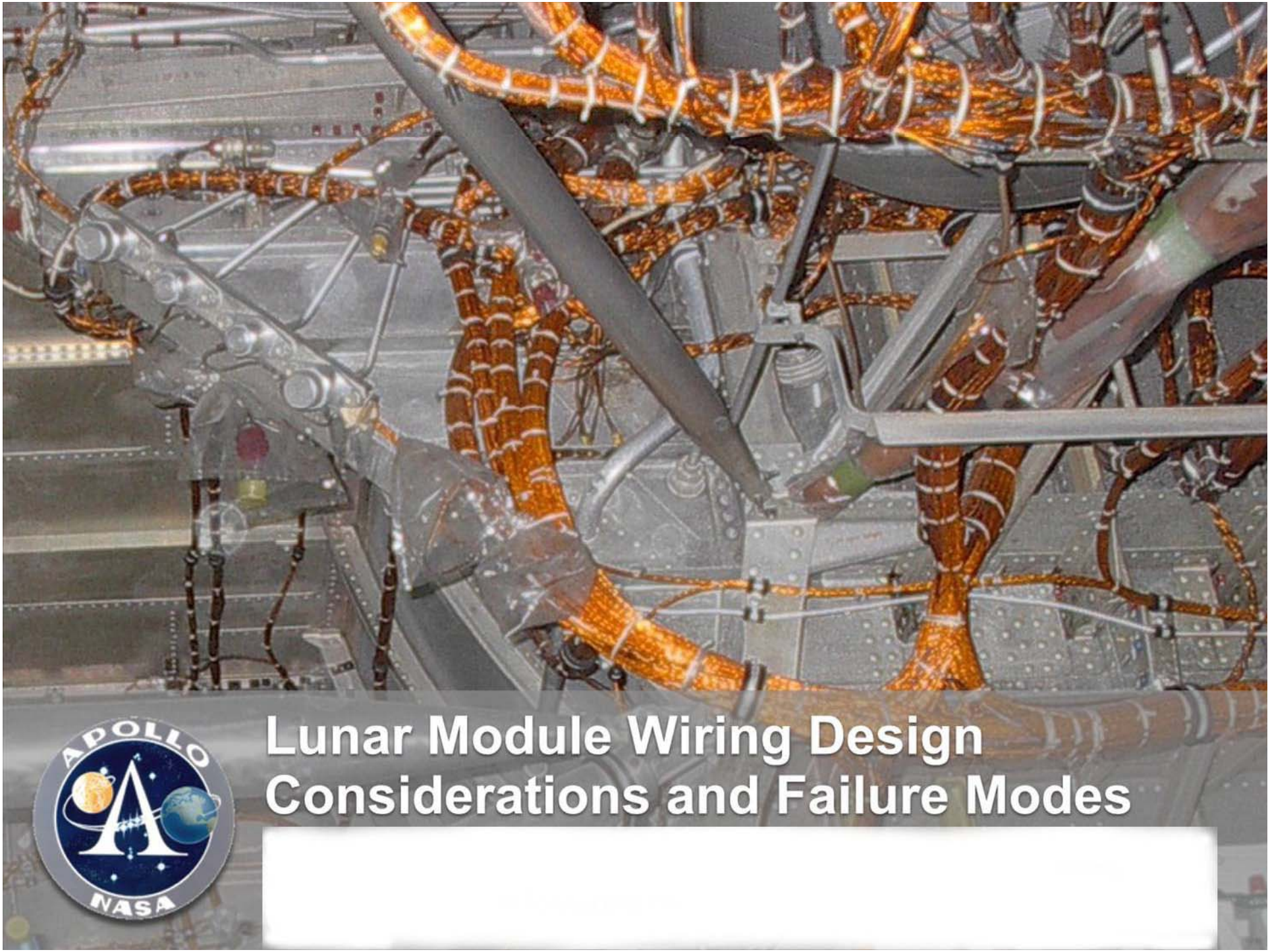
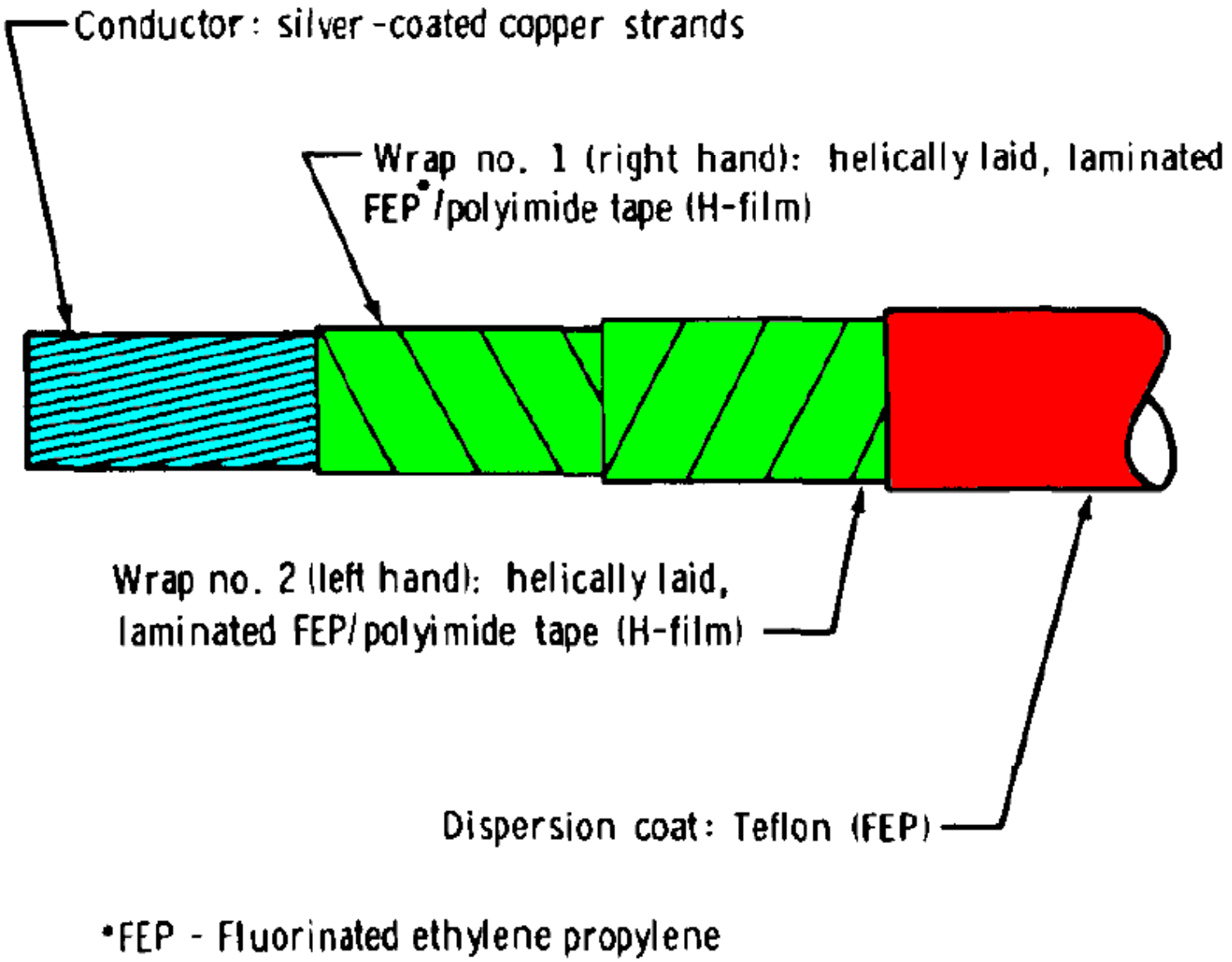


