F-16 System Program Office

Fighter of Choice!

BELL LAB'S CORROSION PREVENTIVE COMPOUND (MIL-L-87177A GRADE B)

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NDIA SYS ENG CONF 24 OCT 2001

BELL LAB'S CPC

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4. BATTELLE RSRCH; CPC SPRAYED F-16 AVIONICS GOLD/GOLD LRU CONNECTORS; RELIABILITY+ & MC RATE +, MMH & COSTS TRACKED THRU REMIS;
5. CURRENT ACTIONS & RECOMMENDATIONS.

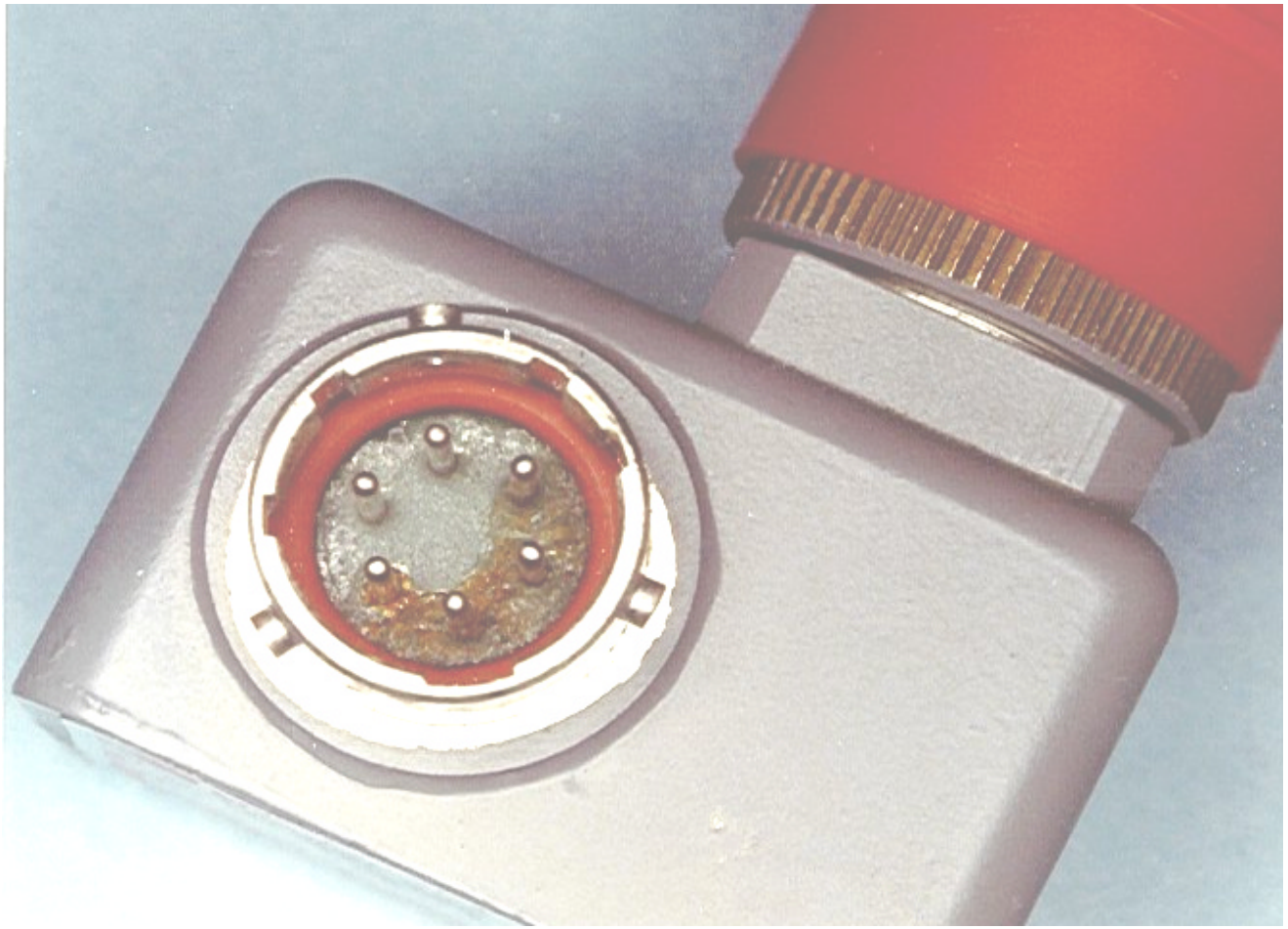
BELL LAB'S CPC

- ELECTRONIC EQUIPMENT FAILURES PLAGUED BELL SYSTEM AT BOTH AREAS PERCEIVED OK ENVIRONMENTALLY AND KNOWN CORROSIVE, i.e.
  - SNOWCAT TO MONTANA MICROWAVE TOWERS,
  - FREQUENT FAILURES AT COSTAL ENVIRONS EVEN WITH GOLD/GOLD CONTACTS;
- CHEM ENG INVENTED A CORROSION PREVENTIVE COMPOUND (CPC) TO IMPROVE RELIABILITY;
- AIR FORCE MATERIALS LAB (NOW AFRL) WROTE MIL-L-87177 TO DESCRIBE THE BELL LABS CPC.

BELL LAB'S CPC
1. SEARCH FOR MFSOV CLOSURE CAUSES

-MFSOV UNCOMMANDED CLOSURES PUZZLED AF SINCE F-16 PRE-PRODUCTION!
-MFSOV WIRED TO *OPEN* DURING FAILSAFE MODULE MFG; REPORTED ANOMOLIES STOPPED; PIN CORROSION SEEN.
-AFTER MODULE INSTALLATION ANOMOLIES CONTINUED.
-GD REPORT NOTED AU/SN CONNECTOR SETS AS OK.
-ARMY CORROSION ENGINEER RECOMMENDED USE OF POLYALPHAOLEFIN MIL-L-87177 FOR DISSIMILAR METALS.
-TCTO, TREAT MFSOV CONNECTORS WITH MIL-L 87177.
-MFSOV ANOMOLIES CEASED FOR ABOUT 7-MONTHS.
-F-16 SM TASKED BATTELLE TO STUDY MFSOV CONTROL CIRCUITRY TO EVALUATE POSSIBLE CAUSES AND FIXES.
-BATTELLE REPORTED FRETTING CORROSION.

