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**ORBITER KAPTON WIRE**  
**OPERATIONAL REQUIREMENTS AND EXPERIENCE**

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**LEWIS RESEARCH CENTER**  
**SPACE APPLICATION WIRING WORKSHOP**  
**JULY 23, 1991**

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213-922-3144

## **AGENDA**

- **ORBITER WIRE SELECTION REQUIREMENTS**
- **ORBITER WIRE USAGE**
- **FABRICATION & TEST REQUIREMENTS**
- **TYPICAL WIRING INSTALLATIONS**
- **KAPTON WIRE EXPERIENCE**
- **NASA KAPTON WIRE TESTING**
- **SUMMARY**
- **BACKUP DATA**

## **ORBITER REQUIREMENTS FOR GENERAL PURPOSE WIRE (6/73)**

- **MINIMUM WEIGHT WITHOUT COMPROMISING CONDUCTOR INSULATION INTEGRITY**
- **TEMPERATURE (OPERATING) -100°F TO 260°F**
- **NON-FLAMMABLE/NO OUTGASSING/NON-TOXIC**
- **RESISTANCE TO DAMAGE DURING & AFTER INSTALLATION**
- **NO DEGRADATION DUE TO VACUUM EXPOSURE**
- **COMPLIANCE WITH ELECTRICAL REQUIREMENTS**
- **PRODUCIBILITY-UTILIZATION OF STANDARD TOOLS & TECHNIQUES TO FABRICATE HARNESSES & TERMINATE WIRES IN CRIMP OR SOLDER CONNECTIONS AND MARKABILITY**
- **MINIMUM COST**

## WIRE PROPERTIES SUMMARY

















JUNE, 73

INSULATION PROPERTY	KAPTON	TEFLON TE	POLY-Y	TEFZEL	HALAR
<b>Physical</b>					
<b>Specific Gravity</b>	1.42	2.15	1.33	1.70	1.68
<b>Tensile/Yield</b>	19k/7.9k	3-5k	13.2k	6.5k/4.0k	5.26k
<b>Flex Life; Insulated Wire</b>	130 cycles	160 cycles	Not Tested	85 cycles	Not Tested
<b>Cut-Through Resistance 150°C</b>	pass	pass	pass	Fail	Fail
<b>Notch Sensitivity</b>	8.25kv at 4 mil cut In 6 mil Insul vs 49kv w/o cut	26kv at 4 mil cut In 10 mil Insul vs 34.2kv w/o cut	3kv 6 mil cut In 10 mil wall	Passes 60% Notch	No Data
<b>Wear Abrasion Resistance</b>					
<b>Scrape 25°C</b>	4k cycles  10 mils	5k cycles  12 mil	30 cycles  10 mil	No Data	No Data
<b>Tape 25°C</b>	3 Inches 1/4 lb load 	30 Inches 1/4 lb load	63 In 1 lb load	35 Inches	28.5 Inches
<b>Tape  25°C</b>	normal wt 6 Inches light wt 1 Inch	10 Inches	10.5 Inches	7 1/8 inches	Not Tested
<b>Thermal</b>					
<b>Service Temp</b>	200°C	250°C	200°C	150°C	165°C
<b>Melting Point</b>	None	327°C	365°C	271°C	245°C
<b>Flammability/Smoke</b>	pass	pass	pass	pass	pass
<b>Low Temp Embrittlement</b>	-65°C	-100°C	-65°C	-100°C	180° Bend @ -5°C per MIL- W-22759/13
<b>Low Temp Embrittlement (Note 1)</b>	pass -65°C	pass - 65°C	pass - 65°C	pass - 65°C	Not Tested
<b>Heat Distortion</b>	no change	no change	no change	no change	Not Tested
<b>Insul. Shrinkage</b>	no change	no change	no change	no change	Not Tested

Legend: Indicates data source - see enclosure

WIRE PROPERTIES SUMMARY (continued)

JUNE, 73

INSULATION		KAPTON	TEFLON TE	POLY-Y	TEFZEL	HALAR
PROPERTY						
<b>Electrical</b>						
Dielectric Constant		3.46	2.1	3.4	2.6	2.5
Dielectric Strength v/ml		2500 	1160 	1000 	1480 	1870
Insulation Resistance 25°C Megohm/1000 ft		3000 	2250 	5000 		2000 
175°C		12 	12 	50 	31 	
<b>Chemical</b>						
Water Absorption		1%-3% Note 1	0.1%	0.3% 	0.02%	0.01% 
Chemical Resistance		unaffected	unaffected	unaffected	unaffected	unaffected
to the following chemicals:						
1. Nitrogen Tetroxide						
2. MMH Hydrazine						
3. Skydrol 500A						
4. Aerosafe 2300						
5. Jet Fuel JP4						
6. Ethylene Glycol						
7. Freon						
8. Lube Oil						
<b>Wire Weight</b>						
		107%	124%	100%	Not Quoted	Not Quoted
<b>Cost</b>						
		100%	145%	142%	Not Quoted	Not Quoted

Note 1: Water absorption applies to Kapton mat'l. When fabricated into wire, an impervious top coat is added and provides a barrier to moisture.

## Data Sources

JUNE, 73

▷ LOCKHEED RPT. #24-004 Oct. 10, 1969

1. Cut-Through Resist:: Ref. P.24; Test - 10 mil radius blade forced .05 inch/min into insulation, record pounds req'd.
2. Notch Sensitivity: Ref. P. 23; Test - 4 or 65 mil razor cut then wrap over 1/4" diameter rod cut faces out, record dielectric breakdown volts - indicates decrease in effective insulation.
3. Wear Abrasion: Ref. P. 29; Test - 1kgm wt on 10 mil radius back-and forth, record cycles to fail. (scrape abrasion)

▷ DUPONT TEFZEL SPEC. SHT. APD #4 July 20, 1971

1. Wear Aprasion: Ref. P.3; Test - 1.0 lb vert wt on wire, 400 grit tape abrades wire.  
Record tape length upon contact with conductor.

▷ RAYCHEM SPEC. SHT. "COMPARATIVE TEST DATA - RAYCHEM TYPE 88 AIRFRAME WIRE"

1. Tape Abrasion: Test - 1.0 lb vert wt on wire 400 grit tape abrades wire. Record tape length upon contact with conductor.
2. Scrape Abrasiion: Test - 2.25 lb load on 5 mil flat edge on 90°wedge moved back-and-forth, record cycles to fail.
3. Cut-Through: Test - 5 mil flat on 90° wedge forced 0.2 in./min inot insul., record pounds to fail.

▷ McDAC RPT. MDC A0975 June 16, 1972

1. Cut-Through Resistance: Ref. P.9; Test - 90° edge .010 radius blade applied 205 grams/sec.

▷ ALLIED CHEMICAL CORP. "HALAR FLUOROPOLYMER RESIN" May 1, 1972

1. Chemical Resistance: See Page C-1 thru C-17
2. Flame/Smoke: Test - See Pages F-1 thru F-6

▷ RAYCHEM PAPER "A NEW EXTRUDED ALKANE-IMIDE WIRE" LANZA & HALPERN ATLANTIC CITY Dec. 3, 196-

▷ DUPONT TEFZEL SPEC. SHT. APD #1 February 1, 1971

▷ McDAC RPT. MDC A0515

1. Flex Life: Test plus/minus 90° over 1/8 mandrel

▷ DUPONT PAPER ON TEFZEL (STECCA, FASIG, CHEVRIER) ATLANTIC CITY December 3, 1970

▷ (Telecon) Ron Woloman, McDac/St Louis March 28, 1973

▷ ALLIED CHEMICAL CORP. DATA SHEET "HALAR - NEW GENERATION FLUOROPOLYMER"

▷ ALLIED CHEMICAL CORP. PAPER BY A. ROBERTSON & W. MILLER "HALAR FLUOROPOLYMER - A VERSATILE INSULATION FOR WIRE"

