the Radium paint utilized is exposed to touch or flaking/peeling from handling activities.
- Special optical glass utilizing Thorium Dioxide to provide a glass with a high refractive index and low dispersion, such as for Head-Up Displays.
- Radioluminescent Signs, Markers, and Placards.

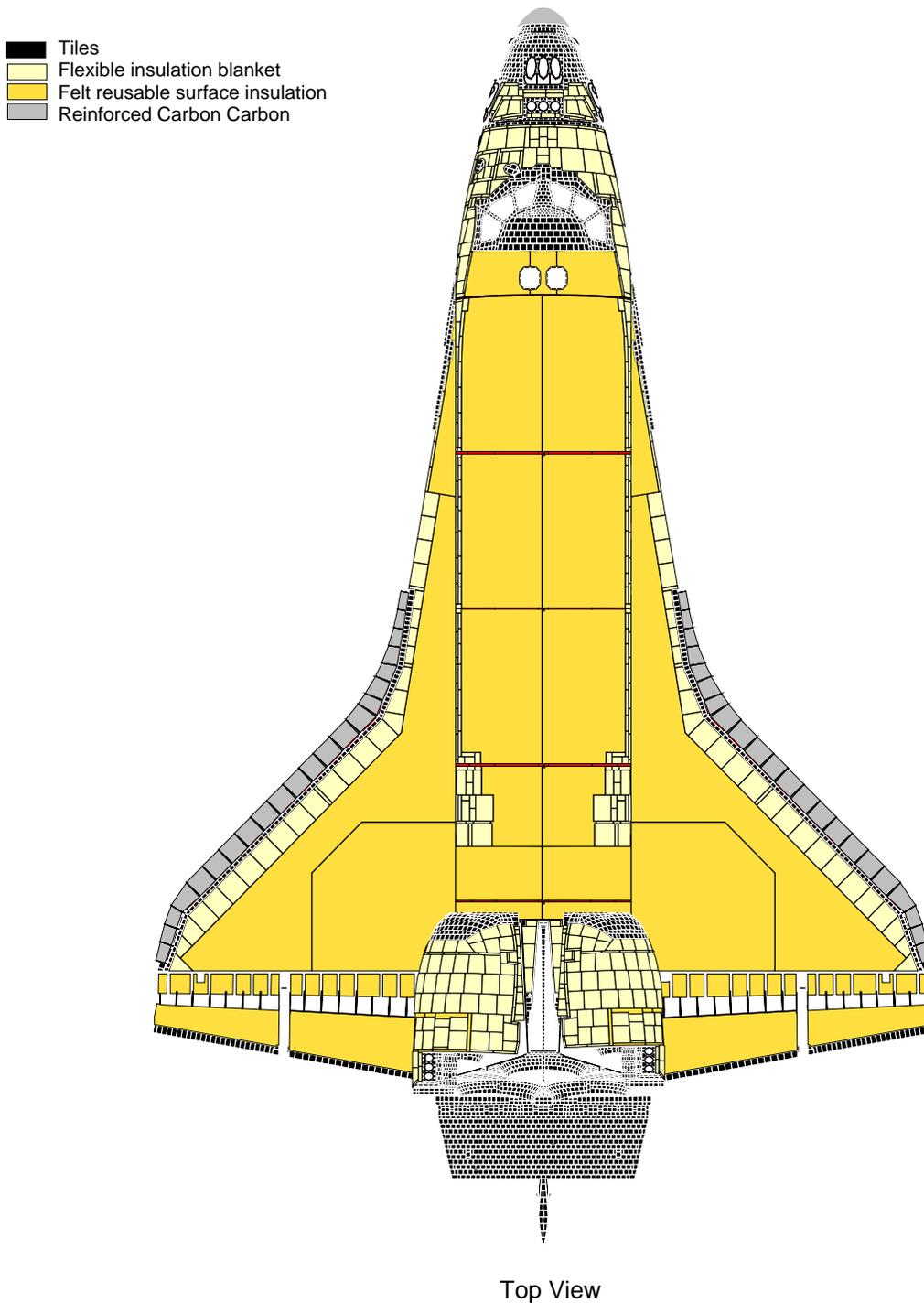
Planned tests to characterize sources and levels of radiation of acceptable levels