BELL LAB'S CPC
1. SEARCH FOR MFSOV CLOSURE CAUSES



- **FAILSAFE MODULE CONNECTOR CORROSION**

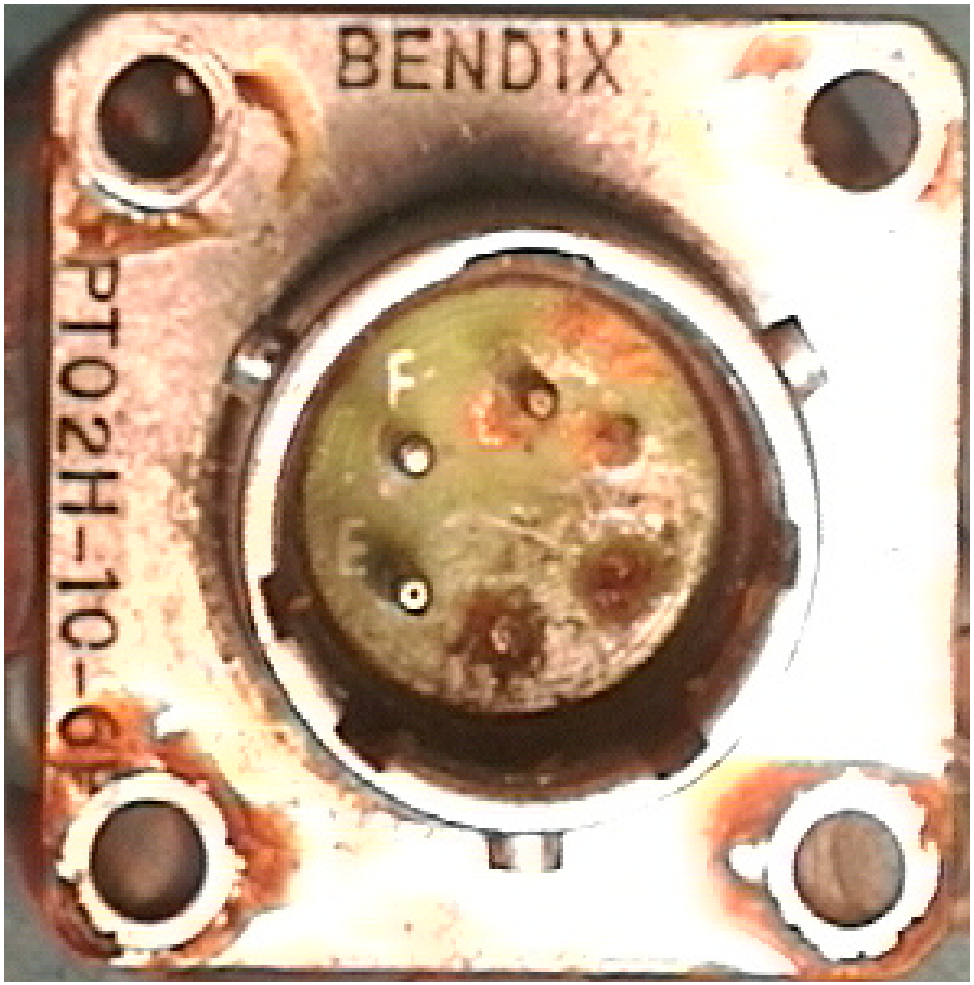
1. SEARCH FOR MFSOV CLOSURE CAUSES

BATTELLE REPORT: 1. *FRETTING* =CAUSE OF ELECTRICAL CONNECTOR CORROSION, & 2. STICKING LIMIT SWITCHES

1. DESCRIPTION OF FRETTING CORROSION:

- TIN REACTS LIKE ALUMINUM WITH O_2 TO FORM SnO_2
- TIN OXIDE DOES NOT ADHERE TIGHTLY TO BASE TIN
- EVEN SOFT MATERIALS CAN WIPE SnO_2 OFF BASE METAL
- NEWLY EXPOSED TIN QUICKLY OXIDIZES AGAIN
- SnO_2 NOT EASILY DIFFERENTIATED FROM BASE METAL
- SnO_2 ON TIN SURFACE HOLDS CONTACTS APART=HIGH R
- WHEN VIBRATION EXISTS SnO_2 BREAKS AWAY
- COATING TIN WITH AN O_2 BARRIOR STOPS FRETTING
- LIGHT OIL=EXCELLENT O_2 BARRIOR & VIBRATION LUBE
- GALVANIC CORROSION AFTER TIN PLATE GONE =RUST

BELL LAB'S CPC
1. SEARCH FOR MFSOV CLOSURE CAUSES



- MAIN FUEL SHUTOFF VALVE ACTUATOR TIN PIN CONNECTOR CORROSION (MATES WITH GOLD SOCKETS ON HARNESS CONNECTOR)
- ACTUATOR SENT TO BE OVERHAULED…BASE NOT IDENTIFIED

BELL LAB'S CPC
1. SEARCH FOR MFSOV CLOSURE CAUSES

- SAME CONNECTOR
  - DIFFERENT VIEW
- ONE MORE THIN PIN
- PINS LEFT ARE
  - GROUND
  - BLANK

BELL LAB'S CPC

1. SEARCH FOR MFSOV CLOSURE CAUSES

BATTELLE REPORT:

1. ELECTRICAL CONNECTOR CORROSION CAUSE WAS *FRETTING.*

2. LIMIT SWITCHES STICKING IN THE *OPEN* POSITION BLOCKED CURRENT TO THE OPEN WINDINGS.

- LIMIT SWITCHES MOTOR DRIVEN *OPEN* MECHANICALLY.
- SPRING LOADED TO *CLOSE* TO DRIVE MOTOR TO "OPEN."
- SILICON CONTAMINATED LIMIT SWITCH=HIGH FRICTION SO THAT SWITCHES STICK IN *OPEN* POSITION.

3. SILICON CONTAMINATED CONTACTS=HIGH RESISTANCE

BELL LAB'S CPC
2. WPAFB FACTS OFFICE STUDY

- BATTELLE TESTED EFFECTIVENESS OF 12 DOD USED "CPCs" IN LAB (NaCl Cabnt) & AT 10 LOCATIONS:

-SPRINGFIELD ANGB, OH;
- ELLINGTON ANGB, TEXAS;
-BATTELLE, FL; MARINE RSRCH, DAYTONA BEACH;
-BATTELLE, FL; MARINE RSRCH, LAB @ TIDAL RIVER;
-HILL AFB, UT; INSIDE ACFT REPAIR HANGAR, 2 SITES
-SHAW AFB, SC; OPEN HANGAR AT END OF RUNWAY;
-MONTANA ANG, GR.FALLS I.A. SHELTERED AREA;
-TINKER AFB, OK; INDUSTRIAL WASTE TREATMENT PLANT (2) METALS TREATMENT AREA & CHEM FEED

BELL LAB'S CPC
2. WPAFB FACTS OFFICE STUDY

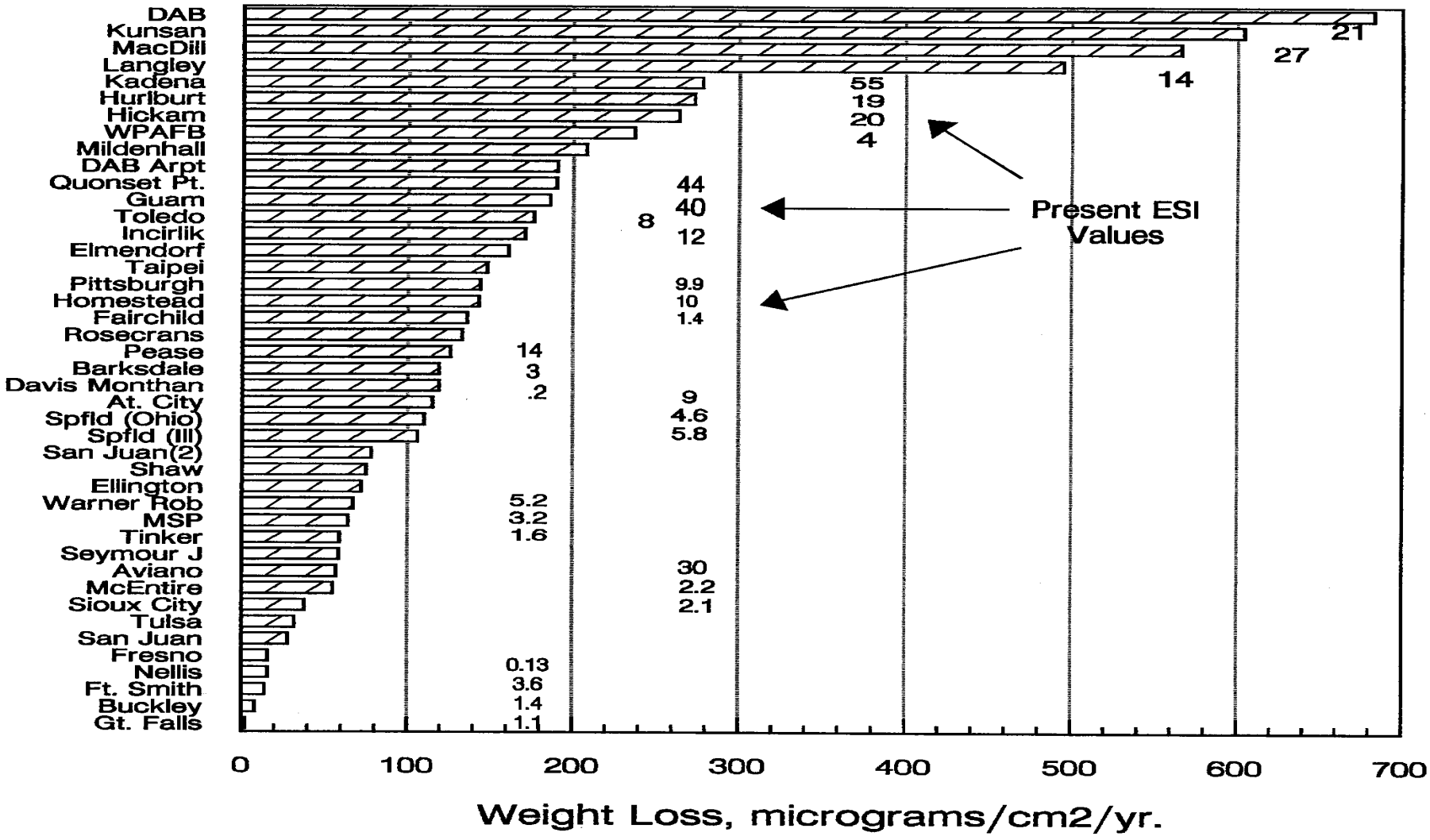
-RESEARCH TEST ITEMS:

-MILD STEEL TEST PLATES;

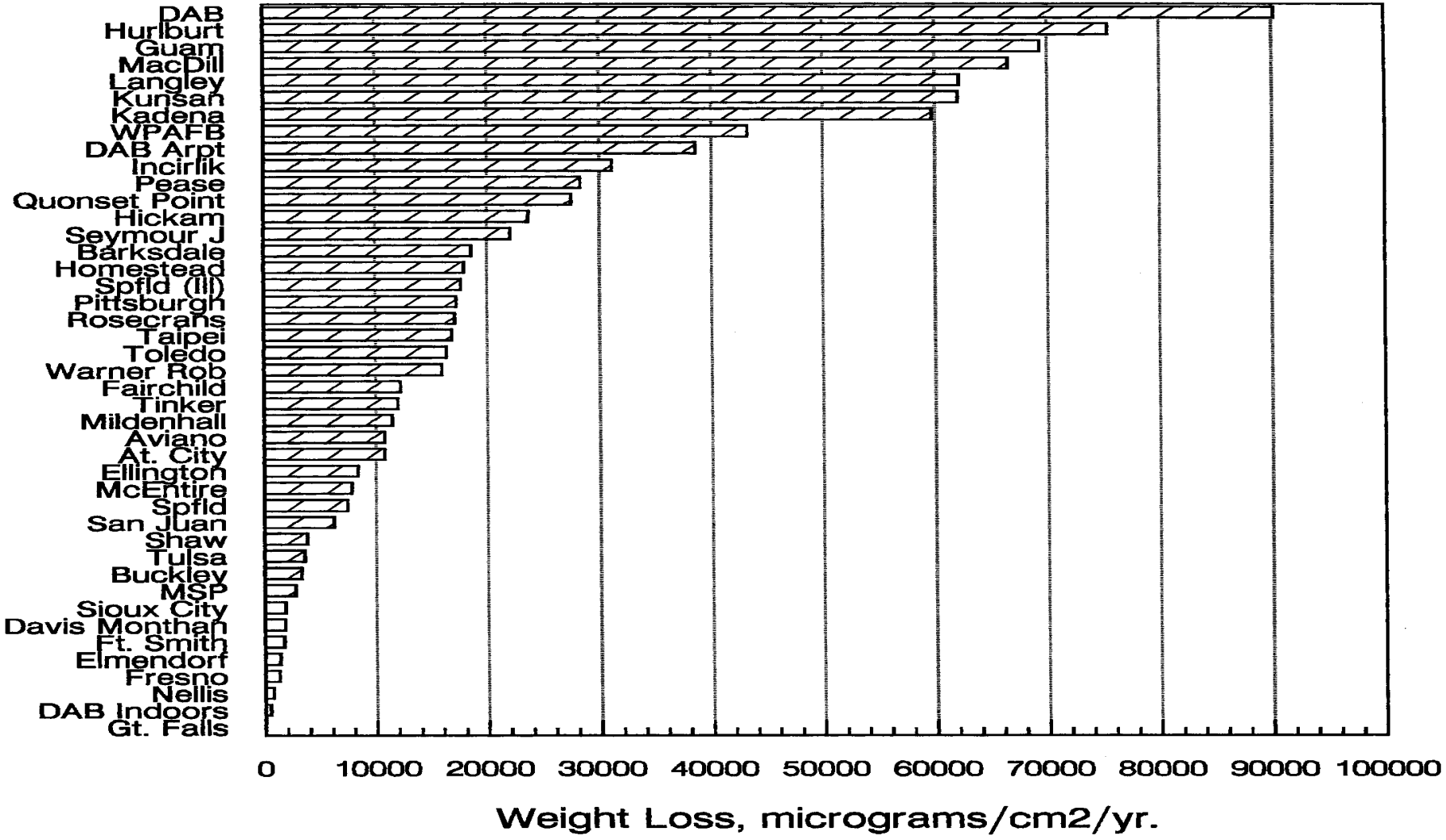
-AMPHENOL 50-POSITION DOUBLE SIDED CARD EDGE CONNECTORS (60-m" NICKEL, 30-m" HARD GOLD) OVER OXYGEN FREE HIGH CONDUCTIVITY COPPER;

