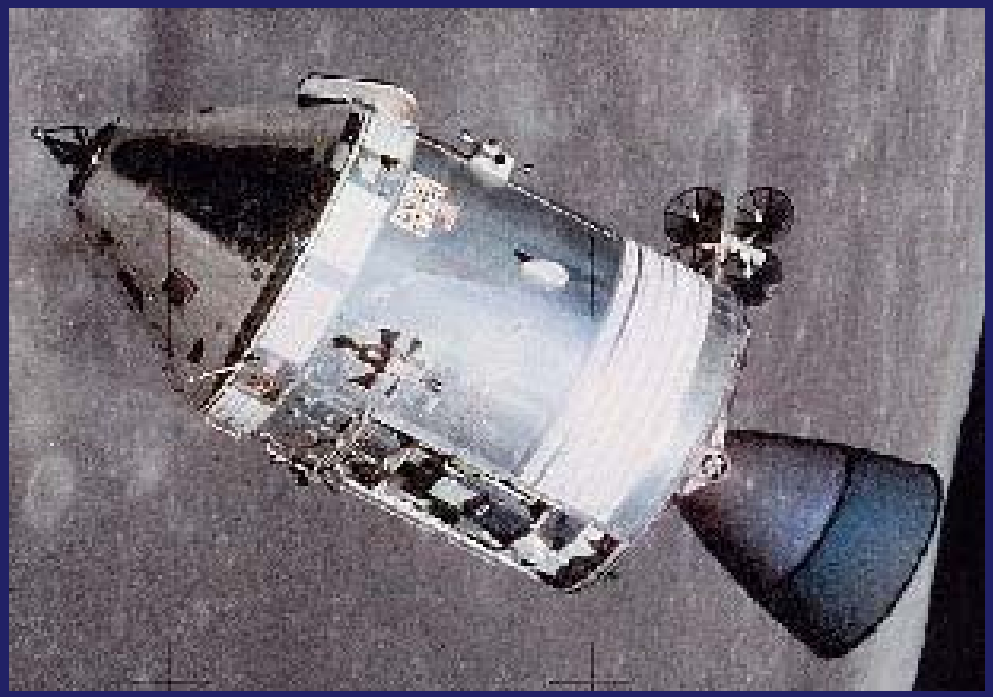


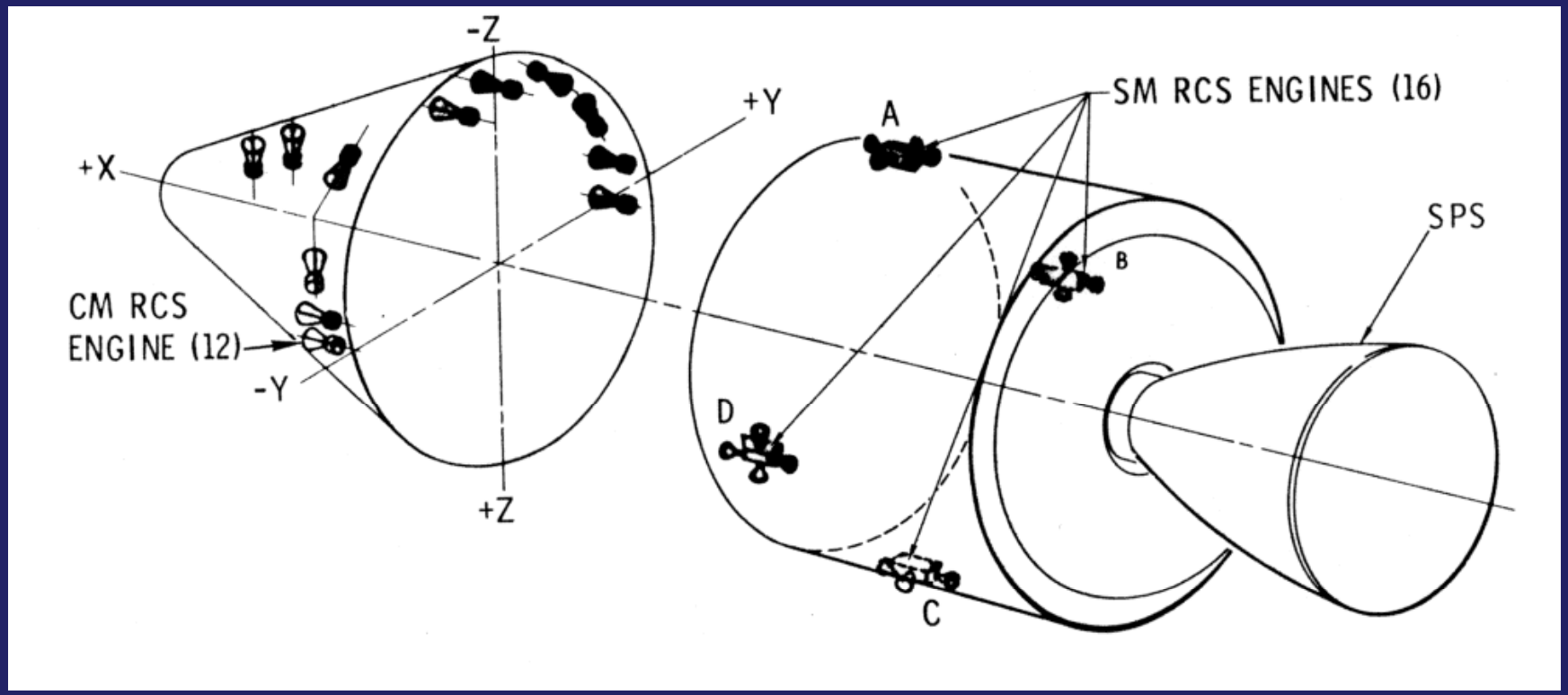
CSM RCS Design Considerations & Failure Modes

Lesson Objectives

- Define major Command and Service Module (CSM) design considerations
- List Command Module (CM) RCS failures and lessons learned
- List Service Module (SM) RCS failures and lessons learned