▷ RAYCHEM DATA - LETTER - C. HAWKINS TO J. D. DOYLE "POLYARLENE TYPE 88B WIRE & CABLE" - 5-9---

▷ JSC/HOUSTON: TEST DATA AVAILABLE AT A LATER DATE

▷ ROCKWELL MEMO: INSULATION ABRASION TEST/H. L. PORTIOUS D/098-411 TO J.E. WELLS D/060 DATED 10-18-72

▷ ROCKWELL L&T REPORT NO. LR9931-901 DATED MAY 1973

▷ ROCKWELL IL 044-110-73-4-11, EVALUATION OF SPACE SHUTTLE WIRE TYPES

▷ ROCKWELL IL M3-053-JEB-1881, SHUTTLE WIRE EVALUATION

## ORBITER WIRE USAGE

- **KAPTON IS PRIMARY WIRE USED ON ORBITER PROGRAM**
  - MIL SPEC 81381, RI SPEC MB0150-048
  - KAPTON PRIMARY INSULATION & OUTER JACKET
  - 26 TO "0" AWG SIZES USED
  - CURRENT CARRYING CHARACTERISTICS ESTABLISHED BY TEST, NASA-JSC, REPORT LEC-1756 & JSC-09156
- **TEFLON USED IN D&C PANELS & POWER & CONTROL ASSEMBLIES**
  - MIL SPEC 22759/12, RI SPEC MB0150-061
  - TFE TEFLON PRIMARY INSULATION
  - KAPTON OUTER JACKET
- **CONTROLLED IMPEDANCE USED FOR DATA BUS WIRE**
  - MIL SPEC 22759/23, RI MB0150-051
  - TFE TEFLON PRIMARY INSULATION
  - KAPTON OUTER JACKET
- **PFA USED FOR LARGE GAGE IN POWER & CONTROL ASSEMBLIES & EQUIPMENT BAYS**
  - MIL SPEC 22759, RI MB0150-062
  - PFA TEFLON PRIMARY INSULATION
- **MPS ENGINE CONTROLLER DATA BUS WIRE**
  - 40 M 50578B22-2SR

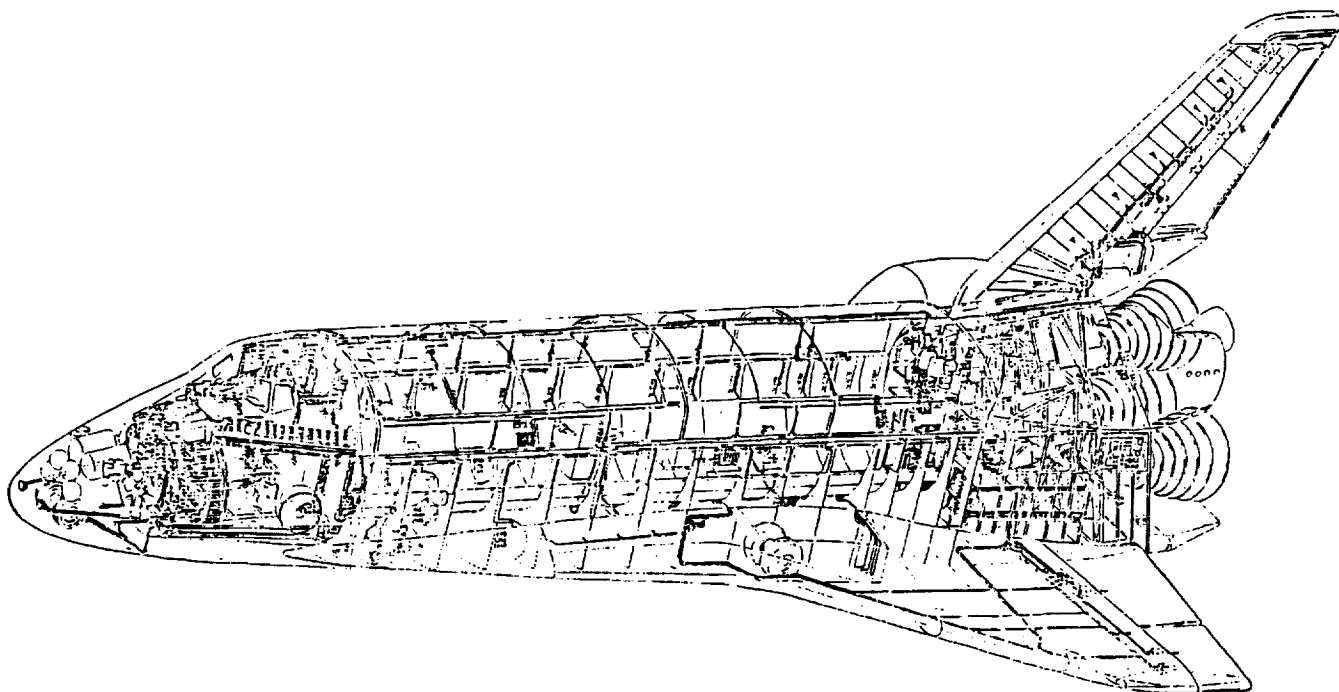
## ORBITER WIRE USAGE PER VEHICLE

• <b>ORBITER WIRE USAGE BY TYPE &amp; LENGTH</b>		
• KAPTON	- UNSHIELDED	577,900 FT.
	- SHIELDED	176,000 FT
	TOTAL	753,900 FT
• TEFLON	- UNSHIELDED	64,500 FT
	- SHIELDED	700 FT
	- PFA (LARGE GAGE)	1100 FT
• DATA BUS (2 CONDUCTOR SHIELDED)		32,600 FT
	TOTAL	98,900 FT
	GRAND TOTAL	852,800 FT
• VEHICLE WIRE SEGMENTS		83,000 SEGMENTS
• D&C PANELS & PWR & CONT. ASSY. WIRE SEGMENTS		32,000 SEGMENTS
	TOTAL SEGMENTS	115,000 SEGMENTS
• TOTAL VEHICLE WIRE WEIGHT (WITH CONNECTORS)		5,369 LBS
• DOES NOT INCLUDE D&C PANELS & PWR & CONT. ASSY'S.		

## FABRICATION & TEST REQUIREMENTS

- **HARNESSES FABRICATION**
  - **ORBITER MOCKUP BUILT FOR WIRING & PLUMBING**
    - **FLIGHT DECK & EQUIPMENT BAY HARNESSES BUILT ON 3D TOOL**
    - **ALL OTHER HARNESSES BUILT ON FLAT BOARDS**
  - **MECHANICAL STRIPPERS USED FOR KAPTON INSULATION**
  - **SLEEVES USED TO MARK WIRES**
- **HARNESSES TEST REQUIREMENTS**
  - **CONTRACT REQUIRES CONTINUITY & 1500 VDC HIGH POTENTIAL TEST AFTER INSTALLATION**
    - **MANUFACTURING PERFORMS SAME TEST ON EACH HARNESSES PRIOR TO INSTALLATION**
  - **AFTER POWER ON TESTING CONTINUITY REQUIRED ON ALL REWORK**
    - **HIGH POTENTIAL TEST ON DATA BUS & PYRO FIRING CIRCUITS**