-CORROSION SENSORS: 1010 STEEL, 6061, Ag, Cu, & 7075

6061 ALUMINUM WEIGHT LOSS AT OUTDOOR FIELD SITES: 90-365-DAY EXPOSURES NORMALIZED TO 1-YEAR



1010 STEEL WEIGHT LOSS AT OUTDOOR FIELD SITES: 90-365-DAY EXPOSURES NORMALIZED TO 1-YEAR



BELL LAB'S CPC
2. WPAFB FACTS OFFICE STUDY

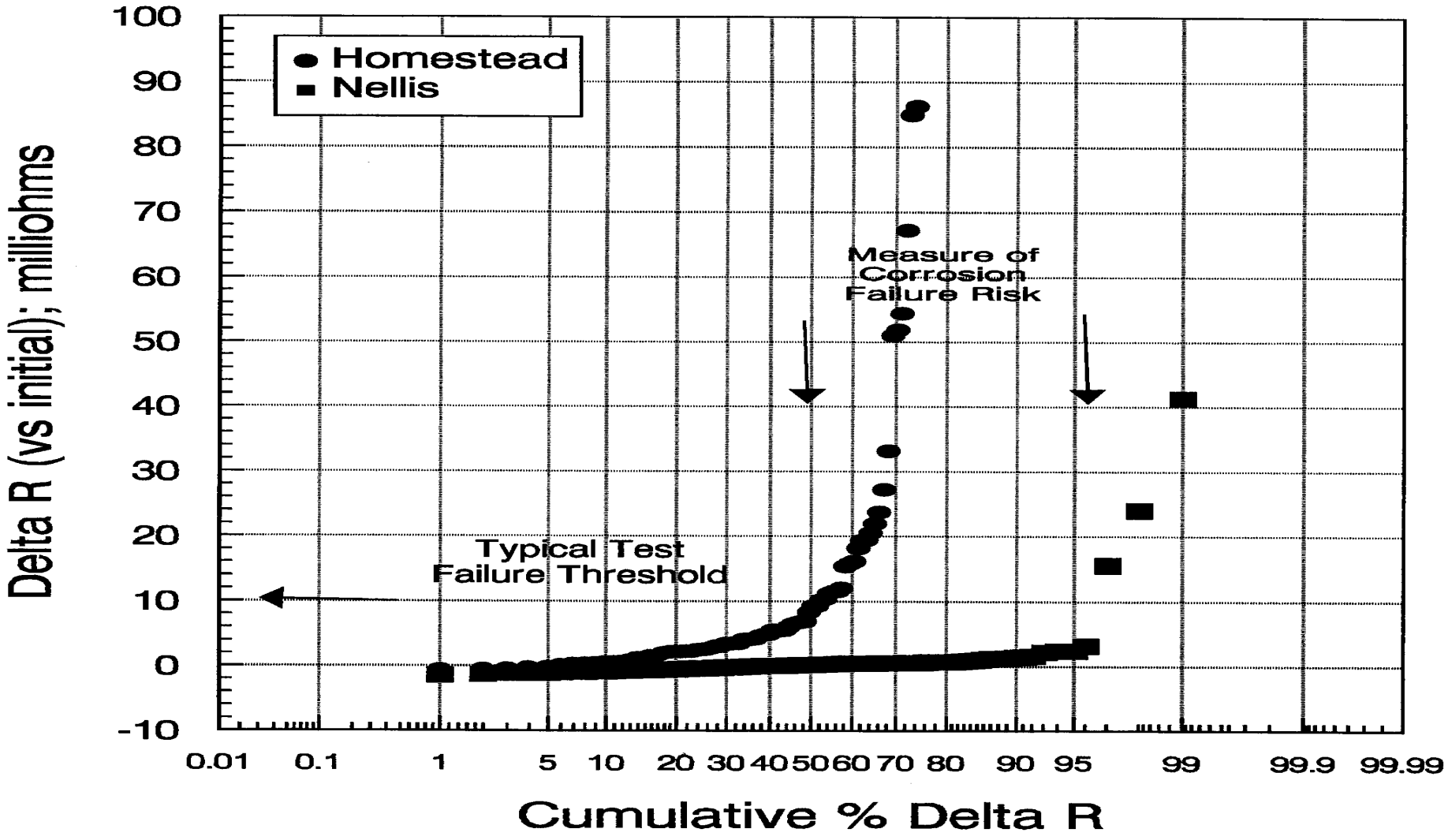
- SIX DOD USED CPCs ACCELERATED CORROSION IN SOME TESTS
  - FIVE QUALIFIED UNDER MIL-C-81309E;

- TWO EXCELLENT LUBES CHOSEN FOR F-16 FLIGHT TESTS
- MIL-L-87177A GRADE B TYPE 1 NSN 6850-01-328-3617 (16-OZ SPRAY CAN) LEKTRO TECH, INC., TAMPA, FL
- P/N D5026NS, ZIP CHEM, SAN JOSE, CA; QUALIFIED TO MIL-C-81309 TYPE II CLASS 2 (LOW FLASH POINT)

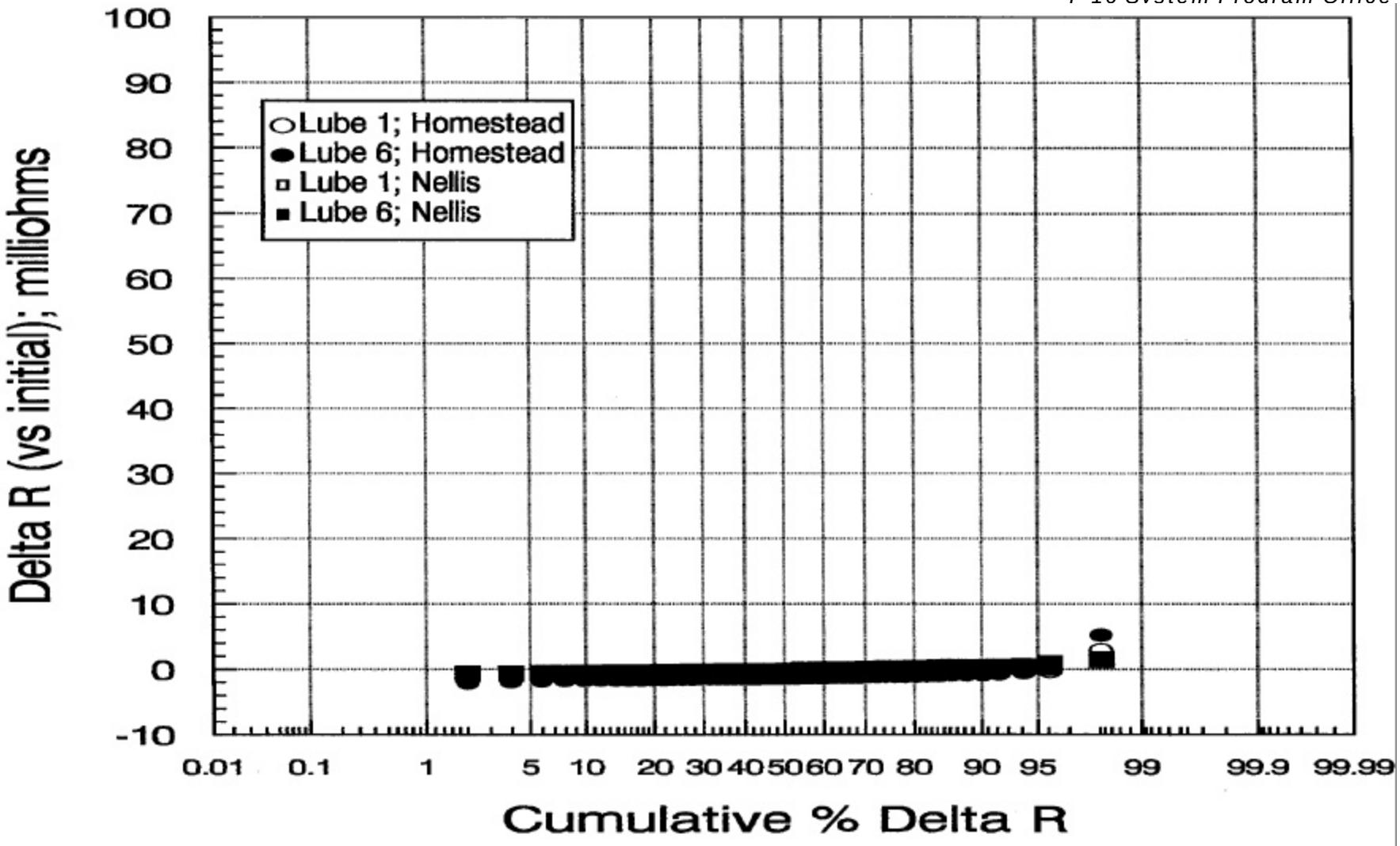
BELL LAB'S CPC
2. WPAFB "FACTS OFFICE" STUDY