Crew Compartment / MEDS

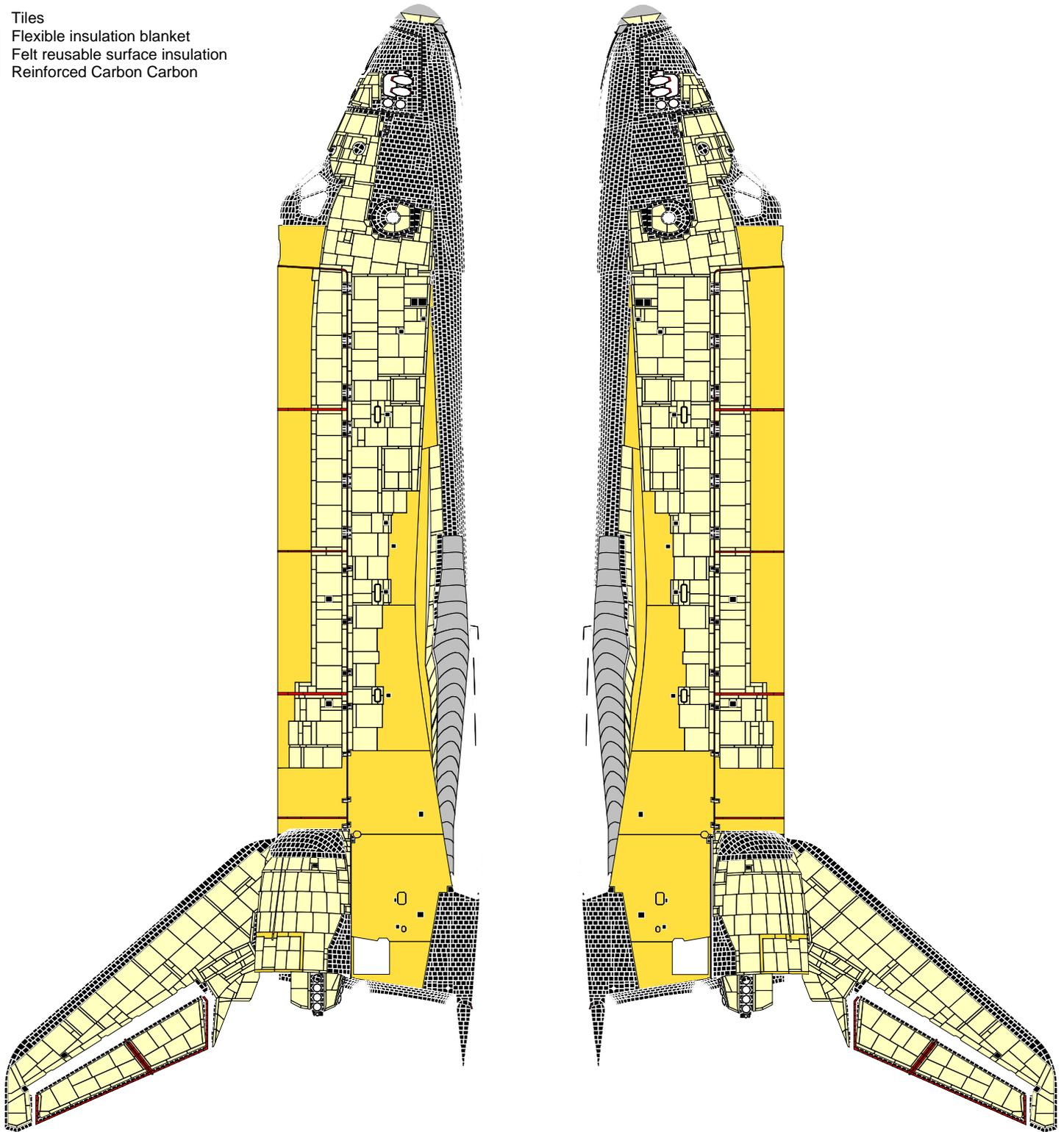
4.25 Thermal Protection System (TPS)

Remains installed on Orbiter. Hazardous condition only due to any TPS disturbances (scratches or openings - ceramic fiber (silica alumina glass) release). Display Acceptable.