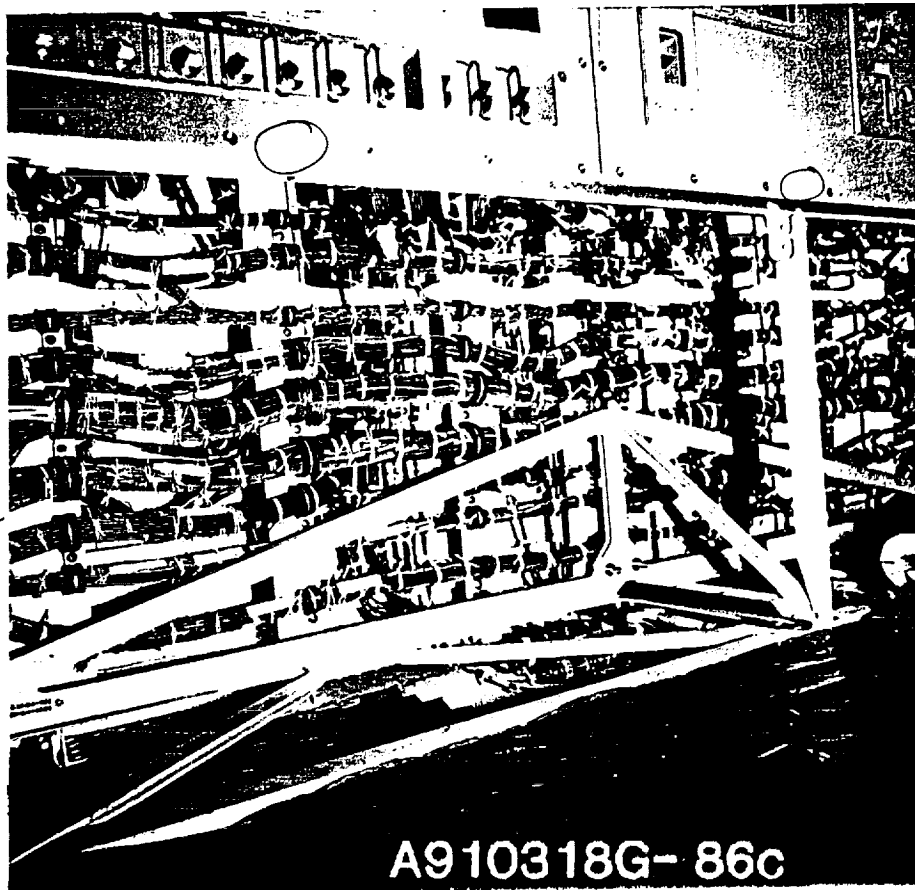
## ORBITER WIRE INSTALLATIONS



## CREW MODULE WIRING INSTALLATION

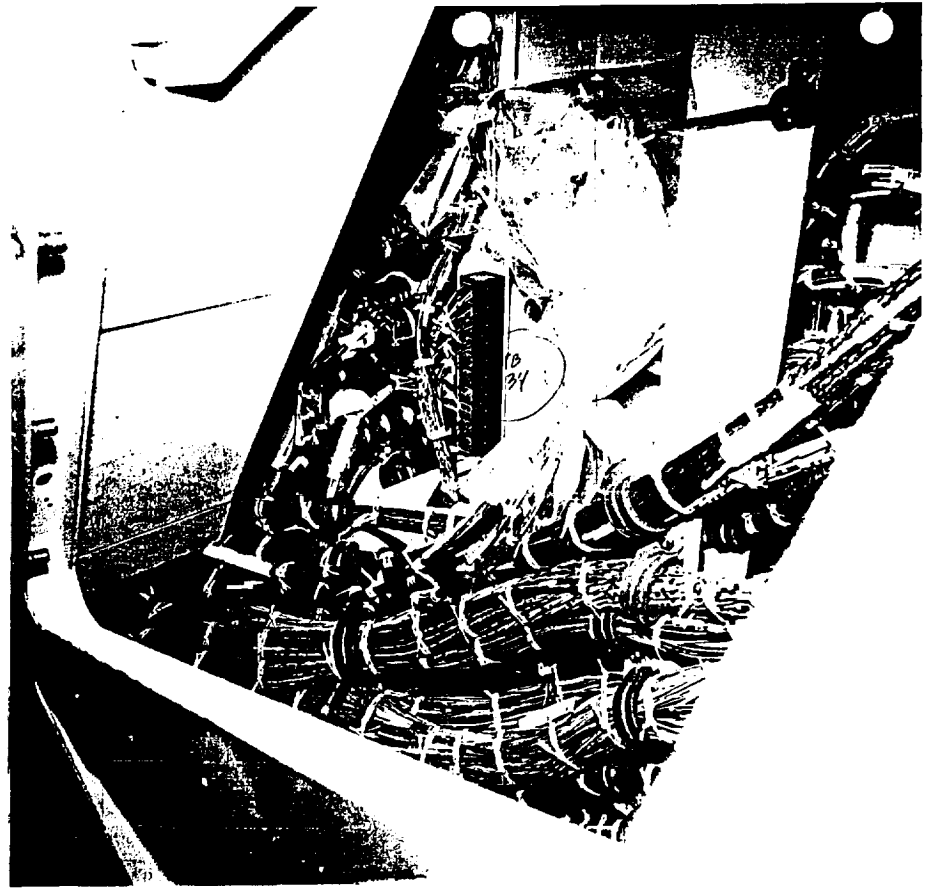
- FLIGHT DECK WIRE CONGESTED DUE TO QUANTITY OF WIRING REQUIRED FOR DISPLAY & CONTROL PANELS
  - LARGE WIRE BUNDLES BEHIND SECONDARY STRUCTURE, D&C PANELS & CLOSE OUT PANELS
- MID DECK EQUIPMENT BAYS HAVE LARGE QUANTITY OF WIRES
  - ROUTED IN WIRE TRAYS IN FRONT OF LRU'S
  - COVERS INSTALLED OVER BAYS
- ENVIRONMENTAL CONTROL BAY CONGESTED WITH WIRE ROUTING FROM EQUIPMENT BAYS THRU PRESSURE BULKHEADS

AFT  
FLIGHT  
DECK  
ON-ORB  
STA  
LKG AFT  
LOWER  
STOWAGE  
AREA





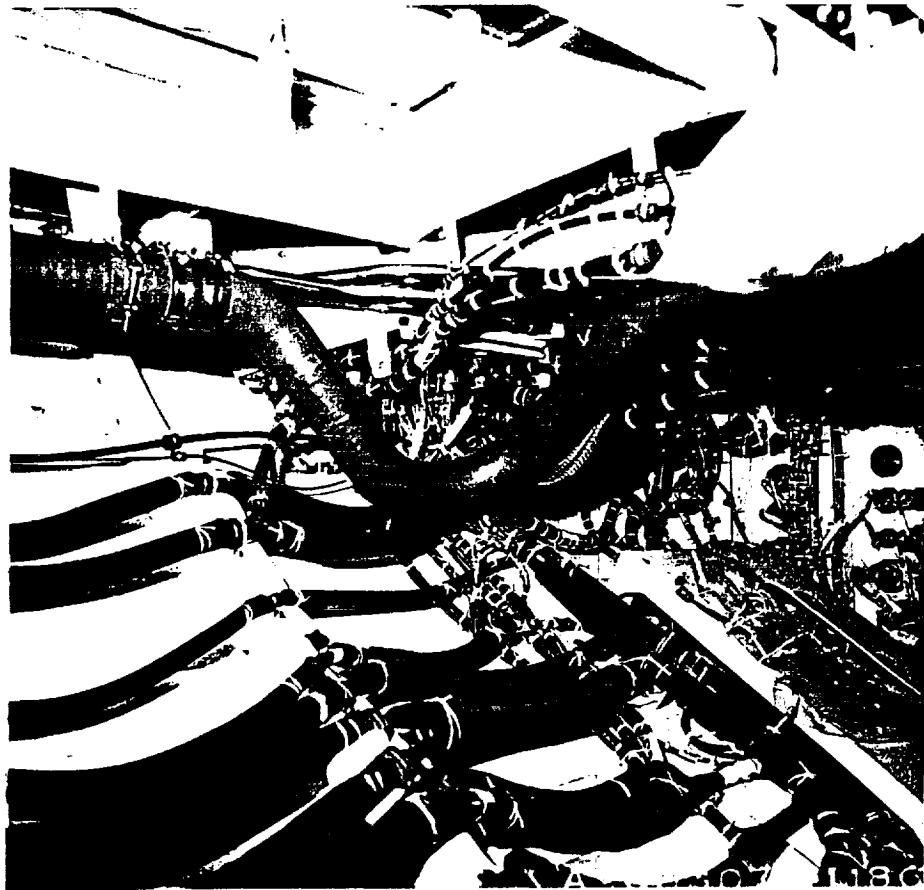
X6574  
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SIDE