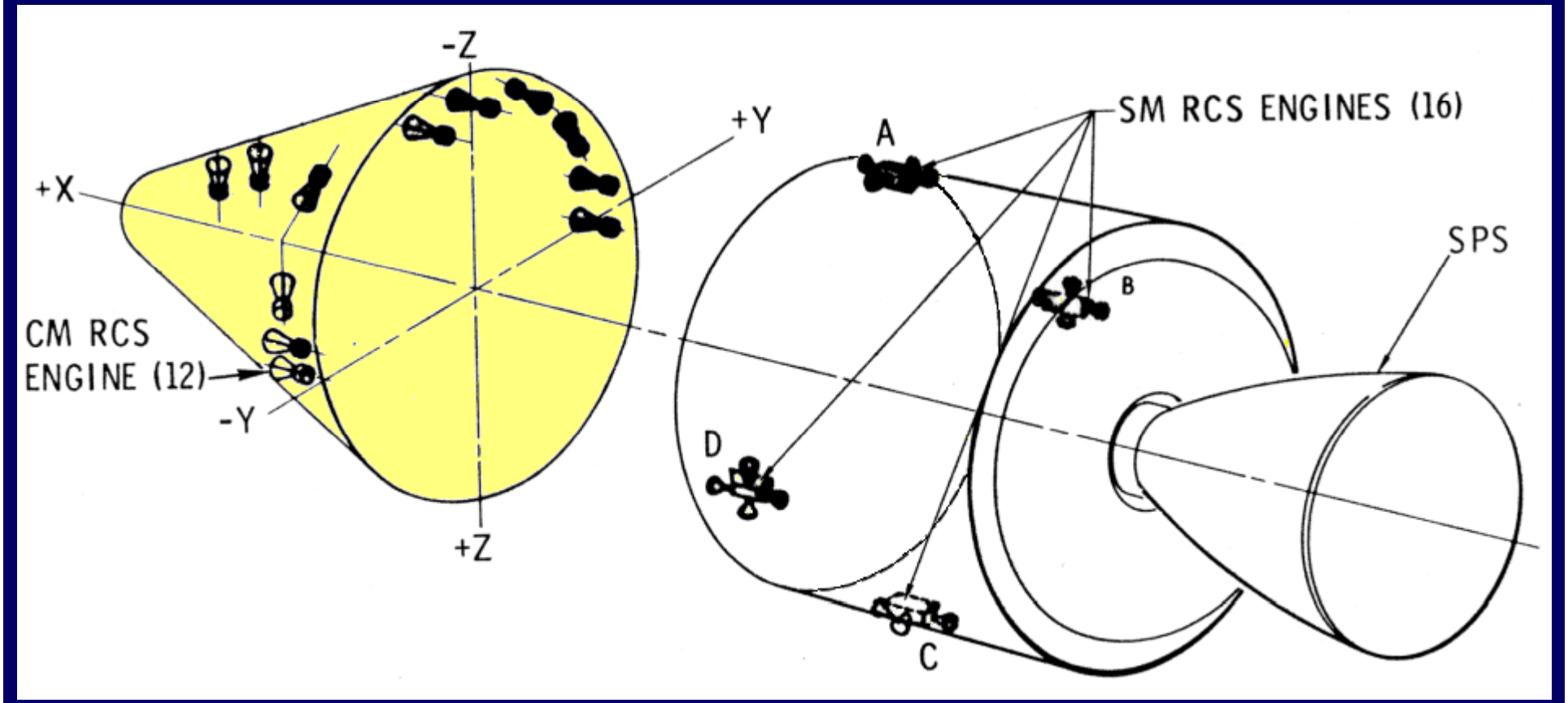
For more information about CSM RCS system please see
http://modspops.jsc.nasa.gov/mod/DA4/CxTraining/Apollo/Apollo%20Wiki/CSM%20Reaction%20Control%20System%20(RCS).aspx