Thermal Protection System (continued)

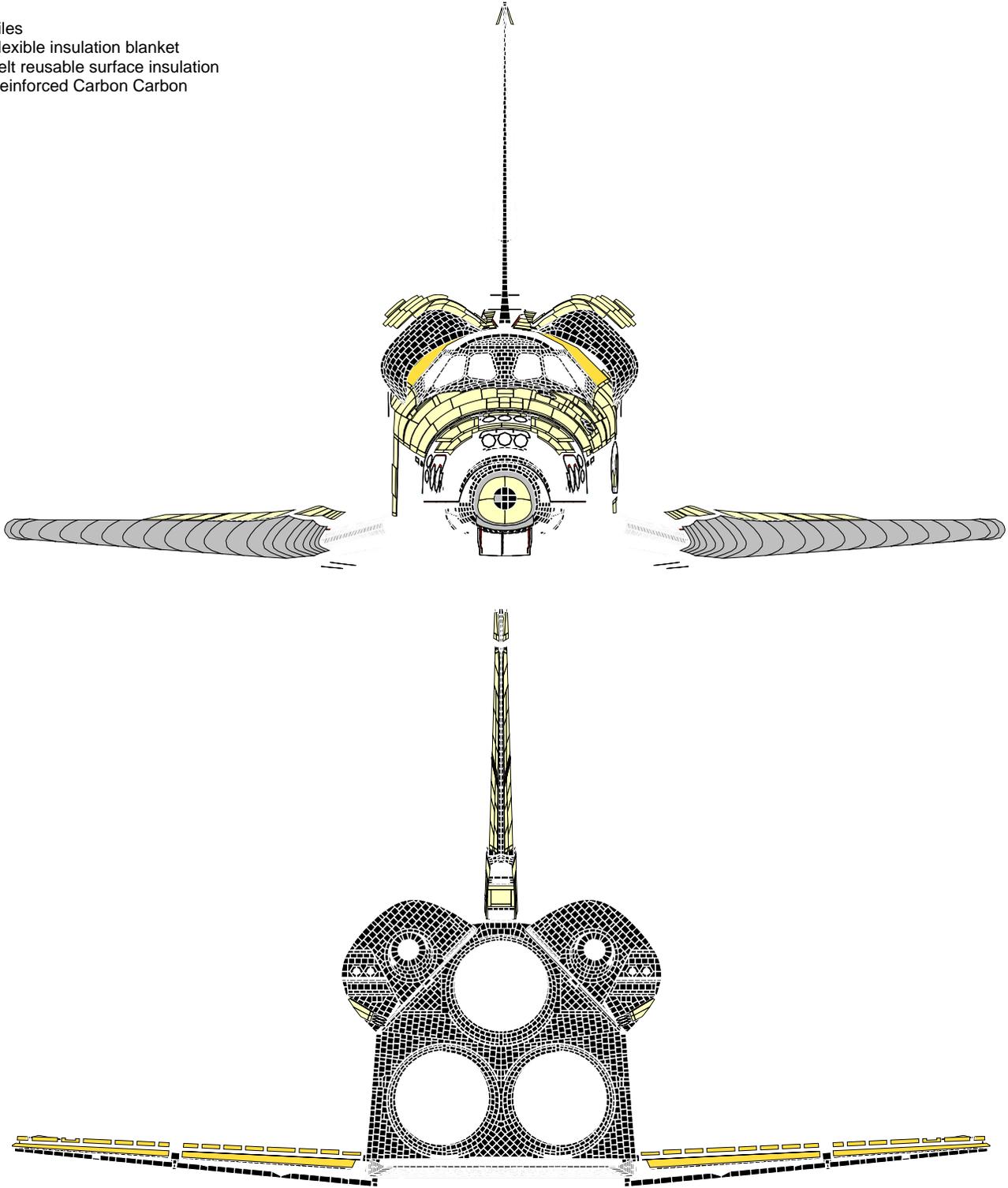
-  Tiles
-  Flexible insulation blanket
-  Felt reusable surface insulation
-  Reinforced Carbon Carbon