AVIONICS  
BAY 1  
LKG FWD  
& OUTBD

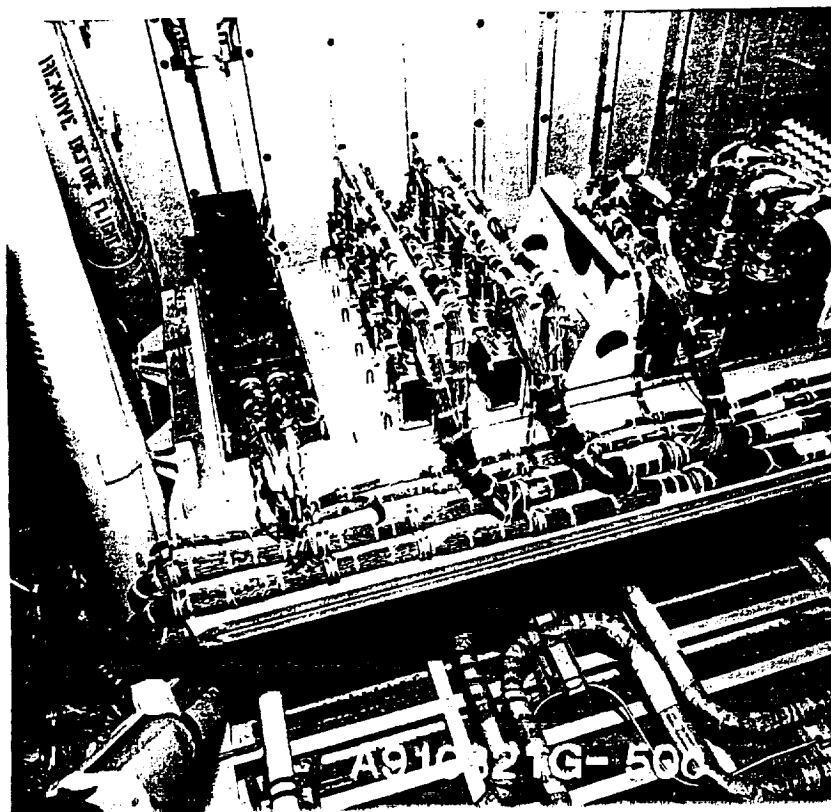
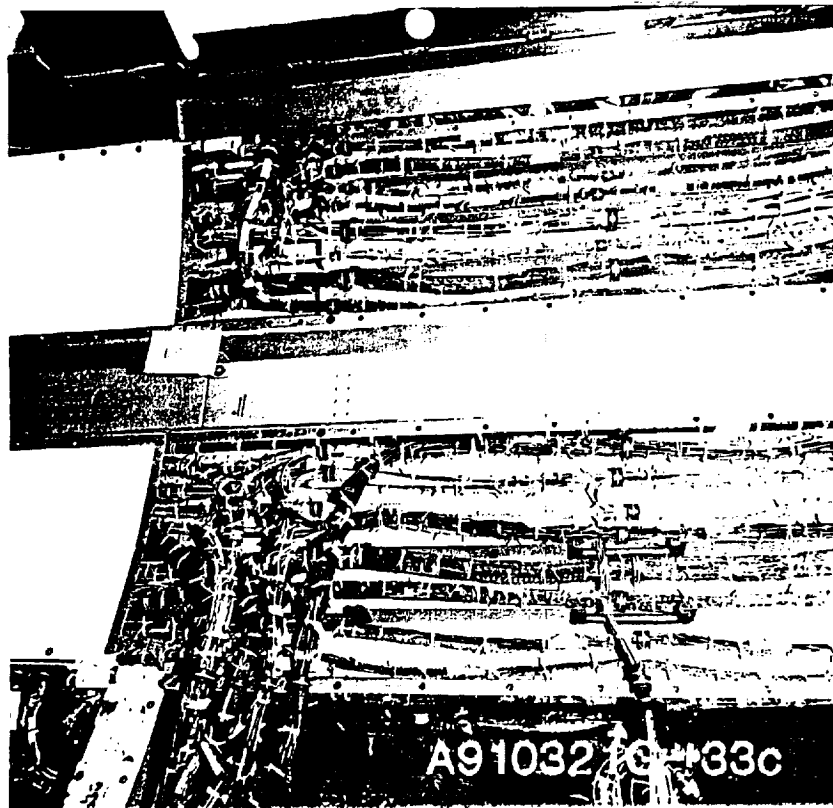


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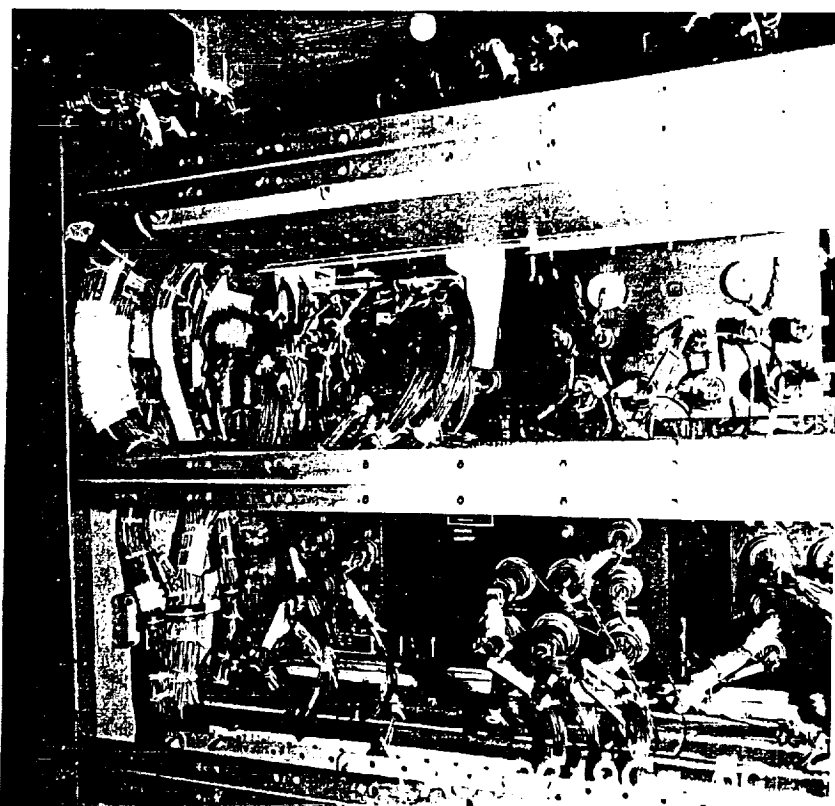
## MID FUSELAGE WIRE INSTALLATIONS

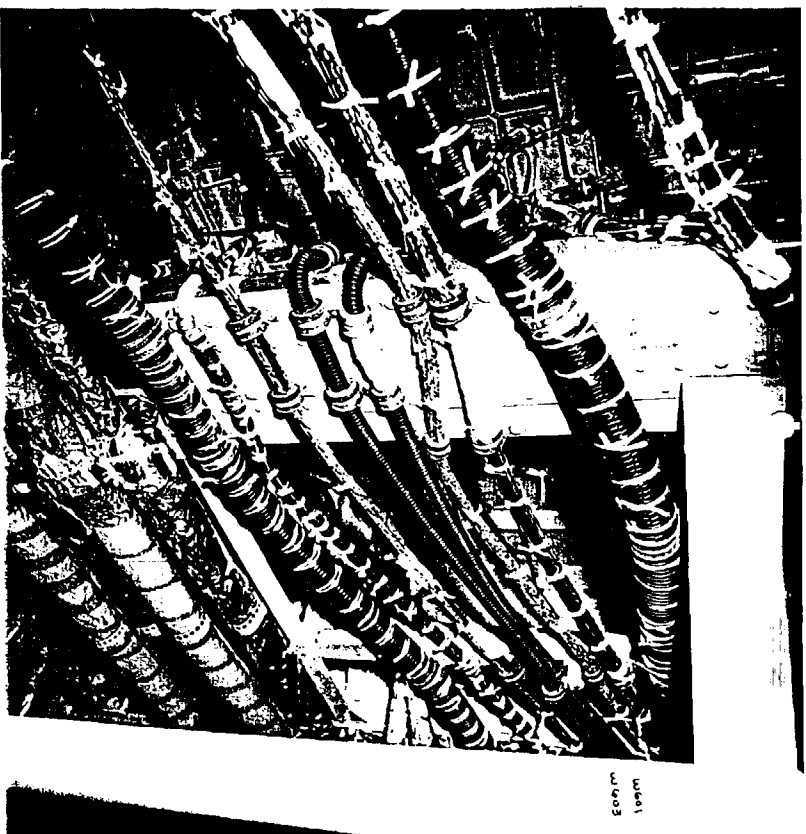
- WIRE TRAYS WITH COVERS ON EACH SIDE OF MID FUSELAGE
- WIRING TO EQUIPMENT PROTECTED FROM TRAFFIC
  - LINER CLOSES OUT LOWER PORTION OF BAY.
  - WIRING FOR PAYLOADS ABOVE LINER
    - TEFLON BRAID ON ALL HARNESSSES FOR ADDED PROTECTION