ID	P/N	MFG	SPEC, TYPE,GRADE	RATED
1.	**D5026NS**	**ZIP CHEM**	**81309 II**	**EXCEL**
2.	**So-Sure**	**LHB Industries**	**81309 III**	**V GOOD**
3.	Spray 706 *	Sprayon Products	81309 II	Not Recom
4.	ACF 50 **	Lear Chem Resrch	81309 II	Not Recom
5.	CRC 3-6 **	CRC Industries	81309E III	Not Recom
6.	**Super Corr B**	**Lektro Tech, Inc**	**87177A I,B**	**EXCEL**
7.	Stabilant 22 **	D.W. Electrochemicals	NONE	Not Recom
8.	NOX Rust 212	Daubert Chemical	81309 II	Good
9.	Omega 2775 *	Fine Organics	81309D	Not Recom
10.	Rust Preventive	Battenfield-American	81309 II	Good
11.	Octoil 5068	Octagon Process	81309 II	Good
12.	Alox 2028C	Alox Corp	81309 II	Not Recom

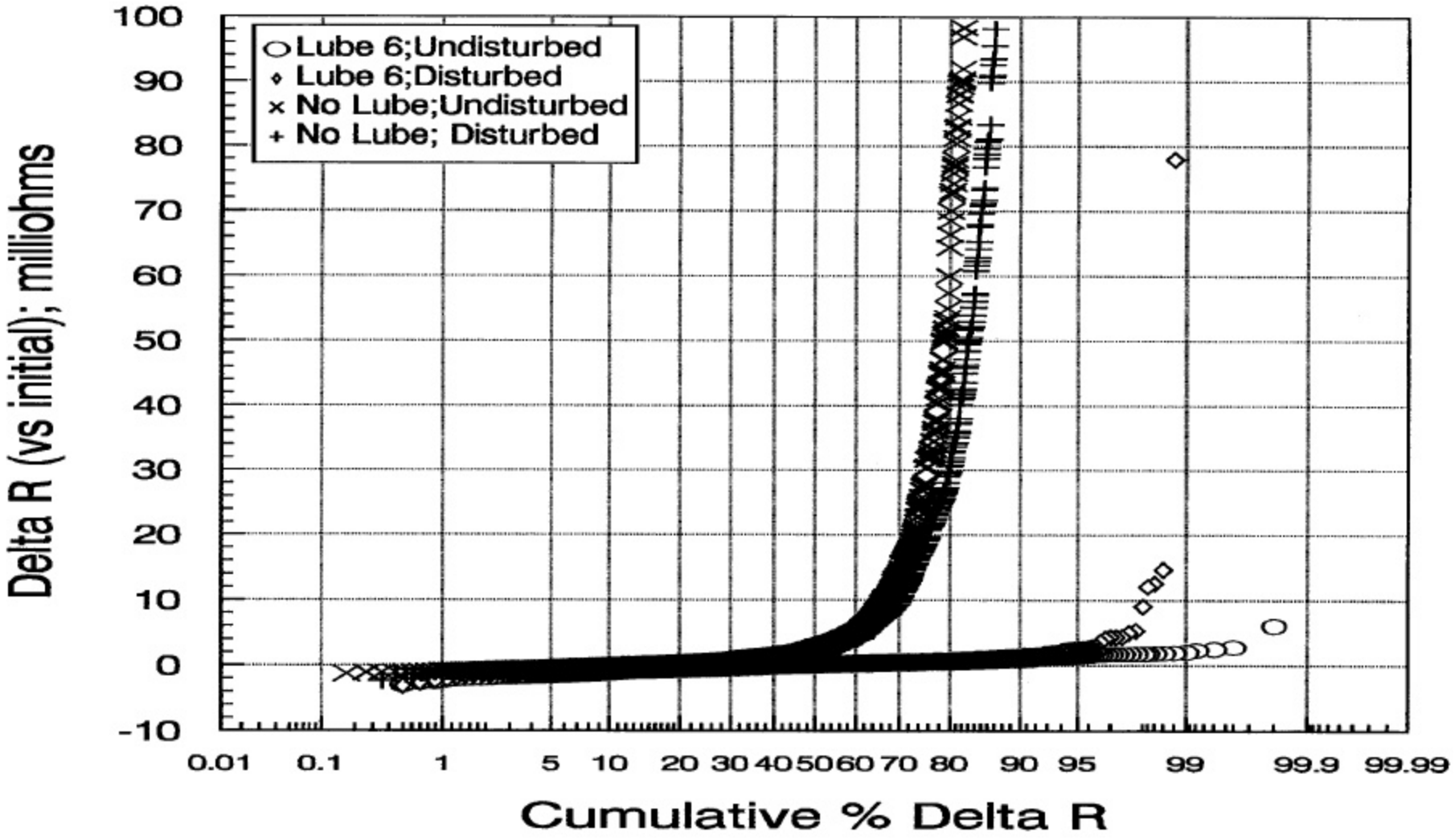
UNLUBED GOLD CONNECTOR CONTACTS RESISTANCE CHANGES; HOMESTEAD & NELLIS; 1-YR EXPOSURE



GOLD PLATED CONNECTOR CONTACT RESISTANCES WITH LUBE; 1-YR EXPOSURE - HOMESTEAD & NELLIS



GOLD PLATED CONTACT CONNECTOR RESISTANCE CHANGES; WITH/WITHOUT LUBRICANT, 1-YEAR EXPOSURE, ALL BASES



BELL LAB'S CPC
3. F-16 AV LRU TREATMENT STUDY

RESISTANCE TESTS GOLD/GOLD CONNECTOR SETS

CUMULATIVE DELTA MILLIOHMS AFTER 1-YEAR

BASIS: TYP FAILURE THRESHOLD =10-MILLIOHMS

BASE	UNLUBRICATED	LUBRICATED
NELLIS	4% > 10-MILLIOHMS	2% >2-MO
NELLIS	1% > 40-MO	
HOMESTEAD	46%> 10-MO	2% > 5-MO
HOMESTEAD	25%> 100-MO	
MACENTIRE	86%> 10-MO	86%< 3-MO
MACENTIRE	55%> 94-MO	6% > 80-M0

BELL LAB'S CPC
3. F-16 AV LRU TREATMENT STUDY

RESISTANCE TESTS GOLD/GOLD CONNECTOR SETS
CUMULATIVE DELTA MILLIOHMS AFTER 1-YEAR
BASIS: TYP FAILURE THRESHOLD =10-MILLIOHMS

BASE	UNLUBRICATED	LUBRICATED
ALL TEST BASES		
UNDISTURBED	36% > 10-MO	0.3% > 6-MO
	18% > 100-MO	
DISTURBED	34% > 10-MO	2% >10-MO
	13% > 100-MO	1% >78-MO