Lunar Module Wiring Design Considerations and Failure Modes

Objectives

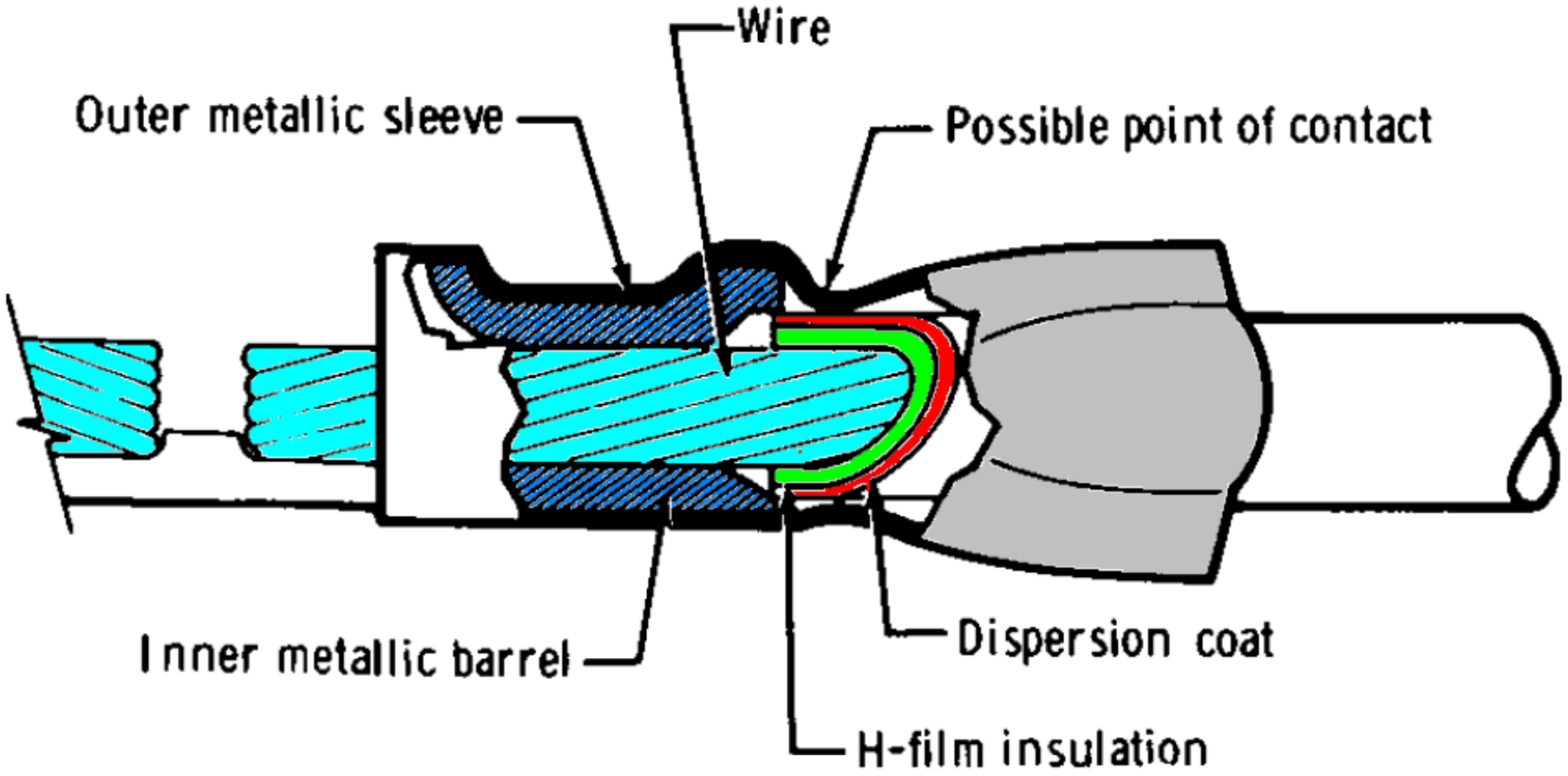
1. Describe the rationale for component type selection.
2. Describe the rationale for the chosen assembly processes.
3. Describe the redesign considerations and lessons learned.