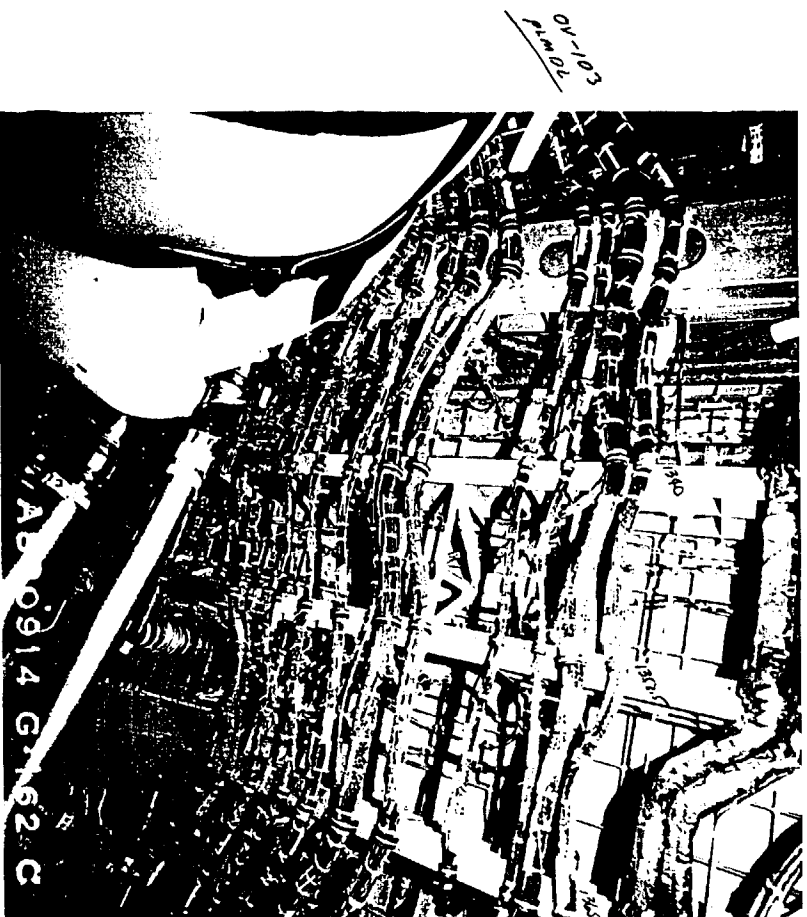
## AFT FUSELAGE WIRE INSTALLATION

- **EQUIPMENT BAYS HAVE LARGE QUANTITY OF WIRES**
  - **WIRE TRAYS IN FRONT OF LRU'S**
  - **COVERS INSTALLED OVER BAYS**
- **AFT FUSELAGE WIRING ROUTED ON SIDE WALLS**
  - **PERMANENT COVERS & CONVOLUTED TUBING ADDED IN HIGH TRAFFIC AREAS**
  - **WIRE TRAYS ORIGINALLY PLANNED BUT DELETED DUE TO WEIGHT**
  - **WORK STANDS ADDED/REMOVED EACH FLOW FOR ACCESS TO EXTERNAL TANK INTERFACES**



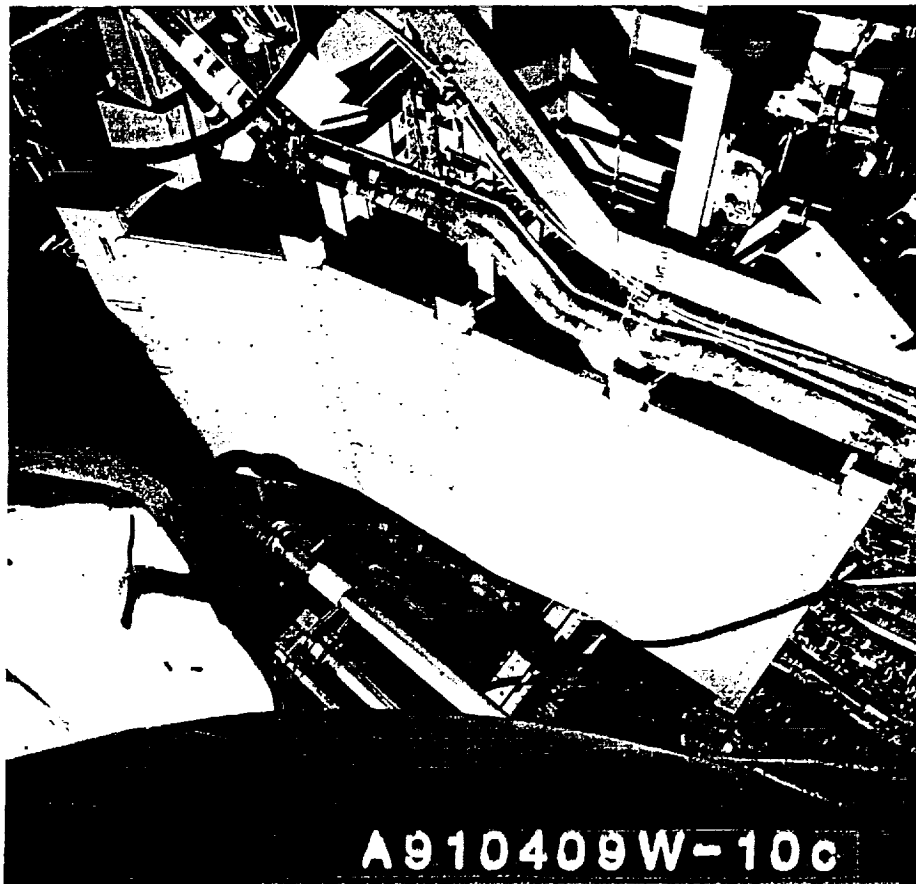


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## **KAPTON WIRE EXPERIENCE**

- **MANY ELECTRICAL SHORT CIRCUITS DUE TO INSULATION DAMAGE HAVE OCCURRED**
  - **PROTECTION DEVICES OPERATED AND INTERRUPTED FAULT CURRENT**
  - **ORBITER HAS EXPERIENCED TWO INSTANCES OF ARC TRACKING**
    - **OV-099 STS-6 HUMIDITY SEPARATOR WIRING**
      - **SIX CONDUCTORS MELTED THRU**
      - **ARCING INTERRUPTED BY FOUR CIRCUIT BREAKERS OPENING**
      - **CORRECTIVE ACTION PERFORMED TO VERIFY CLEARANCE OF ALL STORAGE CONTAINERS AND ADDITIONAL WIRE INSULATION PROTECTION INSTALLED**
    - **OV-102 STS-28 TELEPRINTER CABLE SHORT**
      - **ARC TRACKING OCCURRED FOR APPROXIMATELY 1.6 SECONDS UNTIL ARC EXTINGUISHED ITSELF AT BACK OF CONNECTOR**
      - **CIRCUIT BREAKER DID NOT OPEN**
      - **CORRECTIVE ACTION CHANGED HARNESS WIRES TO TEFLON INSULATION FOR GREATER FLEXIBILITY & USED 90° CONNECTOR AT PANEL INTERFACE**