BELL LAB'S CPC
3. F-16 AV LRU TREATMENT STUDY

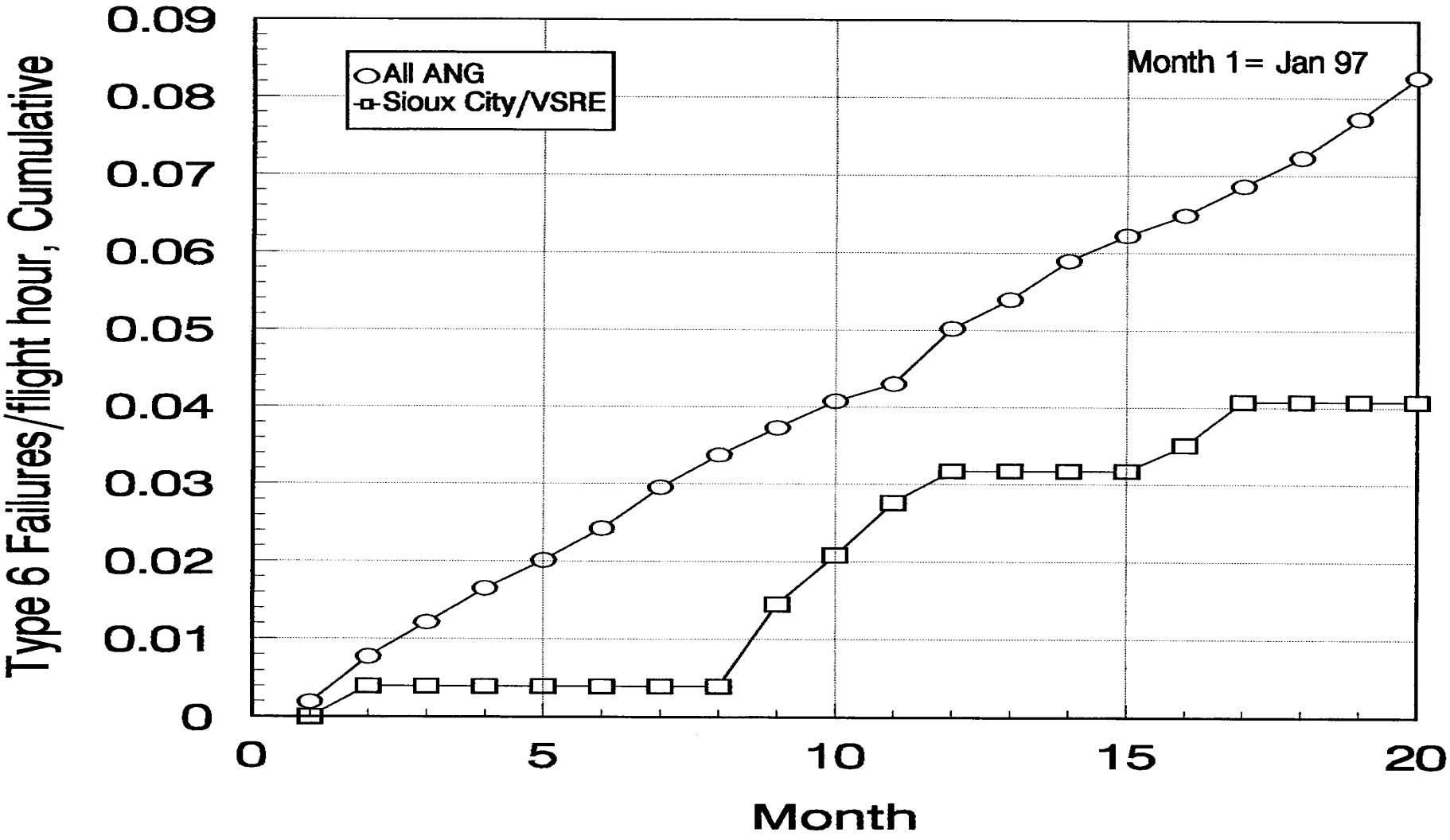
BATTELLE RESEARCH TEST LRUs TREATED:

- F-16A/B: FLIGHT CONTROL COMPUTER (FLCC)
  - DIGITAL SIGNAL PROCESSOR (DSP)
  - RADAR COMPUTER (DC)
  - EXPANDED FIRE CONTROL COMPUTER (XFCC)
  - LOW POWER RF (LPRF);
- F-16C/D: DIGITAL FLIGHT CNTRL COMPUTR (DFLCC)
  - EXPANDED FIRE CONTROL COMPUTER (EFFCC)
  - WAC EXPANDED HEADS UP DISPLAY (WACEU),
  - DATA TRANSFER UNIT (DIU),
  - ADVANCED CENTRAL INTERFACE UNIT (ACIU)

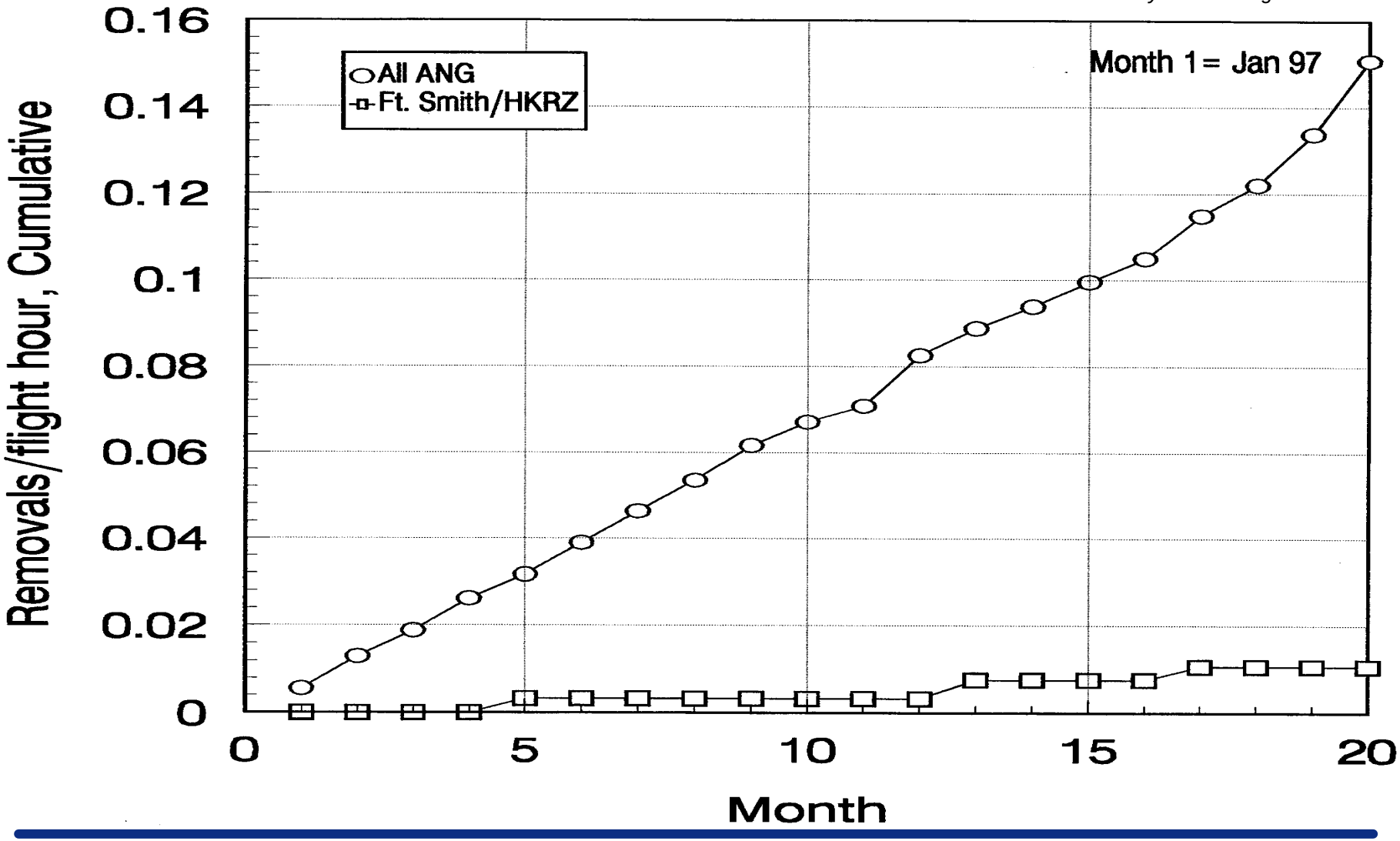
BELL LAB'S CPC
3. F-16 AV LRU TREATMENT STUDY