Starboard and Port Side Views

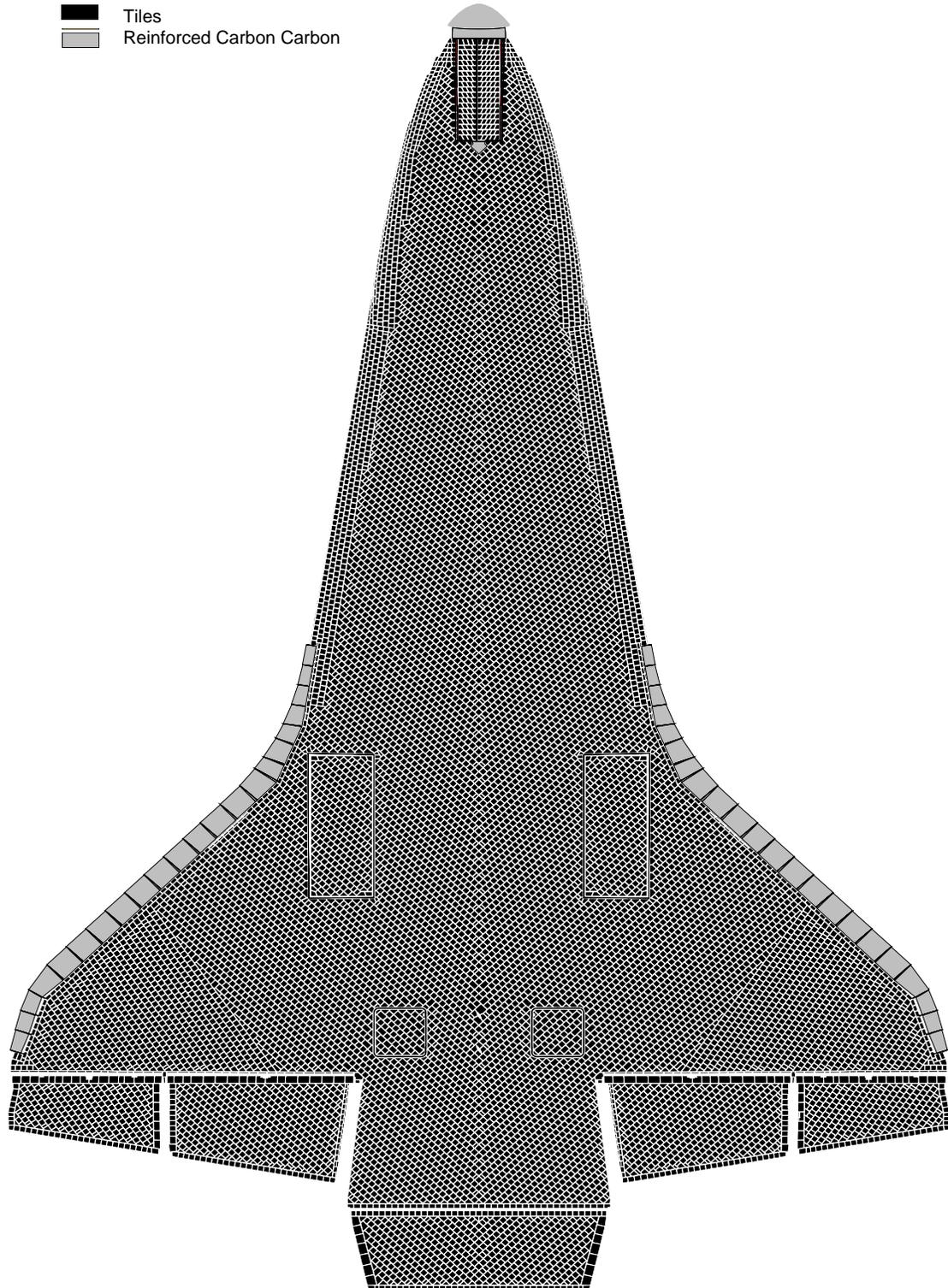
Thermal Protection System (continued)

-  Tiles
-  Flexible insulation blanket
-  Felt reusable surface insulation
-  Reinforced Carbon Carbon