CSM RCS Overview

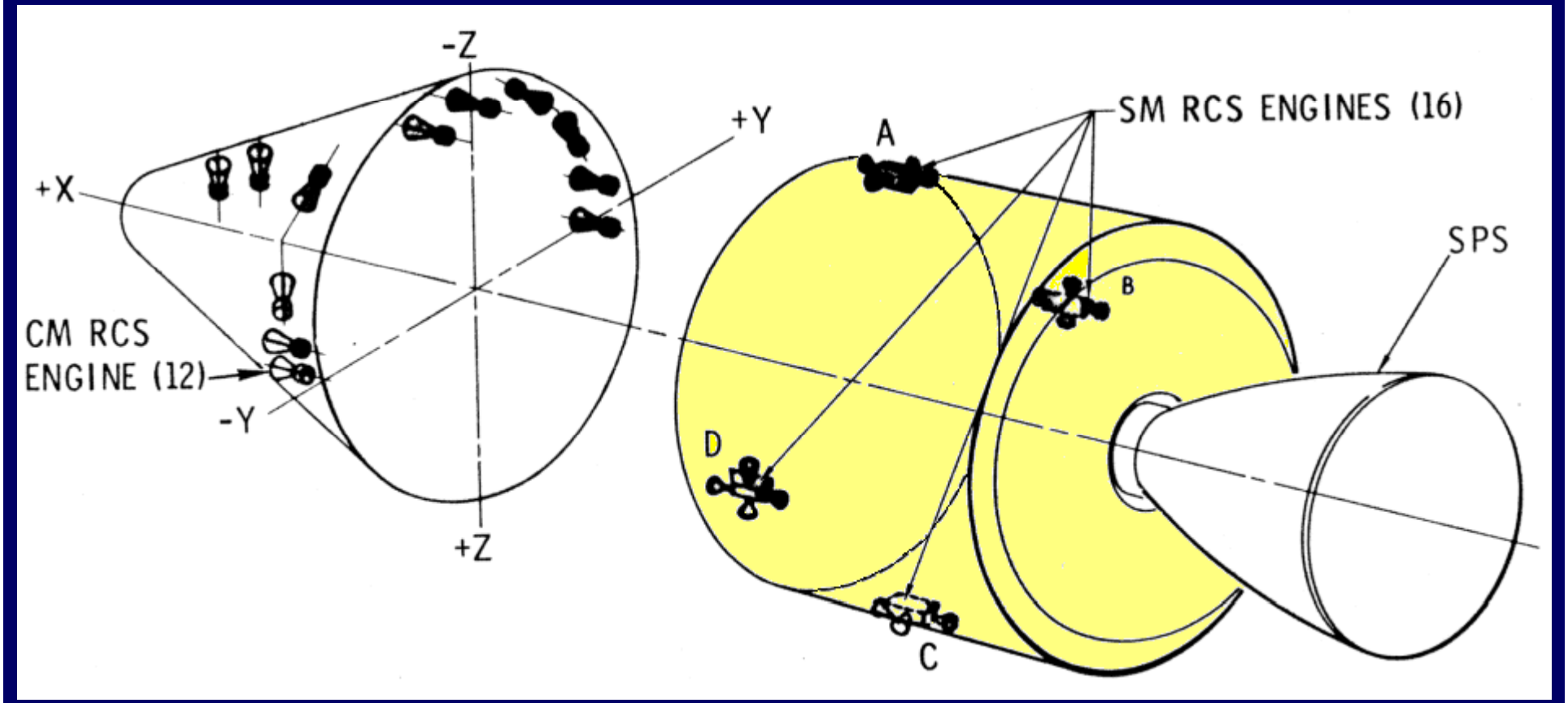


CSM Design Considerations

CM Design Considerations



SM Design Considerations



Lesson Objectives

- Define major Command and Service Module (CSM) design considerations