- **TESTING ON F-16 AVIONICS LRU GOLD/GOLD CONNECTORS SETS**
- **ANG & RES BASES ~ 150 ACFT, 2+YR, START 11/96**
- **SOME LRUs, BCS, & OVERHAULS REDUCED BY 95% BY TREATING CONNECTORS = GOOD LRUs**
- **SOME LRUs ONLY 30% IMPROVEMENT**
- **HOMESTEAD SHOWED 16% NMC IMPROVEMENT**

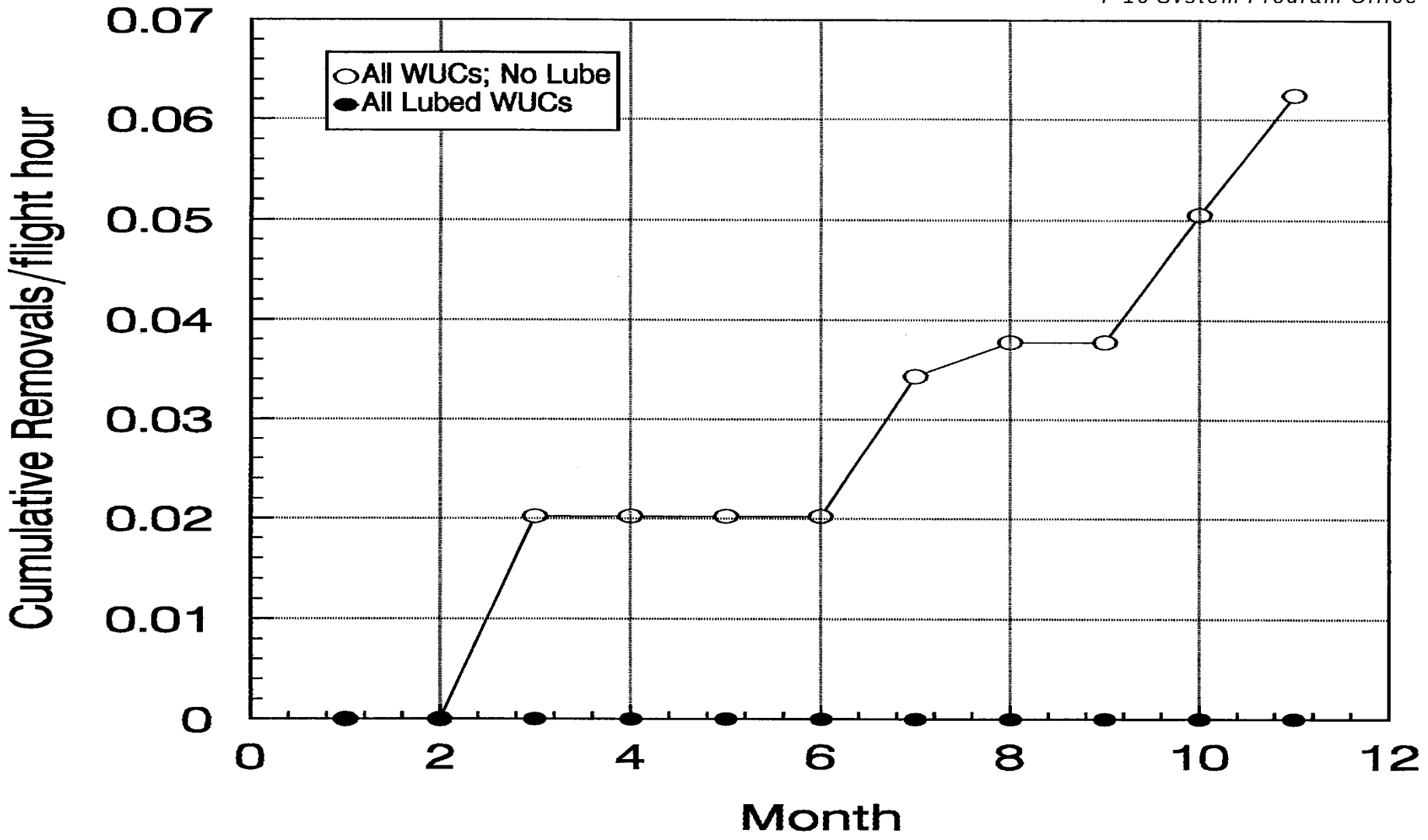
PPS (ON) DATA, NO DEFECT, FAILURES/FLT-HR CLEANED NOT LUBED (SIOUX CTY CONTROL)