Forward and Aft View

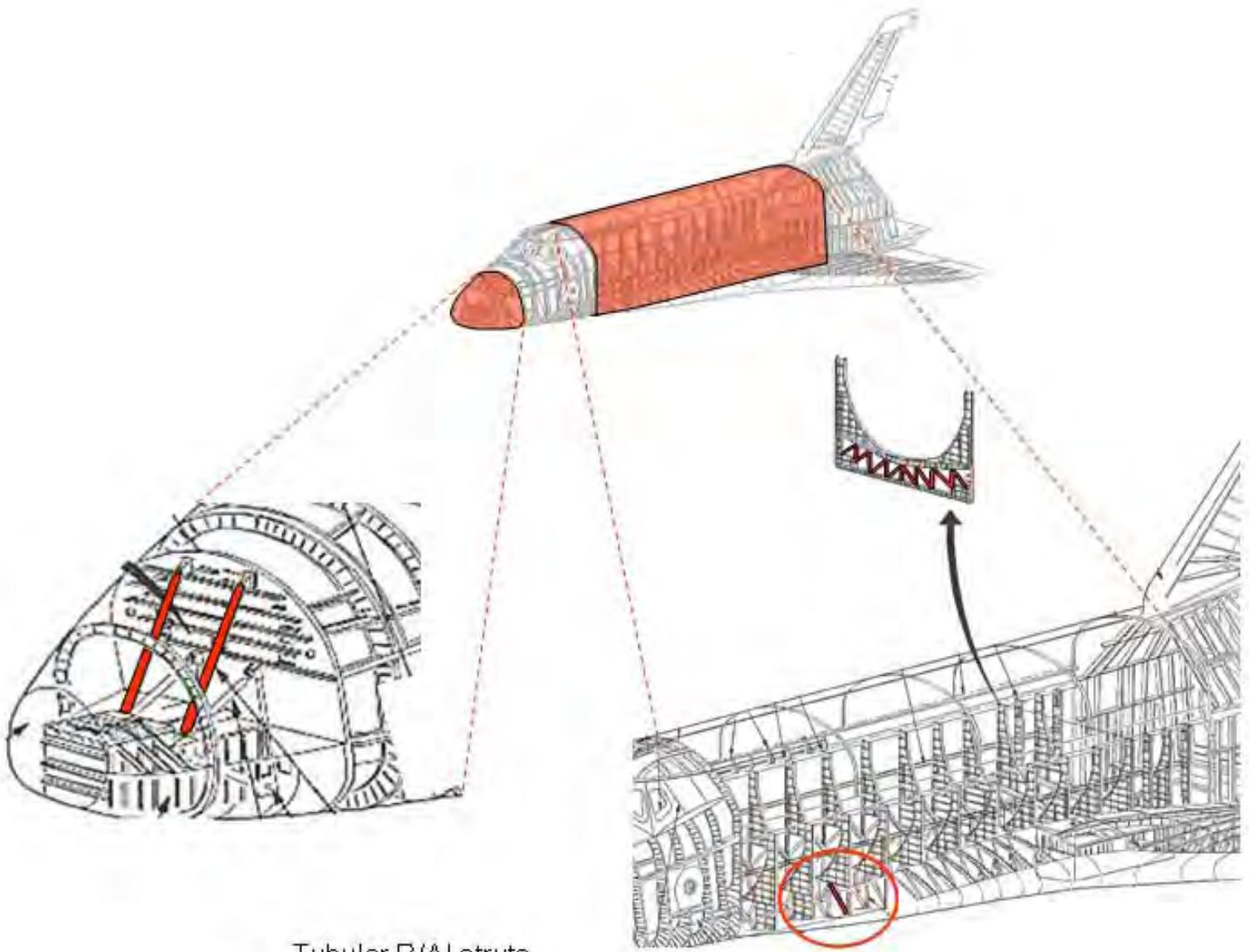
Thermal Protection System (continued)



Bottom View

4.26 Boron Struts

Remains installed on Orbiter. Boron Aluminum (B/Al) cracked/crushed no fibers or residue release. Hazardous condition only due to any disturbances (scratches or openings). Display Acceptable.