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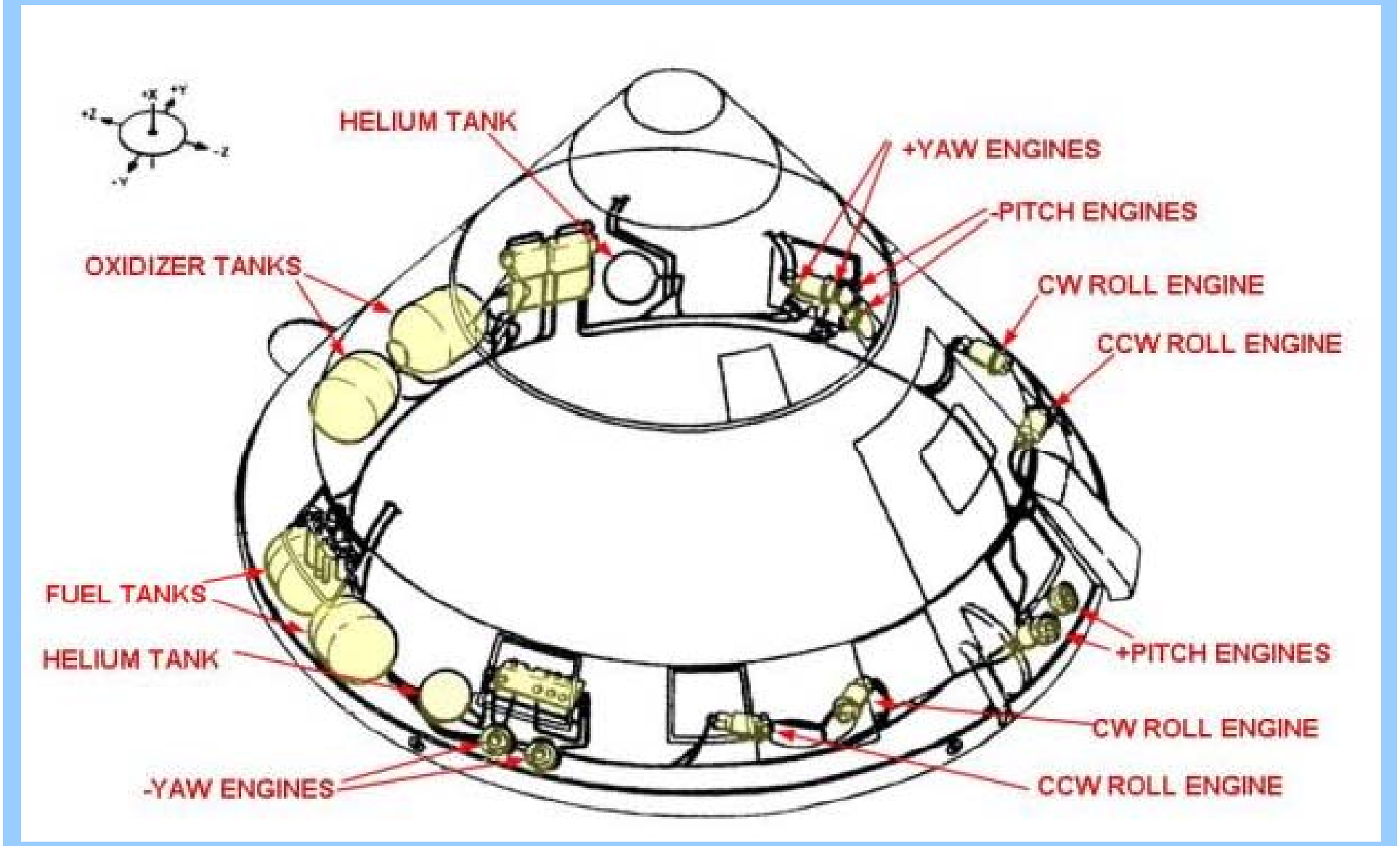
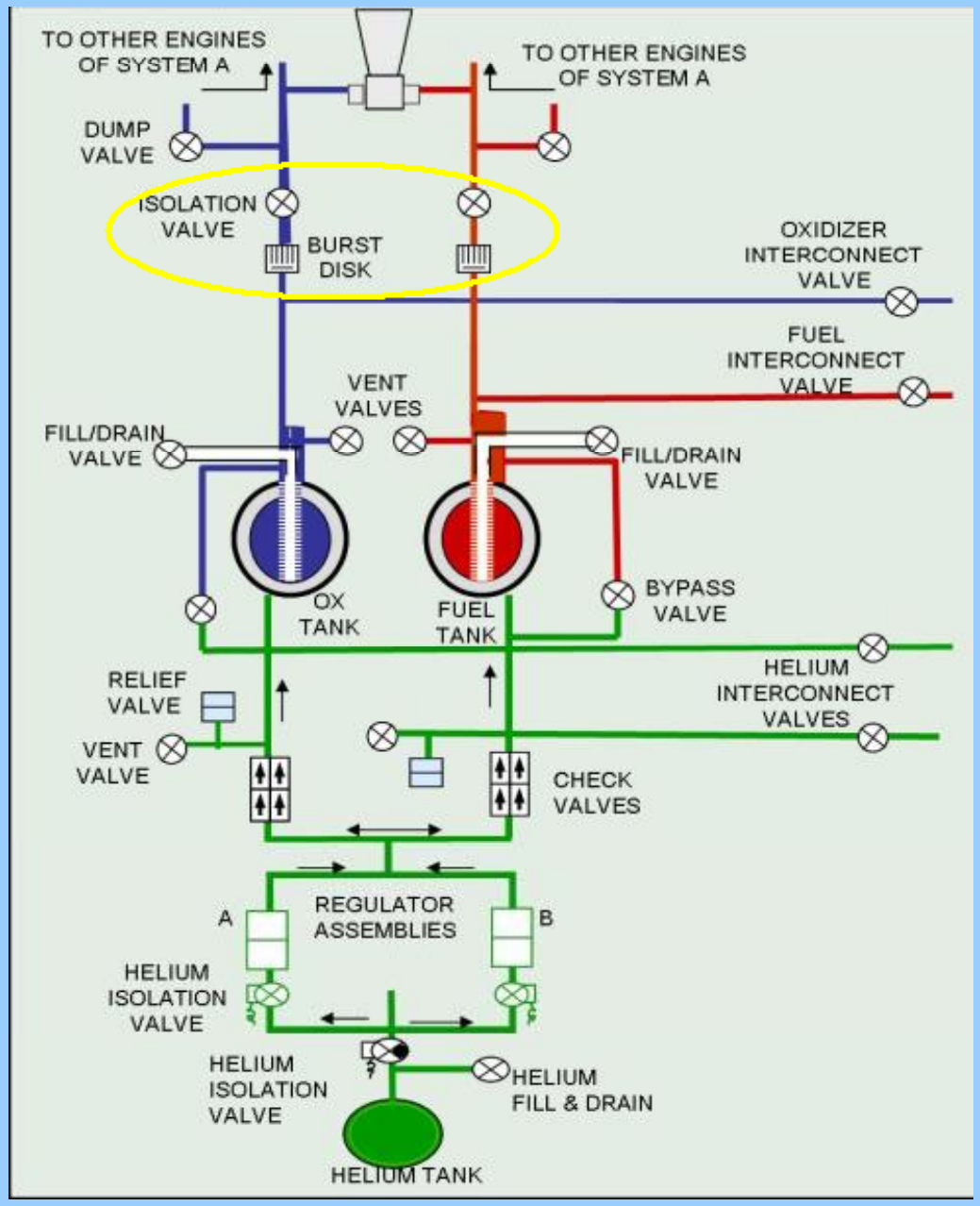
- List Service Module (SM) RCS failures and lessons learned