Choice of Conductors and Insulation

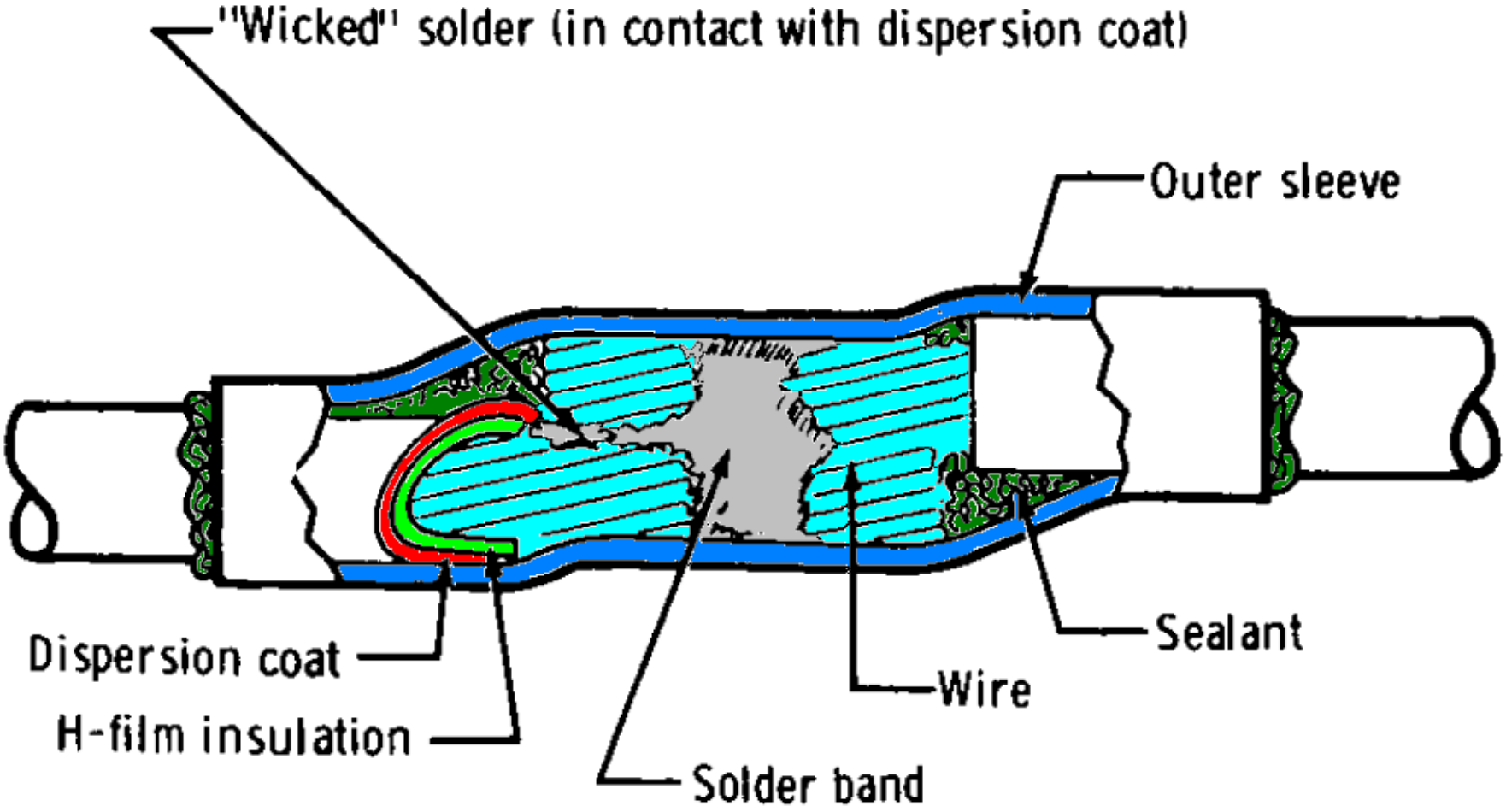


*FEP - Fluorinated ethylene propylene

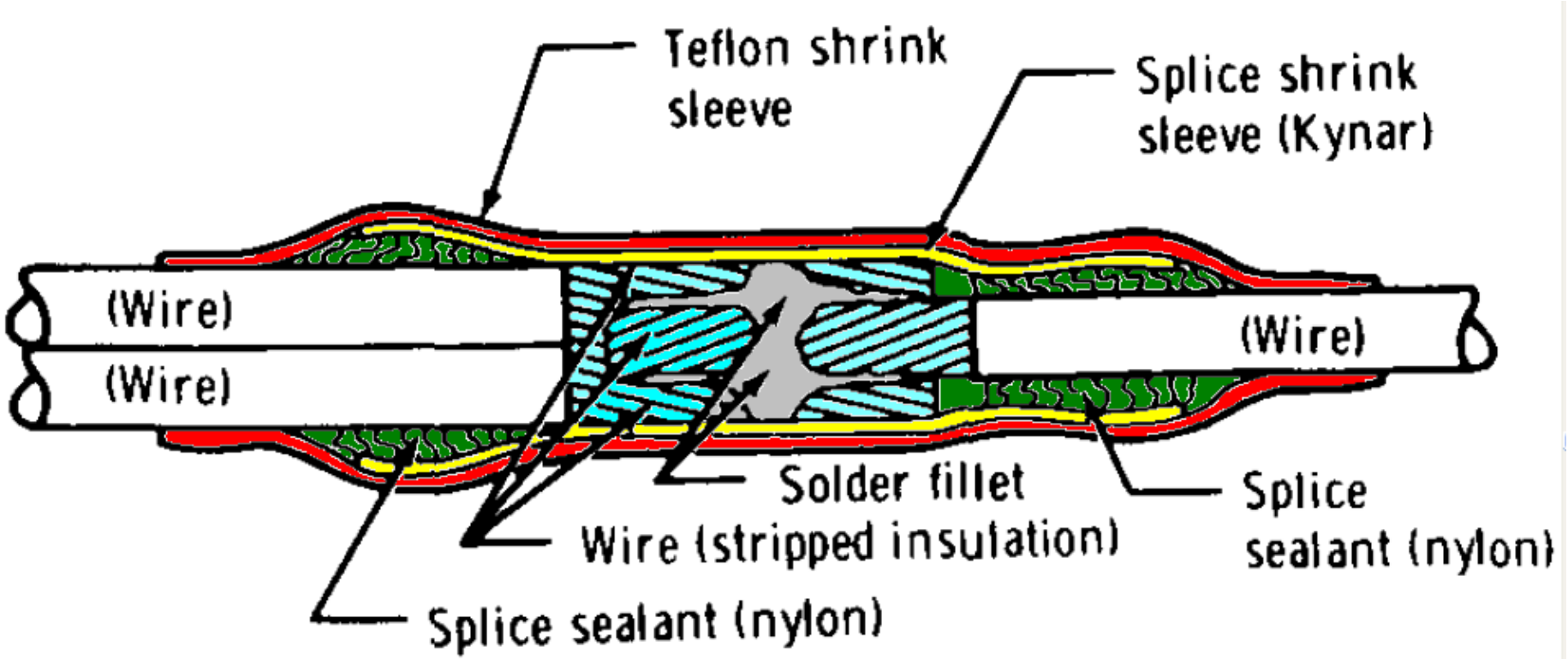
Wire Splices - Crimp



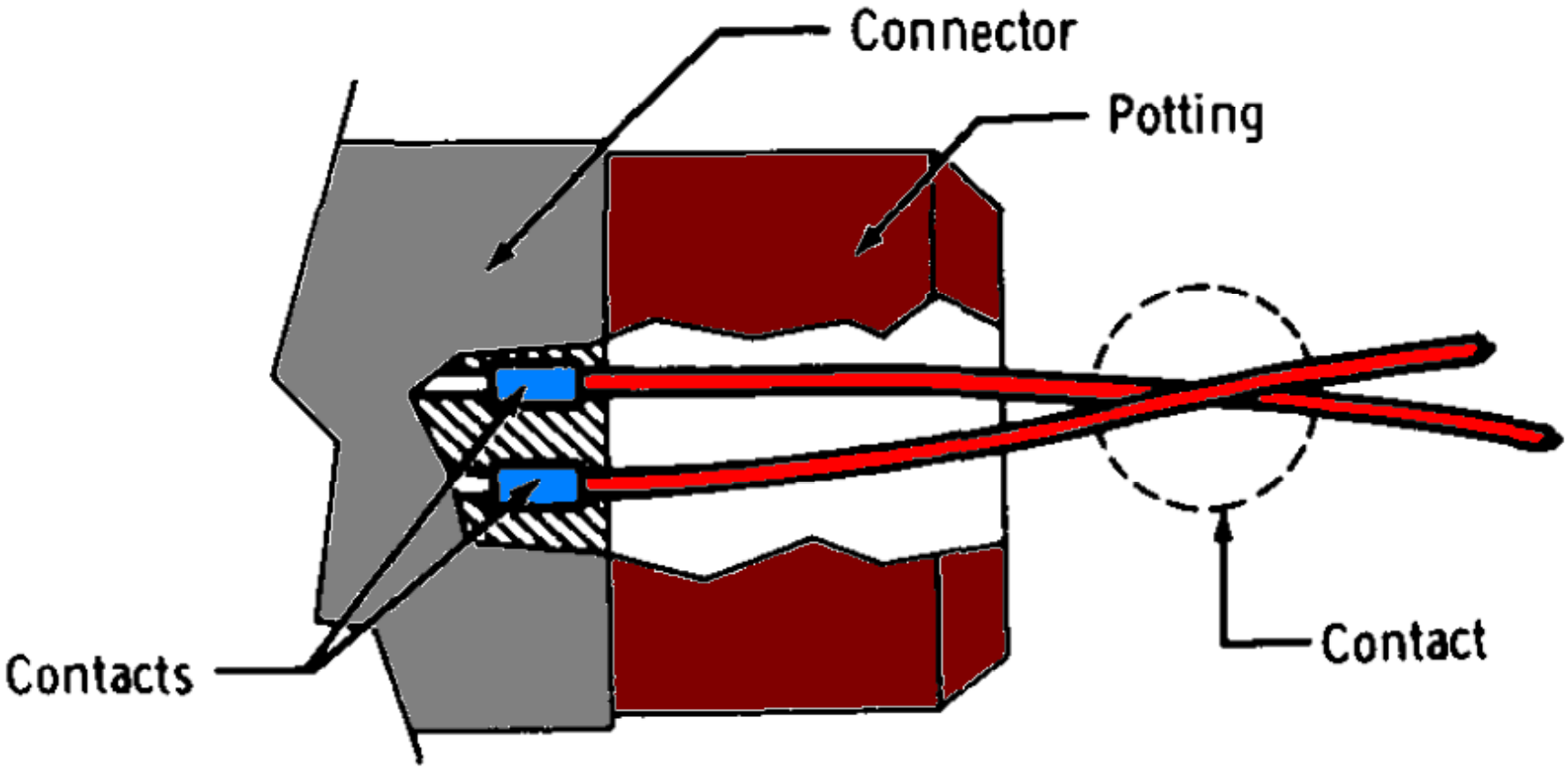
Wire Splices – Solder 1



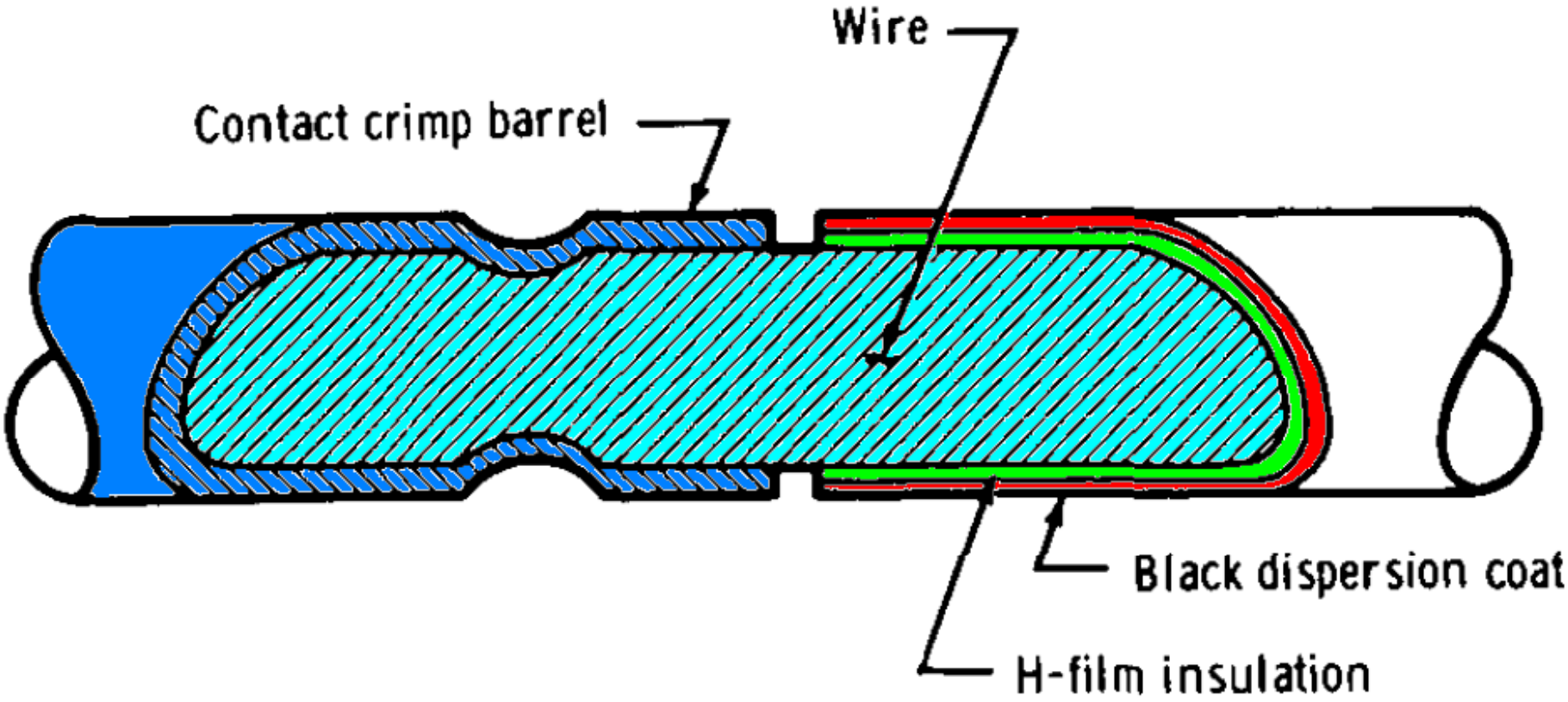