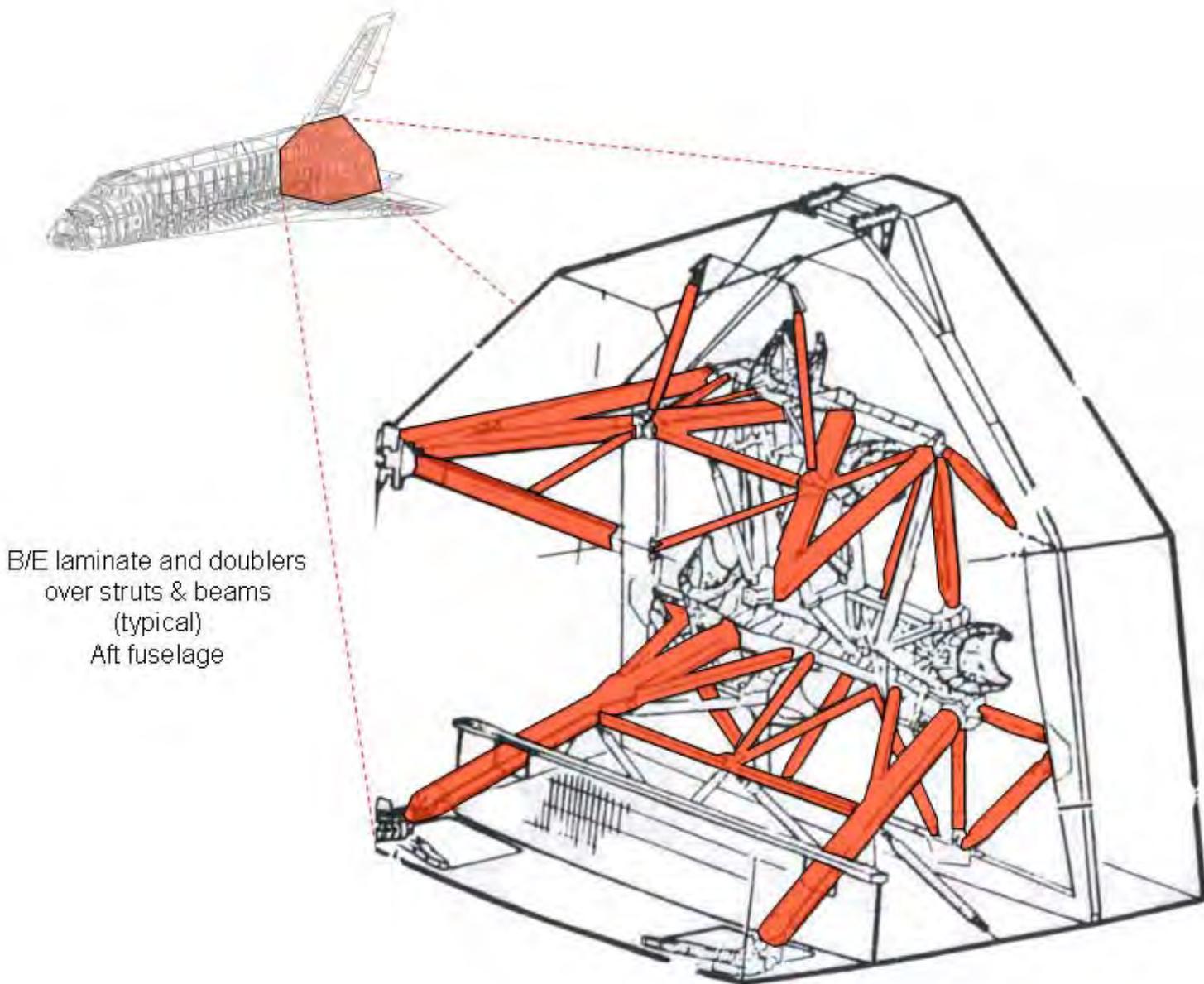


Tubular B/Al struts
(typical)
Forward & Mid-fuselage

Boron Struts

Boron Struts (continued)

Remains installed on Orbiter. Boron Epoxy Laminate (B/E) splinters/cracks possible fiber or residue release. Hazardous condition only due to any disturbances (scratches, fractures or openings). Display Acceptable.