CM Failures and Lessons Learned



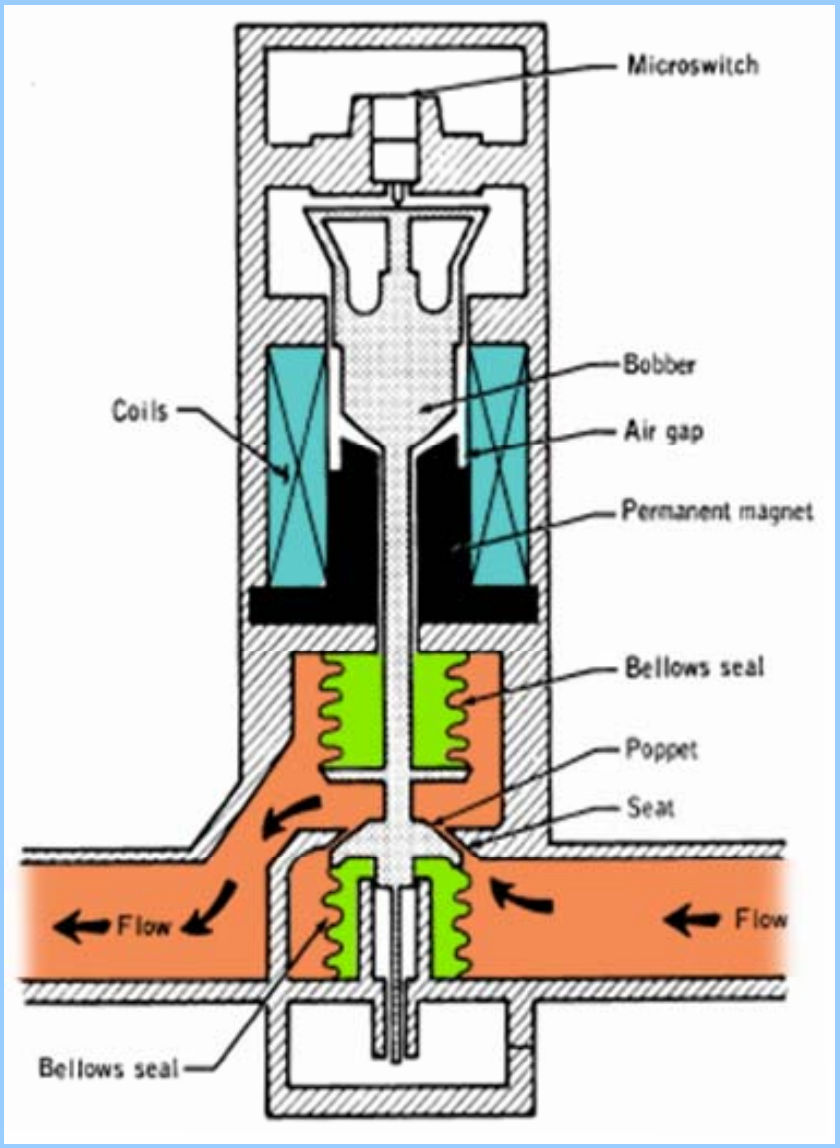
CM Propellant Isolation Valves

- Apollo 7 - damaged bellows
- Apollo 10 - ruptured oxidizer burst diaphragm
- Apollo 12 - damaged bellows
- Apollo 13 - fuel valve coil miswiring