Wire Splices – Solder 2



Wire Connectors

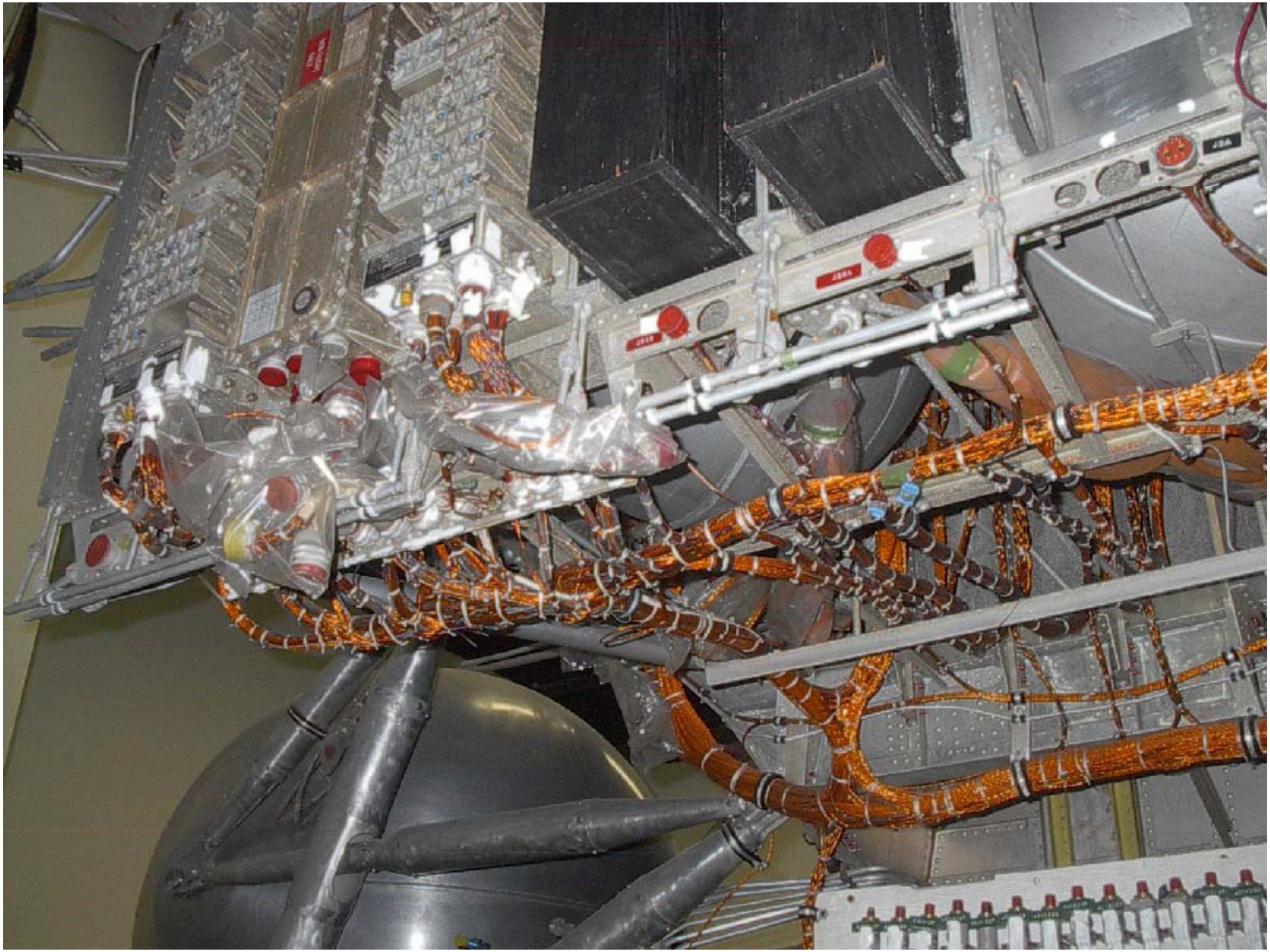


Wire Connectors – Crimp Pins



Wire Connectors

Fabrication of Wire Harnesses



Wires wrong length.

Sharp edge damage.

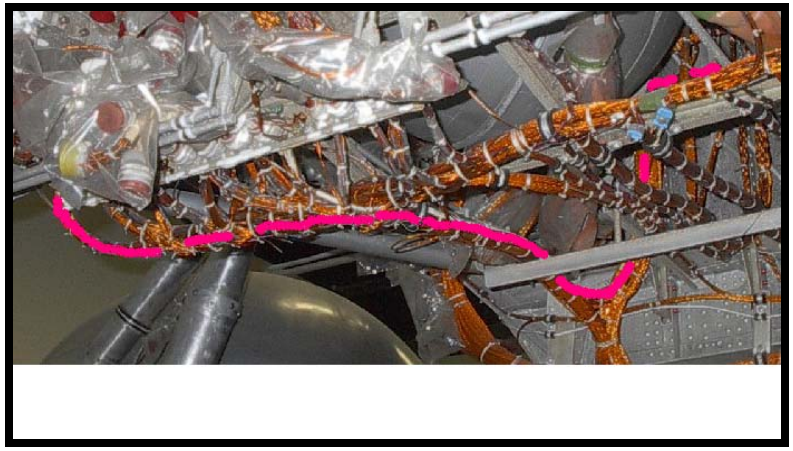
Protective covers.

Support harnesses.