## **KAPTON WIRE EXPERIENCE**

- **VEHICLE INSPECTIONS CONDUCTED TO REVIEW CONDITION OF KAPTON WIRE**
  - **11/6/89 NASA HEADQUARTERS, NASA JSC, NASA KSC, ROCKWELL & LOCKHEED PERSONNEL REVIEWED THREE VEHICLES AT KSC BECAUSE OF ARC TRACKING CONCERNS**
    - **INSPECTION INDICATED ORBITER WIRING WAS GENERALLY IN GOOD SHAPE**
  - **4/9/91 NASA JSC, NASA KSC, ROCKWELL & LOCKHEED INSPECTED OV-102 AFT FUSELAGE - FIRST VEHICLE DELIVERED AND FABRICATION OF HARNESSSES STARTED IN 1977**
    - **OVERALL CONDITION OF WIRING WAS VERY GOOD**
    - **SOME TWO CONDUCTOR SHIELDED CABLES IN HIGH TRAFFIC AREAS HAD TOP COAT CRACKS/FRAYING**
    - **SAW WHERE DAMAGED WIRES HAD BEEN REPAIRED IN HIGH TRAFFIC AREAS**
- **FLUID SPILLS**
  - **FIRST TEST VEHICLE HAD A HYDRAZINE SPILL WHICH CAUSED KAPTON INSULATION TO DETERIORATE**
  - **HYDRAULIC FLUID HAS NOT AFFECTED INSULATION**
- **PROTECT AGAINST DAMAGE**
  - **INSPECTIONS DURING BUILD PHASE TO IDENTIFY AND PROTECT AREAS OF POTENTIAL DAMAGE**
  - **TECHNICIAN TRAINING HAS BEEN EXPANDED TO STRESS IMPORTANCE OF PREVENTING DAMAGE**
  - **WIRING IS INSPECTED FOR DAMAGE AS PART OF CLOSEOUT OF AREAS REQUIRING WORK DURING TURNAROUND**
  - **ORBITER DESIGN REQUIREMENT ROUTE CRITICAL FUNCTIONS IN SEPARATE HARNESSSES**
    - **PRECLUDES SINGLE HARNESS FAILURE FROM CREATING A SAFETY OF FLIGHT CONDITION**
  - **WIRE COVERS BEING ADDED IN HEAVY TRAFFIC AREAS OF AFT FUSELAGE**
  - **CONVOLUTED TUBING ADDED IN AREAS WHERE DAMAGE OR POTENTIAL FOR DAMAGE HAS BEEN IDENTIFIED**

## **NASA KAPTON WIRE TESTING**

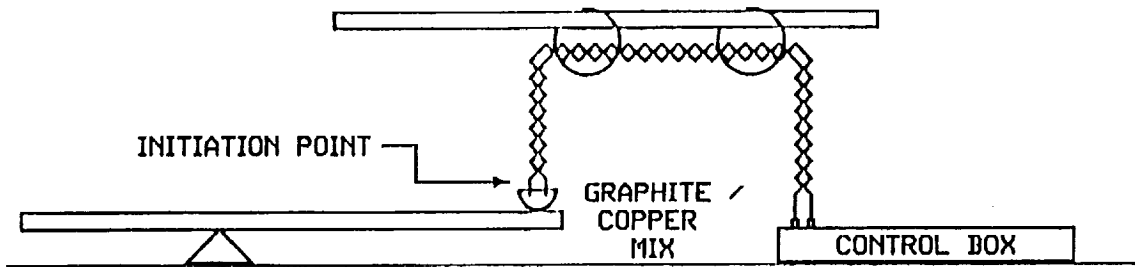
- **ARC TRACKING TESTS PERFORMED AT JSC IN THE ELECTRICAL POWER SYSTEMS LABORATORY**
- **TEST OBJECTIVES WERE:**
  - **OBTAIN DATA FROM TESTS PERFORMED ON KAPTON WIRE IN SIMULATED ORBITER CONFIGURATIONS**
  - **USE DATA TO ASSESS SAFETY OF ORBITER WIRE SYSTEM**
- **ARC TRACKING TESTS EVALUATED EFFECTS OF**
  - **WIRE SIZE/CONFIGURATION**
  - **ORBITER CIRCUIT PROTECTION DEVICES**
  - **AC/DC VOLTAGES**
  - **ARCING TO STRUCTURE**
  - **ELECTRICAL LOADING**
  - **INSTALLATION HARDWARE BUNDLING & ARC PROPAGATION**

## **RESULTS OF ARC TRACKING TEST**

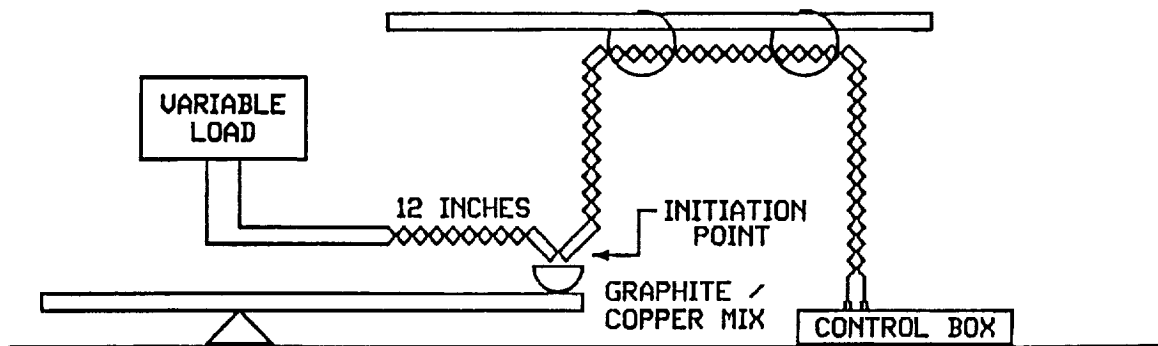
- **SUMMARY OF TESTS**
  - **CIRCUIT PROTECTION DEVICES, AS A RULE, DO NOT PROTECT AGAINST ARC TRACKING**
  - **RE-CLOSING OF TRIPPED CIRCUIT PROTECTION DEVICES REINITIATES ARC TRACKING**
  - **ARC TRACKING OF WIRE IN A BUNDLE CAUSES DAMAGE TO ADJACENT WIRING**
  - **THE HIGHER THE VOLTAGE, THE EASIER IT IS TO START ARC TRACKING**
    - **DISTANCE OF ARC TRAVEL APPEARS TO BE LESS BEFORE CIRCUIT PROTECTION OPENS**
  - **WIRE SIZE 4 AWG WOULD NOT TRACK**