CM Propellant Isolation Valve Lessons Learned

- Proper procedures
- Caution notes and leak checks
- Resistance checks

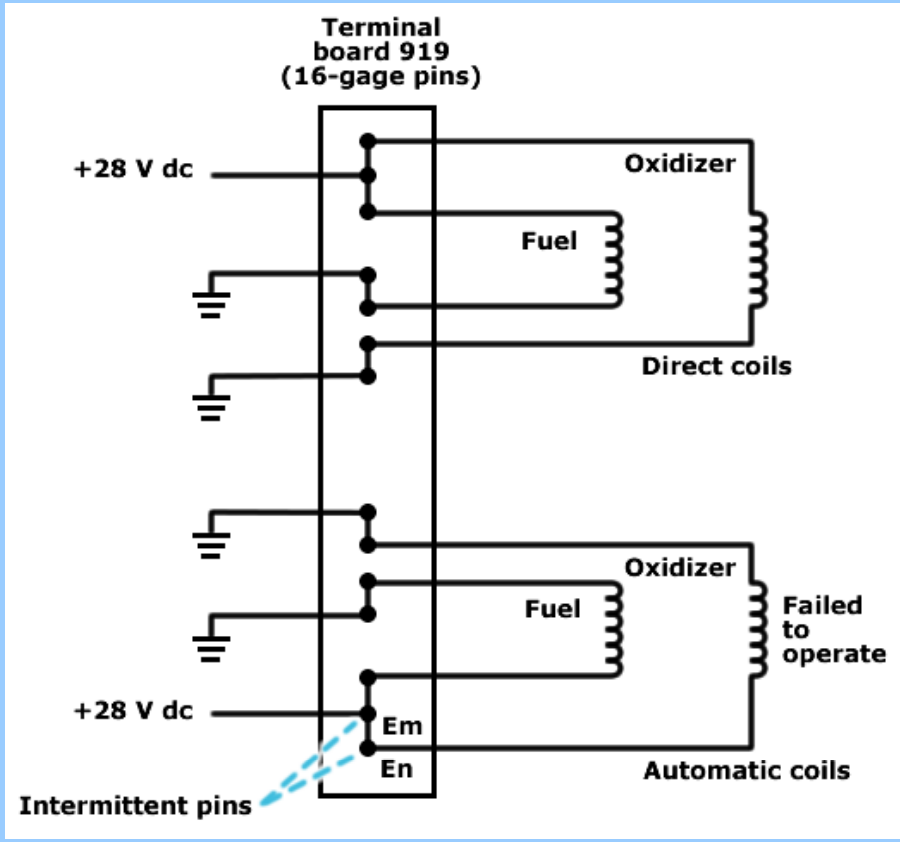


Isolation Valve

CM Helium Manifold

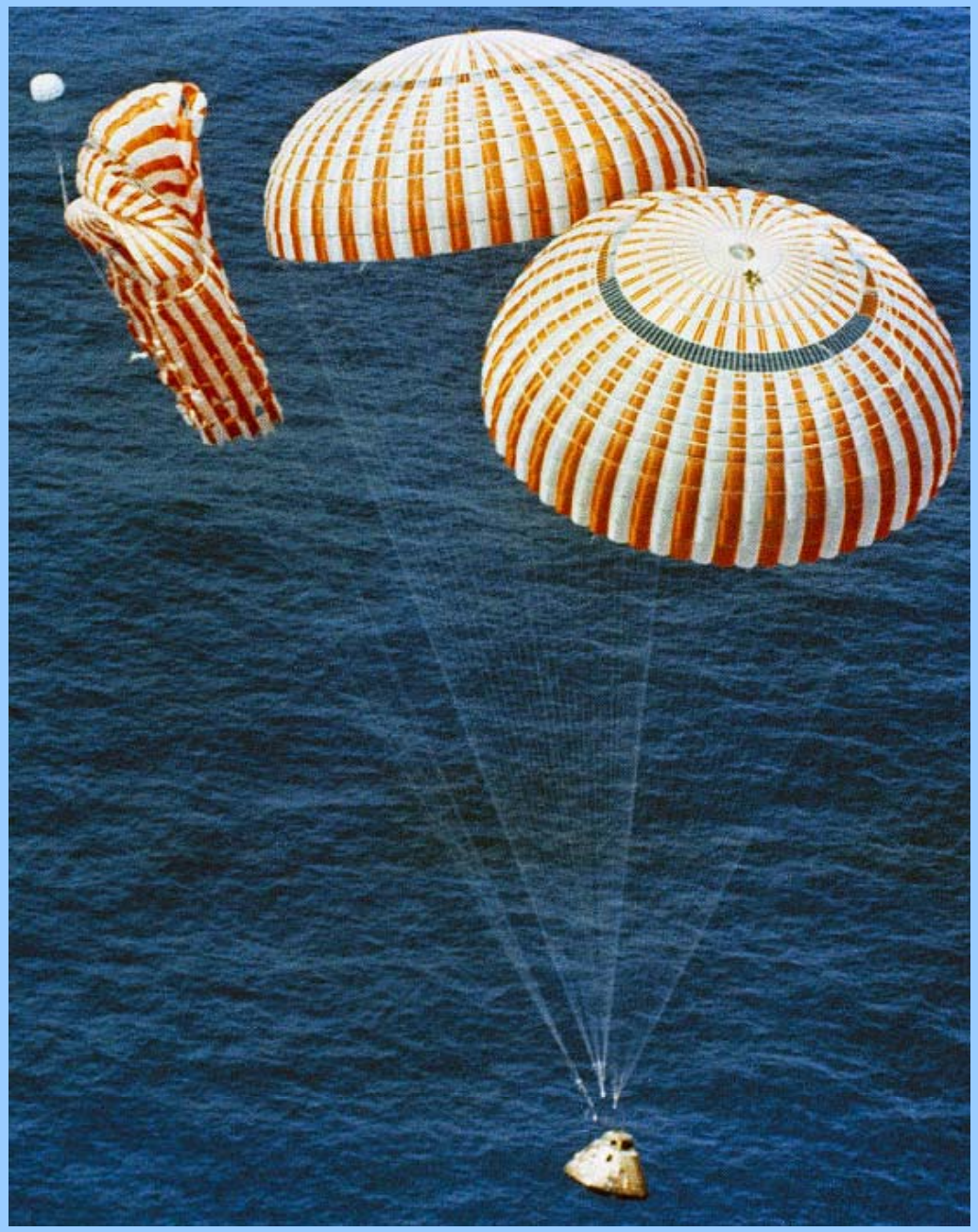
- Anomaly: Helium manifold pressure drop discovered before launch of Apollo 10; no measurable leak was found
- Conclusion: Fuel leg helium manifold was indeed leaking but at an acceptable rate for the mission
- Solution: Pressurized system to 100psi 30 days prior to launch to insure detection of any leak