Inadequate training.

Locate termination points more accurately.

Tooling boards made to include extensive 3-D fixtures.



Fabrication Problems

Wires wrong length.

Sharp edge damage.

Protective covers.

Support harnesses.

Inadequate training.

Tooling boards smoothed to avoid any sharp edges.

Fabrication Problems

Wires wrong length.

Sharp edge damage.

Protective covers.

Support harnesses.

Inadequate training.

Temporary protective covers added for completed sub-assemblies.

Fabrication Problems

Wires wrong length.

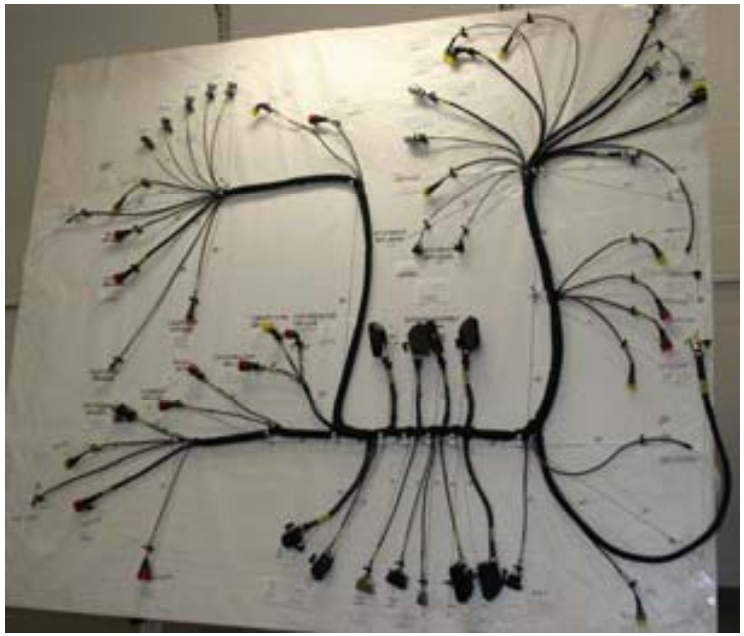
Sharp edge damage.