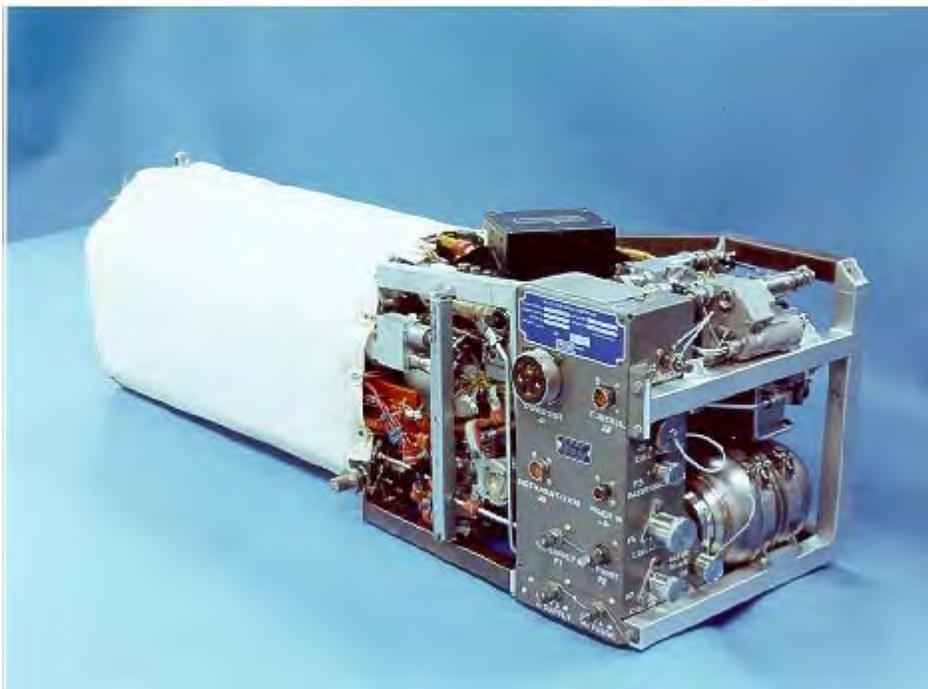


Boron Struts and Truss Members

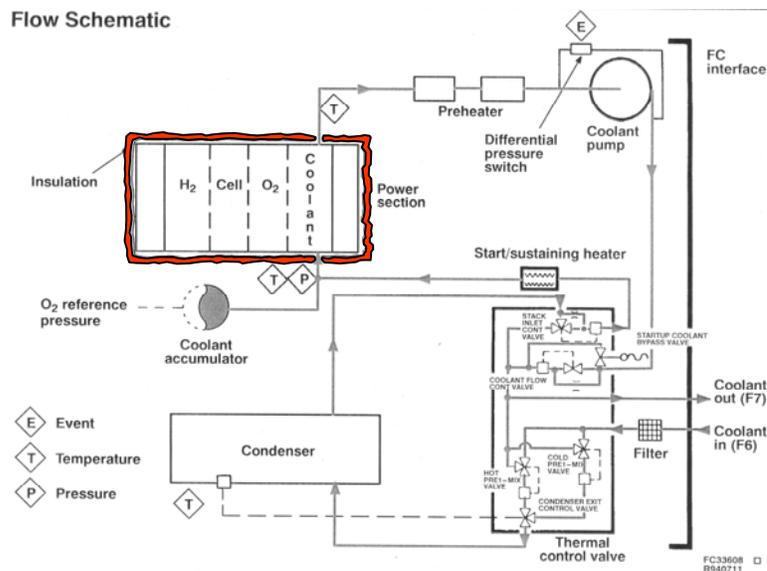
4.27 Asbestos and Potassium Hydroxide (KOH)

Remains installed on Orbiter. Asbestos and KOH (catalytic residuals) sealed within internal fuel cell insulation material.

- Fuel cell assembly.



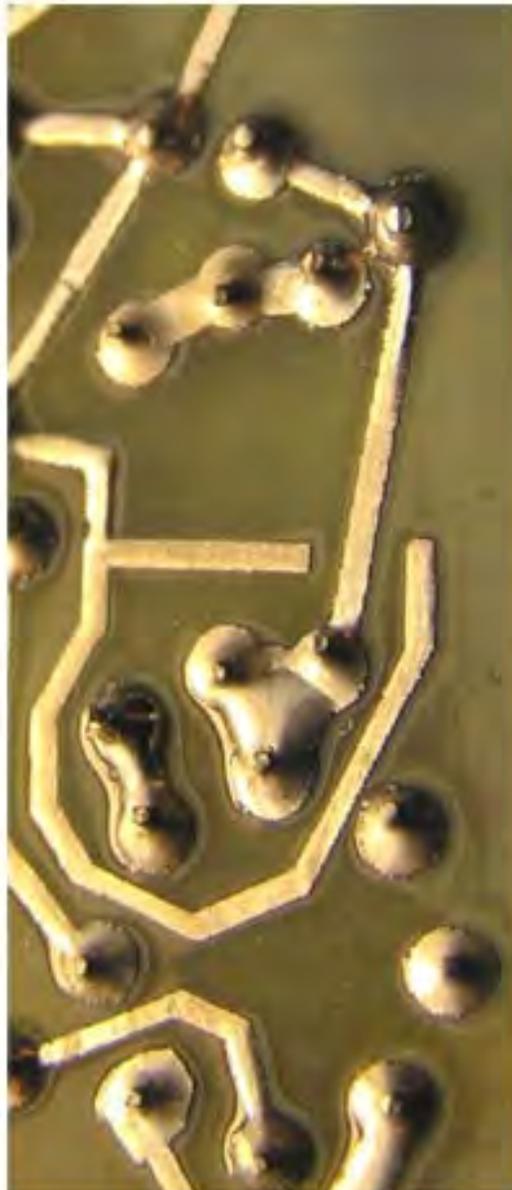
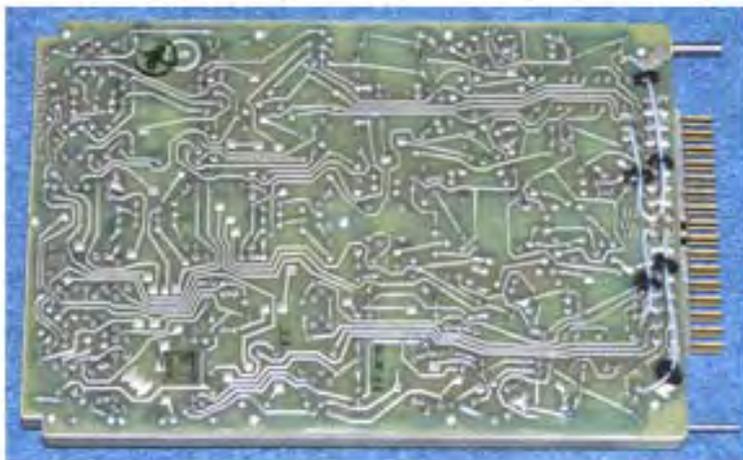
Fuel Cell