CM Automatic Coil



Terminal board schematic for minus-yaw engine

- Anomaly: Faulty terminal board sending erratic firing signals through automatic coils
- Conclusion: Two loose pins causing intermittent continuity to coils
  - Found in all pre-November 1967 terminal boards
- Solution: No corrections made since terminal boards did not affect circuits that jeopardized crew



CM Propellant Dump

- Apollo 15 - Deflated parachute due to CM RCS depletion firing
  - Correction: Procedures changed to allow propellant to remain onboard at landing
- Apollo 16 – Small burn holes caused by yaw engine firings
  - Tests determined maximum pressure and planned for on-the-water operation of the system if required

Lesson Objectives

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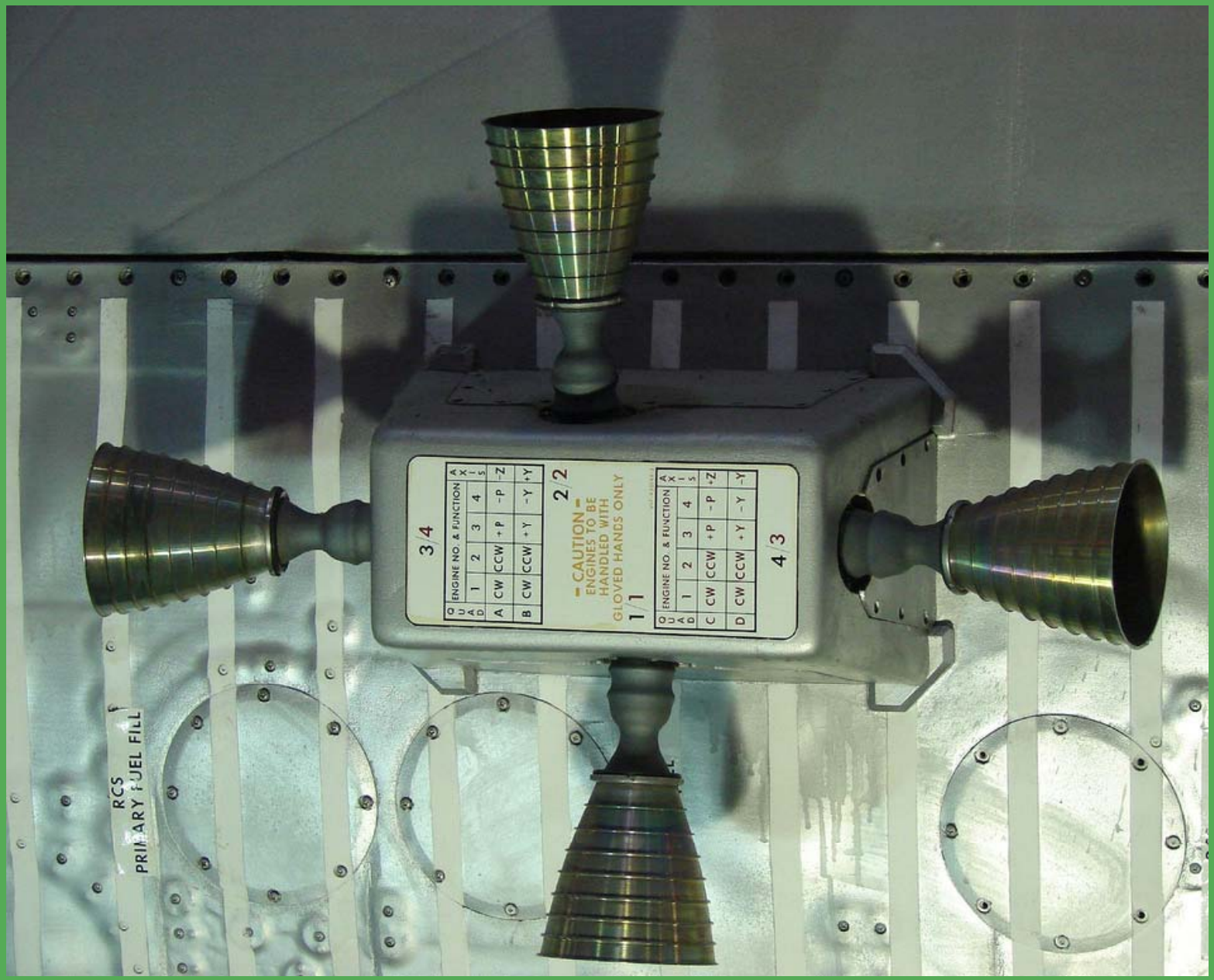
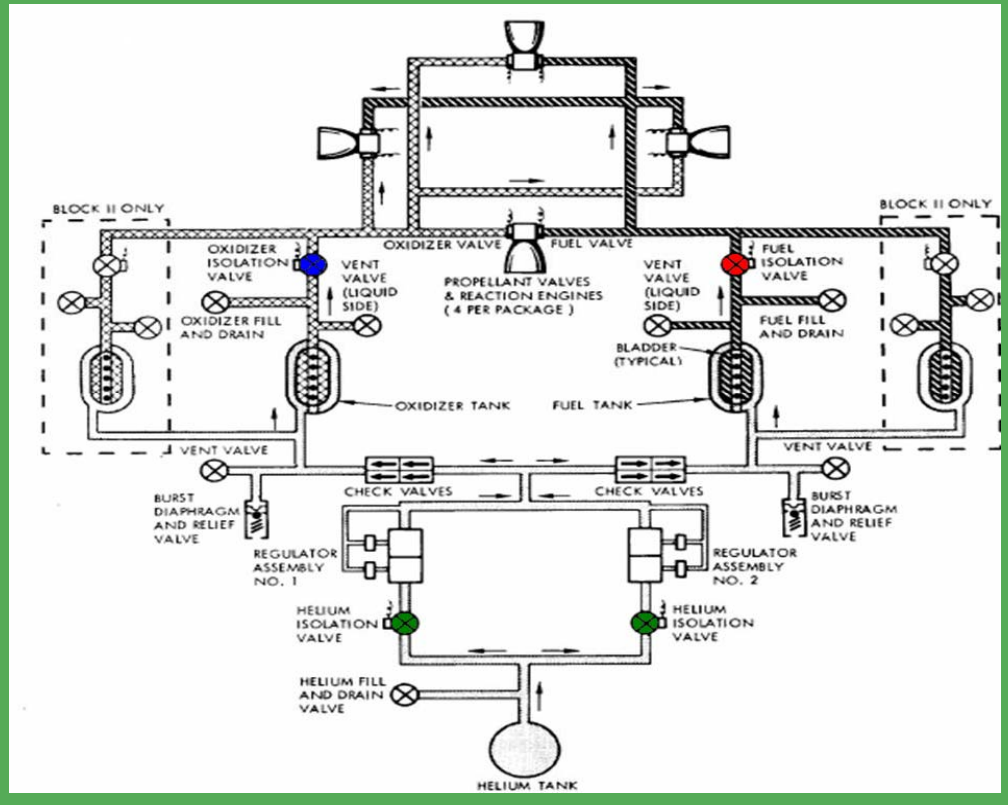
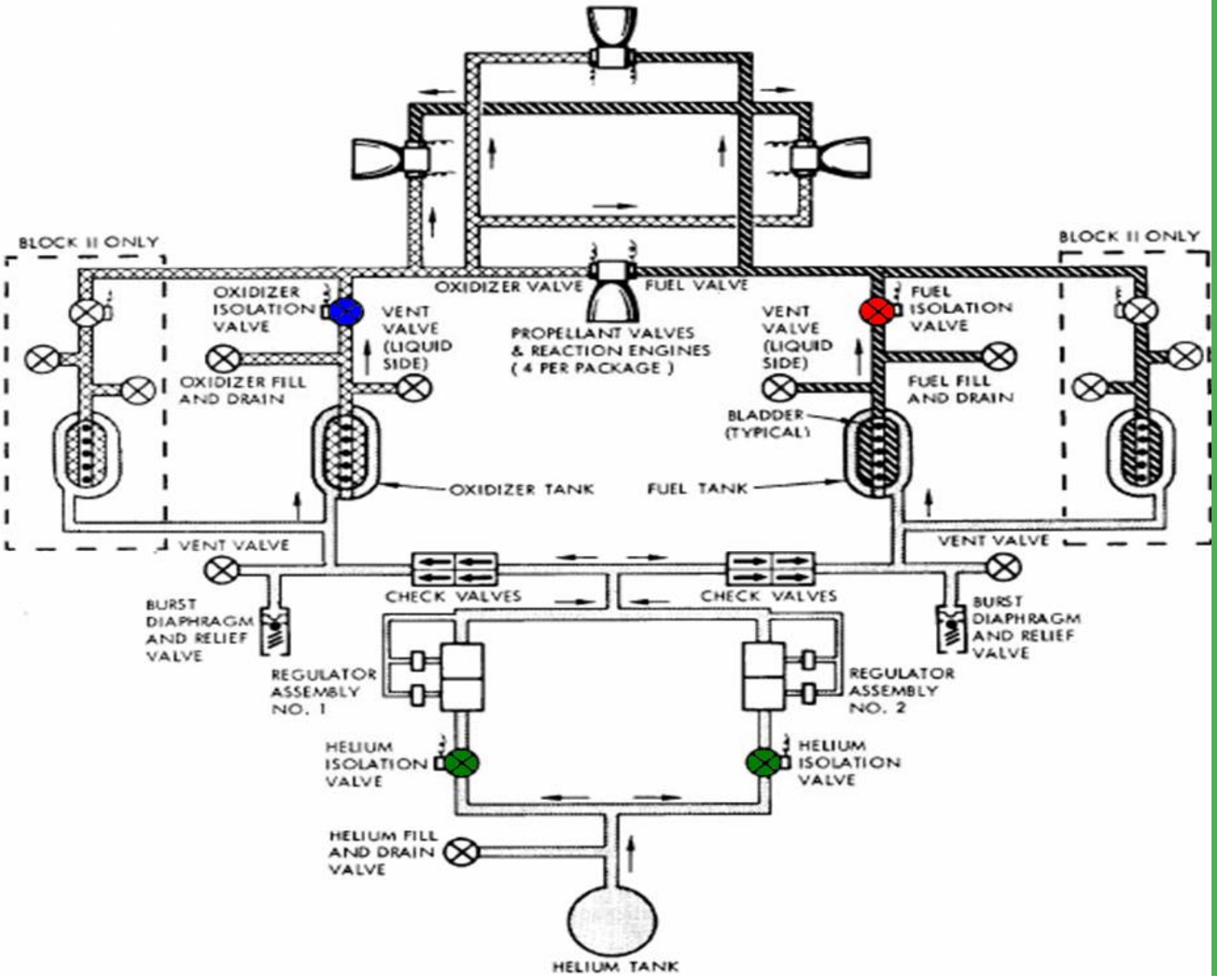
SM RCS Failures and Lessons Learned