Protective covers.

Support harnesses.

Inadequate training.

Tooling aids improved to prevent damage during transport.



Fabrication Problems

Wires wrong length.

Sharp edge damage.

Protective covers.

Support harnesses.

Inadequate training.

Training improved for technical details to create consistent quality fabrication.

Pride in work quality.

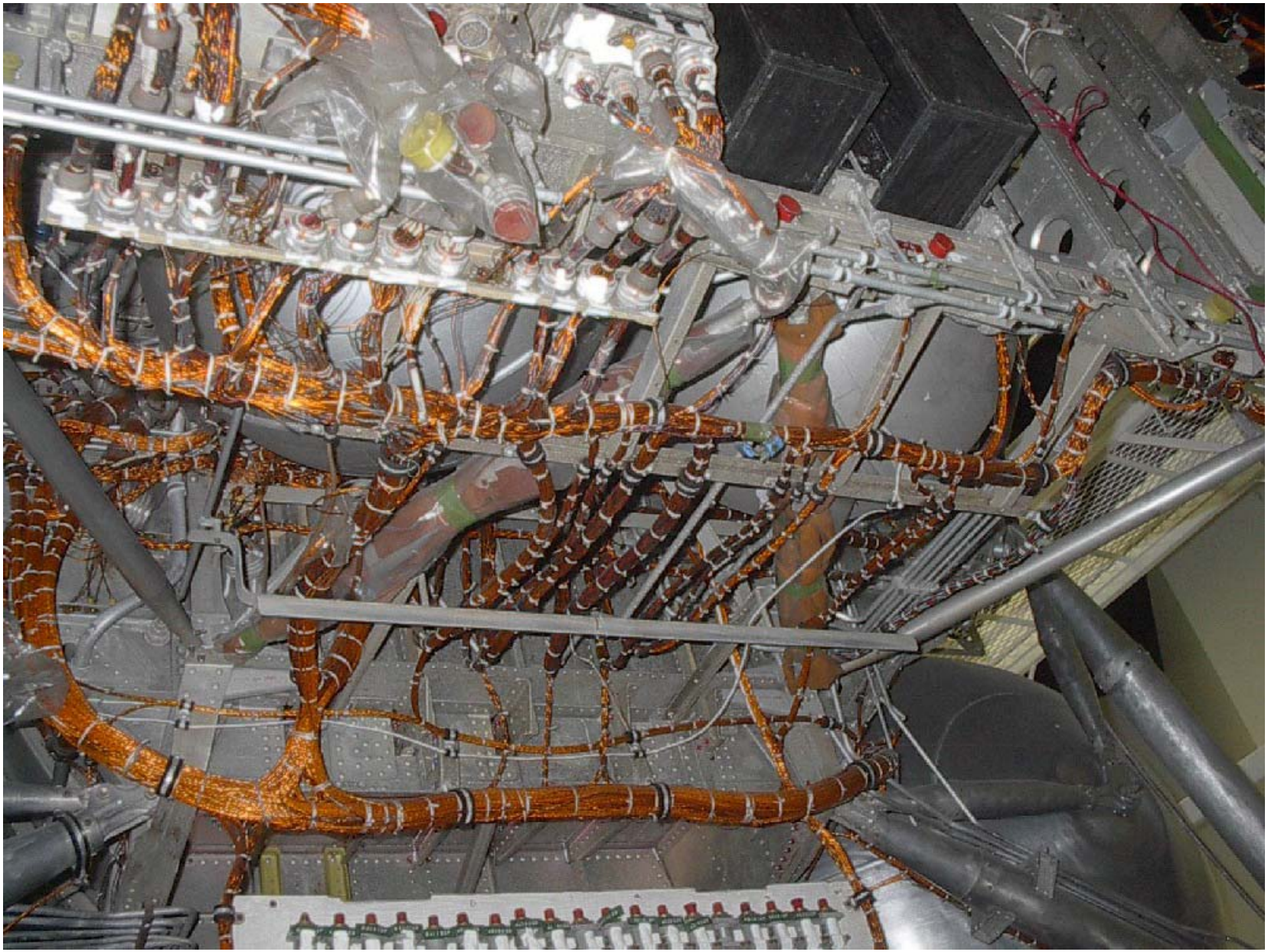
More frequent inspections.

Harnesses checked for electrical characteristics (continuity, conductor resistance, insulation resistance, dielectric strength)

Check before and after installation to locate errors and damage.

Check voltage not to exceed 75% of lowest-rated connector.

Wire Harness Installation



Damage from:

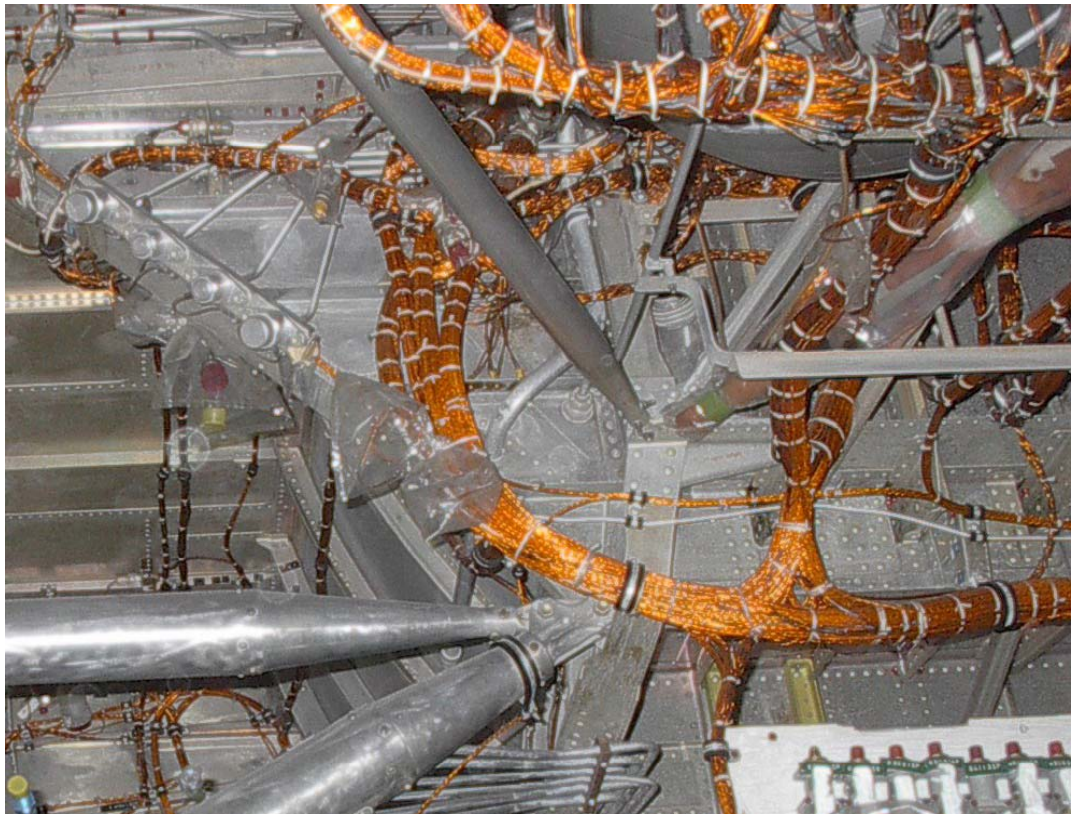
Sharp edges.

Work on adjacent harnesses.

Connector damage.

Breaking wires.

Chafe guards added to protect from sharp edges.



Damage from:

Sharp edges.

Work on adjacent harnesses.

Connector damage.

Breaking wires.

Permanent harness tray covers and temporary harness covers.

Damage from:

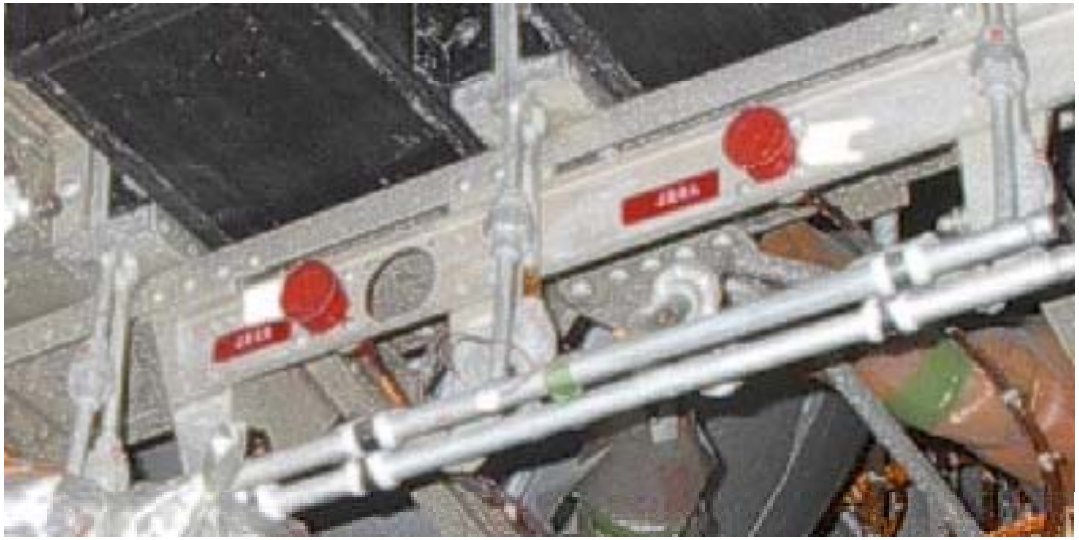
Sharp edges.

Work on adjacent harnesses.

Connector damage.

Breaking wires.

Connector protective covers.



Damage from:

Sharp edges.

Work on adjacent harnesses.

Connector damage.

Breaking wires.

Increased training and emphasis on quality awareness. The space race was on and America's pride was on the line.

No in-flight anomaly was attributable to problems with Lunar Module wiring, despite there being 22,900 m (75,000 ft) of wire in 20,000 segments in a Lunar Module.

Apollo-Era Engineering Suggestions for Future Programs

Use of plated conductors saves weight.

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Small-gage wiring is weaker; so, alloys such as Cu-Cr-Cd should be considered for strength.

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Silver gives lower resistance, but nickel withstands heat better.

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Small-gage wiring is weaker; so, alloys such as Cu-Cr-Cd should be considered for strength.

Silver gives lower resistance, but nickel withstands heat better.

Aluminum should be considered for large electrical busses for weight savings.

Polymer tape-wrap wire insulation is very light weight and effective.

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Other types of modern insulation might be more cost-effective.

Crimp splices are superior to solder splices.

- Lighter weigh
- Greater reliability
- Temperature independence

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- Lighter weight
- Greater reliability
- Temperature independence

Modular plug-ins to join multiple wires to a common point are more reliable, but heavier than crimp splices.

A rear environmental seal that does not require additional potting is preferred.

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Pins should be crimped or welded to the incoming wires and be removable from the rear of the connector.

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Apollo Experience Report -- Electrical Wiring Subsystem

Apollo Experience Report -- Lunar Module Electrical Power Subsystem