## TEST SET-UP FOR TWISTED PAIR TESTING



## TEST SET-UP FOR TWISTED PAIR ELECTRICAL LOADING TESTING



## SUMMARY OF 28VDC ARC TRACK TESTS WITH PROPER SIZED CIRCUIT PROTECTION

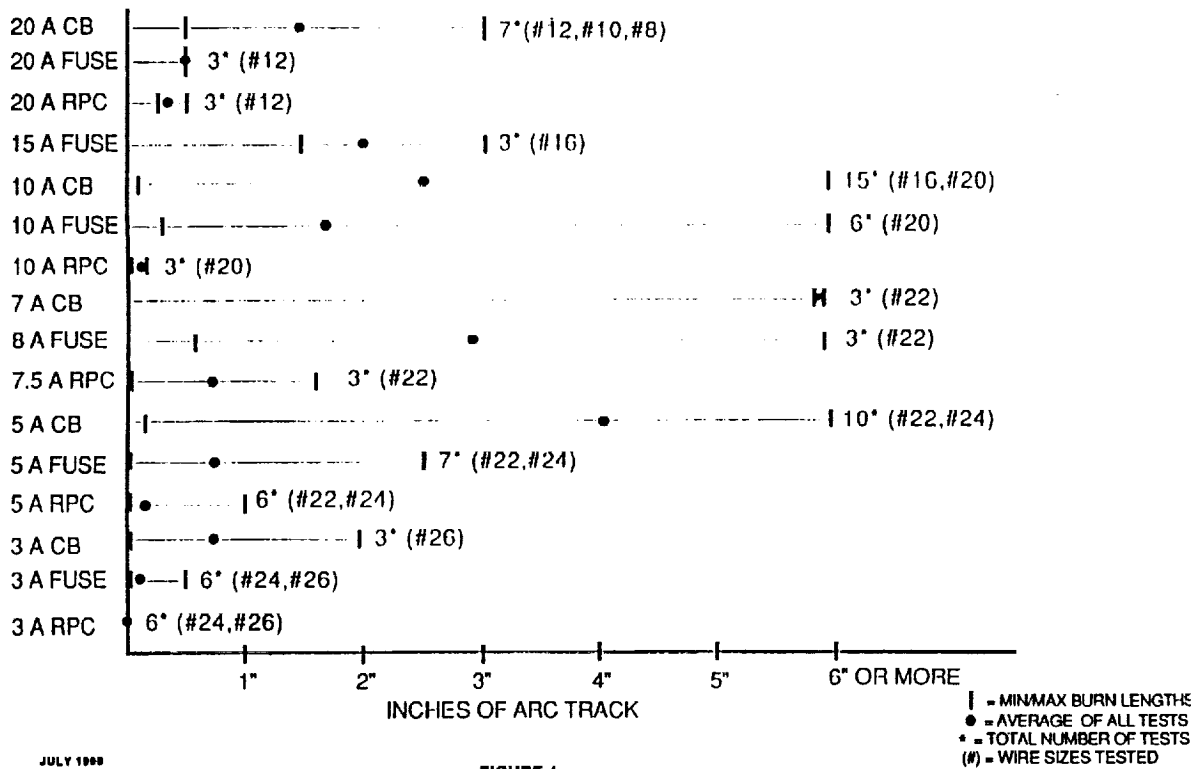


FIGURE 1

## SUMMARY OF 117VAC ARC TRACK TESTS WITH PROPER SIZED CIRCUIT PROTECTION

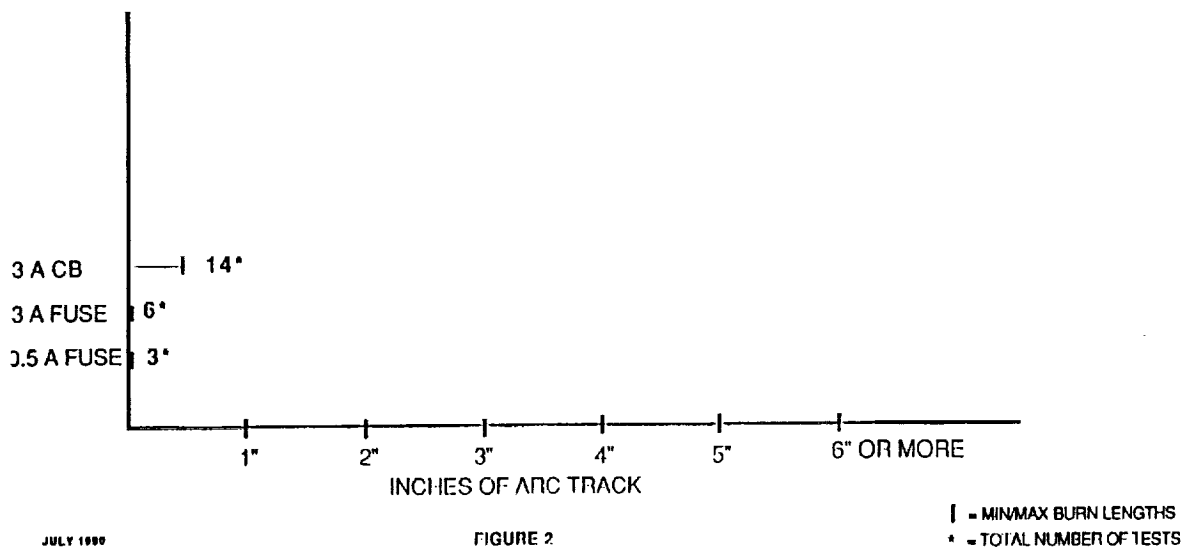


FIGURE 2

## SUMMARY

- INSPECTION OF FLEET SHOWS KAPTON WIRE IN GOOD CONDITION
  - FIRST SET OF HARNESS BUILT 1977
  - WIRE EXPOSED TO A RELATIVE BENIGN ENVIRONMENT
- TWO INSTANCES OF ARC TRACKING HAVE OCCURRED ON THE ORBITER
  - INSULATION MUST BE DAMAGED TO EXPOSE BARE CONDUCTORS
  - PROTECTIVE DEVICES LIMIT DURATION & EXTENT OF ARC TRACKING
- EXPOSED WIRING IN HIGH TRAFFIC AREAS HAS RESULTED IN NUMEROUS INSULATION DAMAGE
  - ON AN AVERAGE ONE SHORT CIRCUIT PER TURNAROUND HAS BEEN OCCURRING
  - EMPHASIS IS PLACED ON PREVENTING/LOCATING WIRE INSULATION DAMAGE
    - PHYSICAL PROTECTION
    - TECHNICIAN TRAINING
    - INSPECTION

## BACK UP

### 1500 VDC HIGH POTENTIAL TEST REQUIREMENTS 10/4/89 CONTRACTOR FURNISHED HARNESSSES

REQUIREMENT	<u>ORBITER</u>		<u>MISSION EQUIPMENT</u>		<u>PAYLOADS</u>	
	BENCH	INSTALLATION	BENCH	INSTALLATION	BENCH	INSTALLATION
• OVEI MJ070-0001-1C(JSC8080)		X		X		
• SEISMJ073-0001B(JSC8080)						X
• ROCKWELL SPECIFICATION ML0201-0003	1*	2	1	2	1 & 3	
• OMRSD FILE II VOLUME I S00 GEN. 410 (REWORK AND/OR REPAIR)		4				
• OMRSD FILE II VOLUME IV S0712A.717 (PAYLOAD & MISSION EQUIPMENT)			5		5	

\* NUMBERS REFER TO TEST REQUIREMENTS EXPLANATION

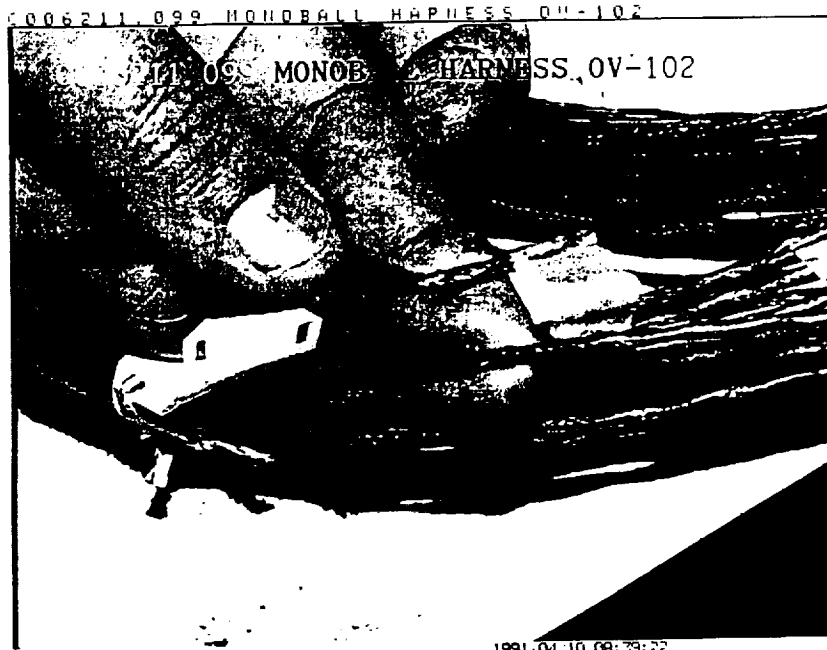
## 1500 VDC HIGH POTENTIAL TEST REQUIREMENTS 10/4/89

1. SPECIFICATION STATES BENCH LEVEL TEST IS OPTIONAL EXCEPT FOR OPERATIONAL SPARE WIRES WHICH IS MANDATORY PRIOR TO INSTALLATION. MANUFACTURING HAS CHOSEN TO TEST ALL HARNESSSES AT THE BENCH LEVEL.
2. SPECIFICATION STATES TEST MANDATORY AFTER INSTALLATION. AFTER POWER ON TEST IT IS MANDATORY THAT TEST BE RUN ON ALL REWORKED DATA BUS, CONTROLLED IMPEDANCE, AND PYRO FIRING WIRES. SOME MISSION EQUIPMENT HARNESSSES ARE INSTALLED DURING ORBITER ASSEMBLY AND NEVER REMOVED.
3. TEFLON WIRE USED FOR HARNESSSES AND MID FUSELAGE HARNESSSES HAVE AN OVERBRAID WHICH REQUIRE HIGH POTENTIAL TEST PRIOR TO AND AFTER BRAIDING.
4. TEST REQUIRED ON REWORKED AND/OR REPAIRED WIRES IS LIMITED TO DATA BUS CABLES, CONTROLLED IMPEDANCE CABLES AND PYRO FIRING WIRES OR CABLES.
5. TEST REQUIRED ON ALL PAYLOAD RELATED KITS. LOCKHEED (SPC) HAS REOCCURRING DOCUMENT OMI V1199 THAT REQUIRES TEST TO BE RUN AT KITTING FACILITY PRIOR TO EACH INSTALLATION.