Fuel Cell Schematic

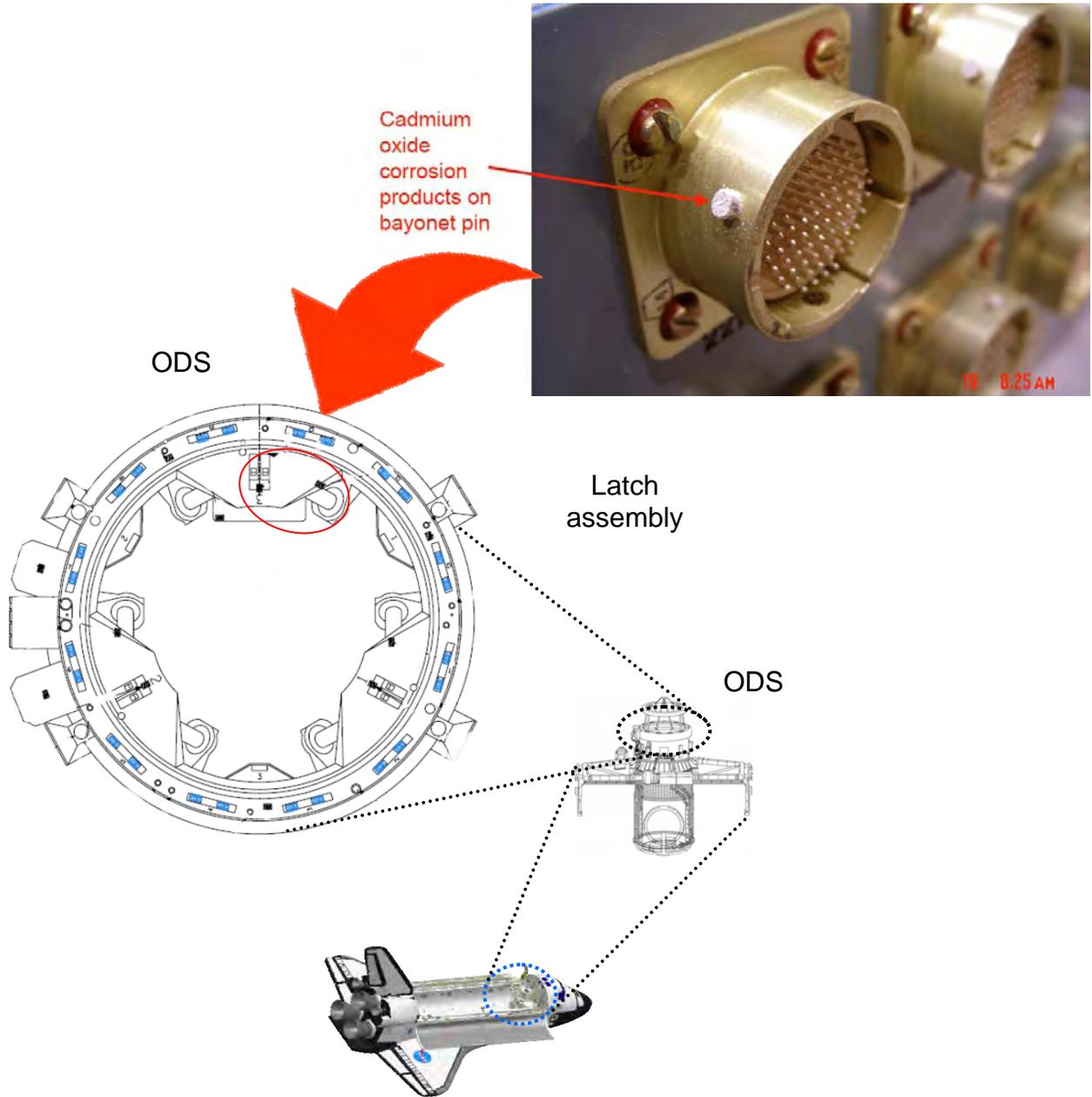
4.28 Lead

Remains installed on Orbiter. Lead in solder joints are isolated within internal electronic circuit boards and or electronic connector assemblies throughout the Orbiter vehicle.



4.29 Cadmium

Cadmium oxide (corrosion) has been detected on Russian connectors associated with the docking system



END OF DOCUMENT