SM Isolation Valves

- Apollo 9 - Valves shocked closed
- Apollo 11 - Valves closed during CSM separation from S-IVB
- Apollo 13 – Valves closed due to oxygen tank anomaly
- Apollo 15 - Degaussed magnets due to reversed polarity



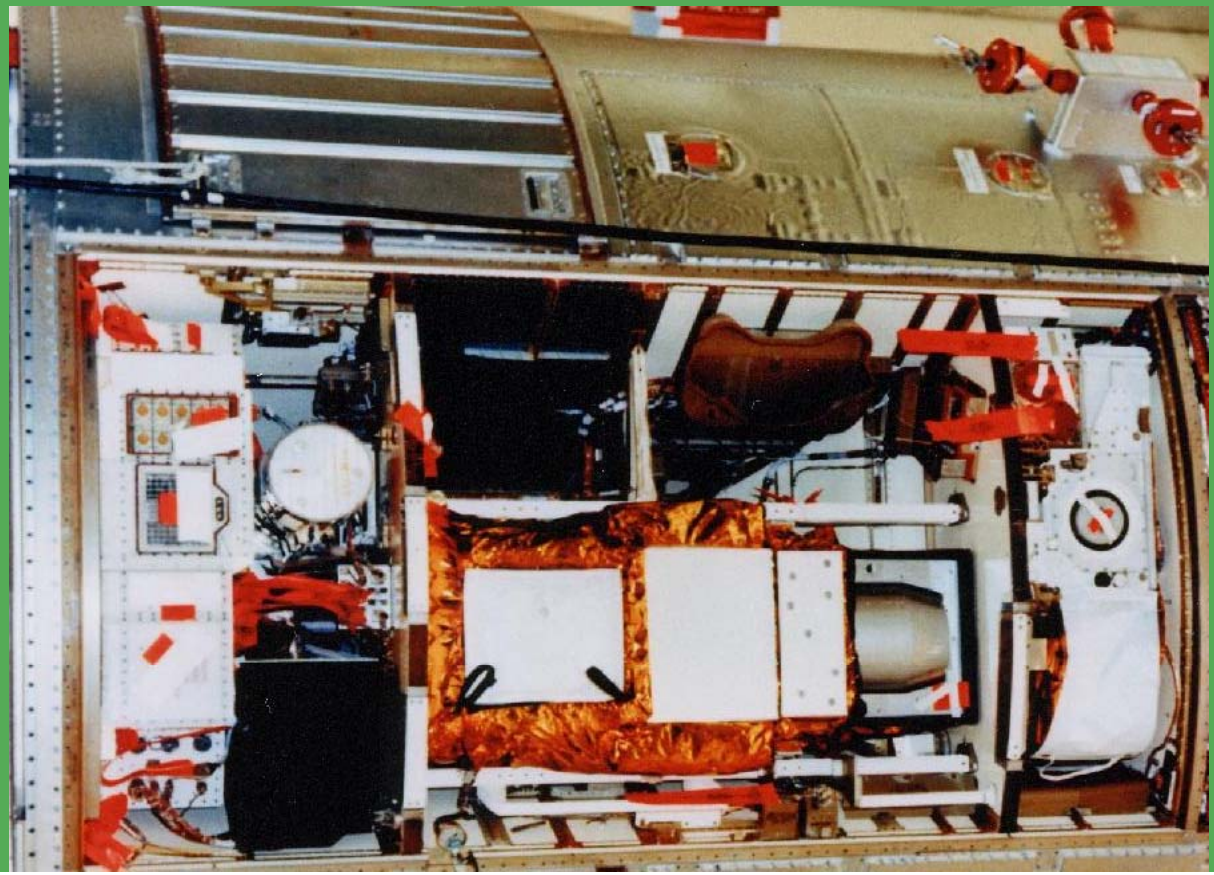

BLOCK II ONLY
BLOCK II ONLY
OXIDIZER ISOLATION VALVE
VENT VALVE (LIQUID SIDE)
OXIDIZER VALVE
FUEL VALVE
PROPELLANT VALVES & REACTION ENGINES (4 PER PACKAGE)
VENT VALVE (LIQUID SIDE)
FUEL ISOLATION VALVE
OXIDIZER FILL AND DRAIN
FUEL FILL AND DRAIN
BLADDER (TYPICAL)
OXIDIZER TANK
FUEL TANK
VENT VALVE
VENT VALVE
CHECK VALVES
CHECK VALVES
BURST DIAPHRAGM AND RELIEF VALVE
BURST DIAPHRAGM AND RELIEF VALVE
REGULATOR ASSEMBLY NO. 1
REGULATOR ASSEMBLY NO. 2
HELIUM ISOLATION VALVE
HELIUM ISOLATION VALVE
HELIUM FILL AND DRAIN VALVE
HELIUM TANK

SM Isolation Valve Lessons Learned

- Apollo Operations Handbook changed to insure that the crew would check isolation valves after separation and reopen any that closed
- A test was performed on all post-Apollo 15 flights to verify acceptable valve latching forces

SM Manifold

- Apollo 12: Helium manifold pressure transducer malfunction
- Apollo 14: Oxidizer manifold pressure out of nominal limits



Summary

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References

- Apollo Mission Reports 6-17
- Apollo Experience Report – Command and Service Module Reaction Control Systems

Use References link below for more information