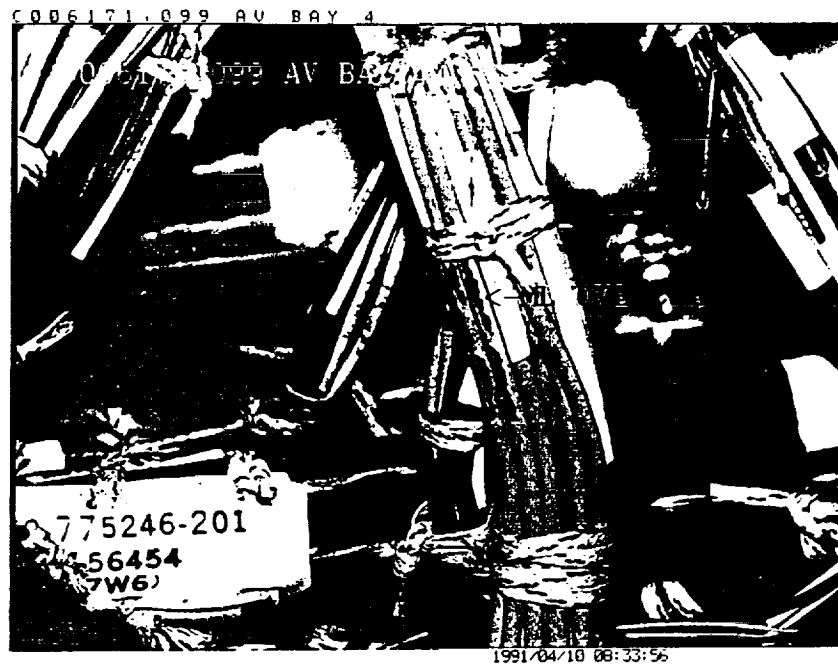
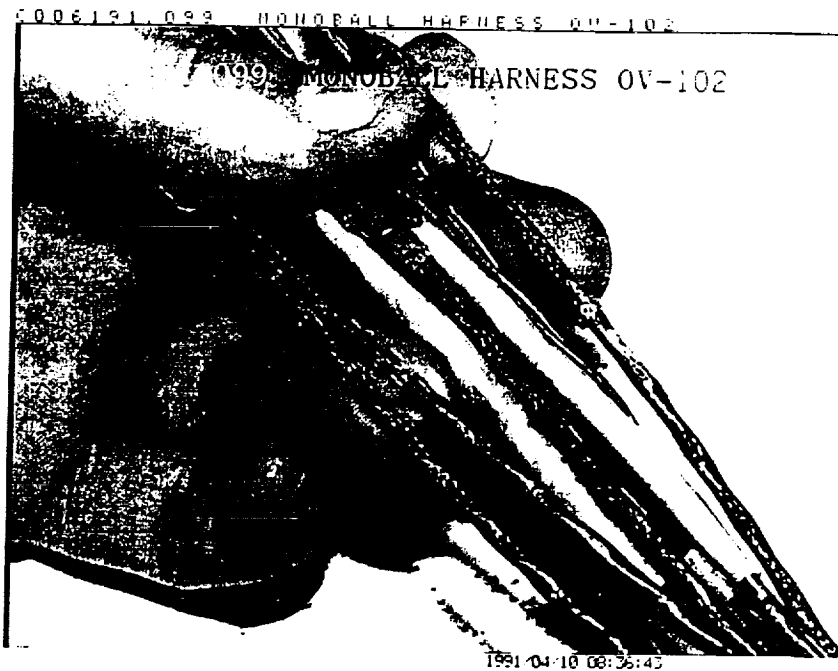
### COMPARISON OF TEFZEL, TEFLON AND KAPTON

	XL-ETFE	TFE	KAPTON
CUT-THROUGH RESISTANCE	GOOD	FAIR	EXCELLENT
ABRASION RESISTANCE	EXCELLENT	FAIR	EXCELLENT
FLEXIBILITY/ HANDLING	GOOD	EXCELLENT	POOR
ARC-TRACKING RESISTANCE	EXCELLENT	EXCELLENT	POOR
WEIGHT	GOOD	FAIR	EXCELLENT
MOISTURE RESISTANCE	EXCELLENT	EXCELLENT	GOOD
COLD-FLOW RESISTANCE	GOOD	FAIR	EXCELLENT
TEMPERATURE RANGE	GOOD	EXCELLENT	EXCELLENT
OUTGASSING	EXCELLENT	EXCELLENT	EXCELLENT
FLAMABILITY	GOOD	EXCELLENT	EXCELLENT
COLORABILITY	EXCELLENT	EXCELLENT	POOR

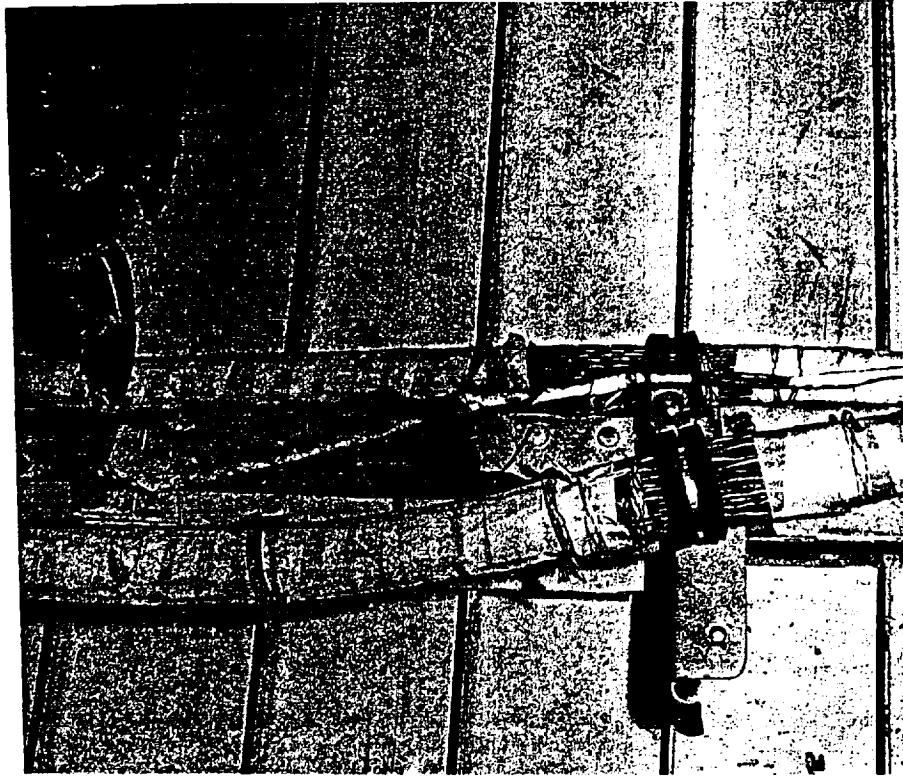
# TYPICAL COSMETIC WIRE DAMAGE FOUND DURING 4/91 REVIEW OF OV-102



# TYPICAL COSMETIC WIRE DAMAGE FOUND DURING 4/91 REVIEW OF OV-102



OV-099, STS-26 HUMIDITY SEPARATOR  
DAMAGED WIRING



\*1 MOTOR WIRE

↑  
CANN  
10X