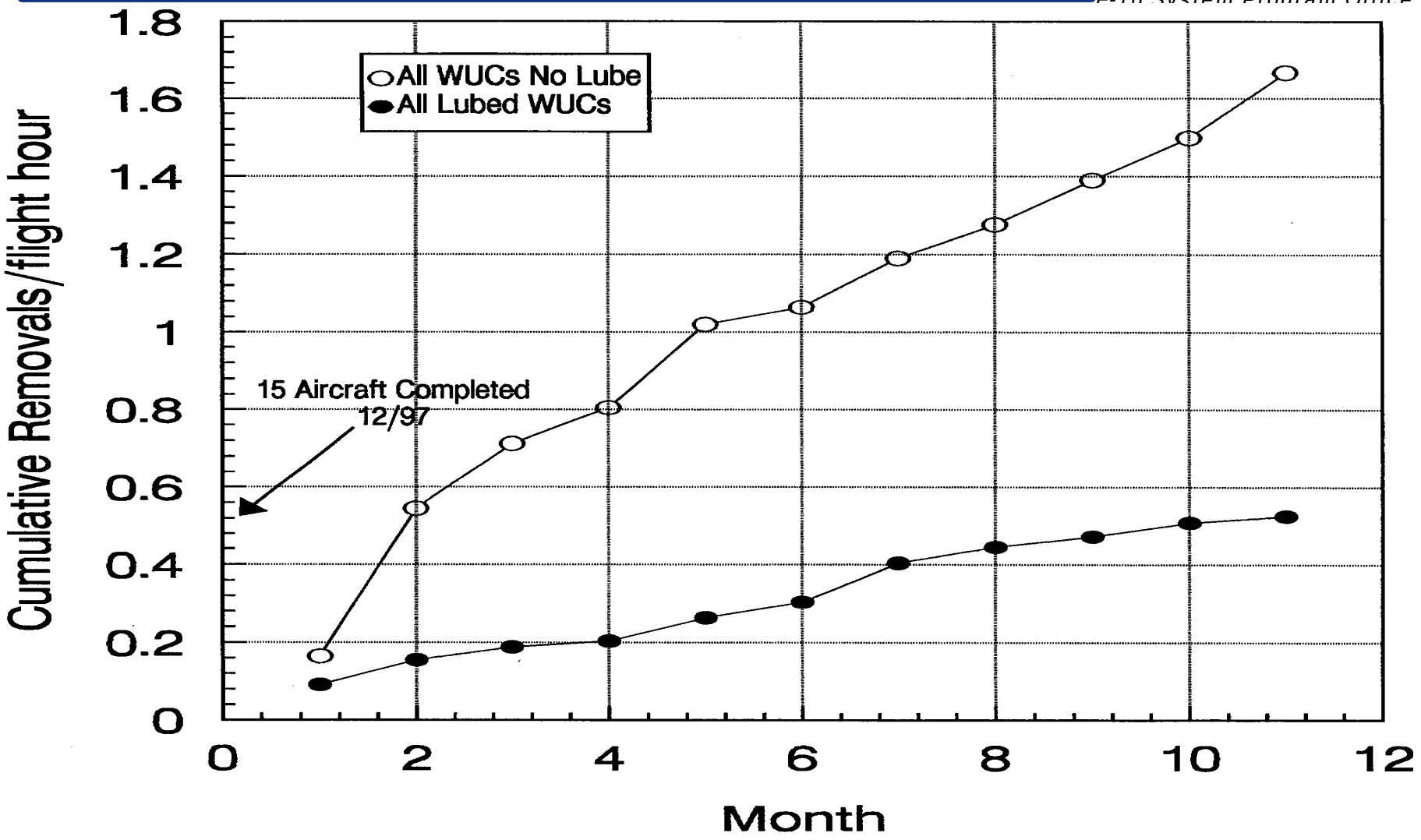
PPS (ON) DATA; REMOVALS/FLT HR, LUBED FLIGHT CONTROL COMPUTER CONNECTORS



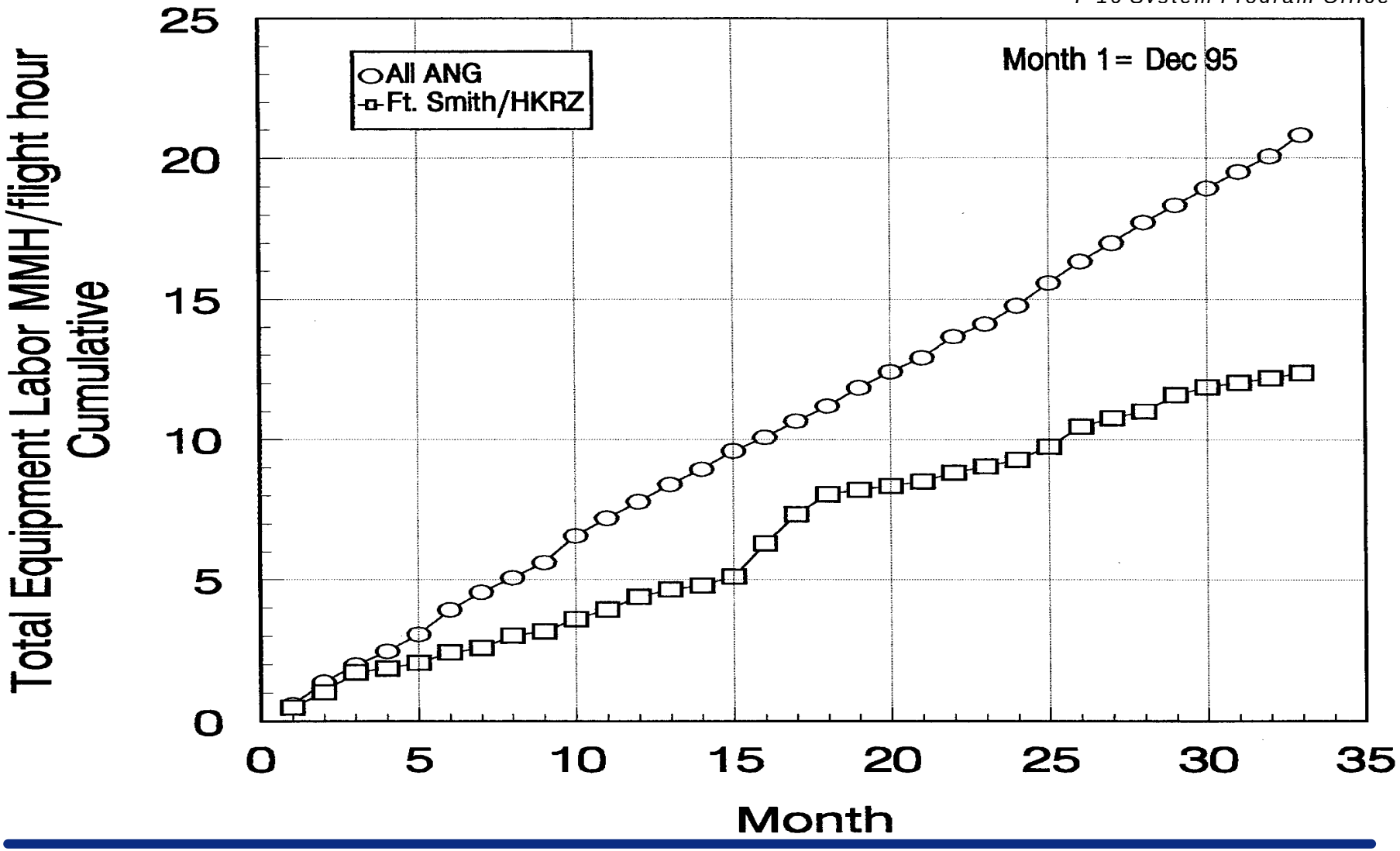
PPS (ON) DATA FOR 13 SYS AT NELLIS; REMOVALS/FLT-HR, WITH/WITHOUT LUBE



PPS (ON) DATA FOR ALL NELLIS LRUs REMOVALS/FLT-HR, WITH/WITHOUT LUBE



ON+OFF EQUIPMENT LABOR MMH/FLIGHT-HR LUBED FIRE CONTROL SYS



BELL LAB'S CPC
3. F-16 AV LRU TREATMENT STUDY

COST SAVINGS FOR PARTICIPATING BASES DUE TO MORE RELIABLE LRUs THAN NON-TEST BASES

DATA FROM REMUS OF LRU CHANGEOUTS AND COST TO OVERHAUL AT NON-TEST BASES/FLIGHT HOUR USED AS BASELINE FOR EACH LRU

- **F-16 SPO COST ANALYSIS OFFICE COMPARED TEST BASE DATA TO NON-TEST BASE BASELINE**
- **COST FOR THE TEST PROGRAM $400K**
- **HIGHER RELIABILITY COST AVOIDANCE ~$50MIL**
- **USAF SAVED > $100 FOR EACH PENNY SPENT ON CPC (CPC COST $5K, ~1% OF TOTAL TEST)**

BELL LAB'S CPC

IMPORTANT AEROSPACE WEAPONS SYSTEMS CPC PARAMETERS, WHY RECOMMEND MIL-L-87177A

LOW VAPOR PRESSURE NOT EVAPORATE < 50-mm Hg

LOW SURFACE TENSION: DISPLACE WATER, SPREADS

LIQUID TO MINUS 70 DEG F

STABLE COMPOUND, NO GUMS, POLYALPHAOLEFIN

STABLE AT MODERATE TEMP, 450-DEG F

REASONABLE COST

NO HEALTH, ENVIRONMENTAL, FUNCTIONAL HAZARD

BELL LAB'S CPC
3. F-16 AV LRU TREATMENT STUDY

NO HAZARD OR REASON TO AVOID USE OF THE PRODUCTS FOUND TO BE EXCELLENT CPCs WAS IDENTIFIED IN EITHER THE FACTS OFFICE RESEARCH PROGRAM OR THE F-16 OPERATIONAL TEST PROGRAM IF NORMAL SAFE OPERATING PRACTICES ARE EMPLOYED.

THE CPC USE IS CONSIDERED TO BE ENTIRELY SAFE ON THE AIRCRAFT.

RECOMMENDED CPCs

- MIL-L-87177A GRADE B TYPE 1 NSN 6850-01-328-3617 (16-OZ AEROSOL) LEKTRO TECH, INC., TAMPA, FL (813)254-1380 OR (888)254-1380
- ILFC = INTERNATIONAL LUBRICANT & FUEL CONSULTANTS, RIO RANCHO, NM P/N 1006-CON-TAC QUALIFIED AS, MIL-L-87177A GRADE B (PINT CANS IN BULK, SPRAYER REQUIRED); (505)892-1666 OR (800)237-4532

BELL LAB'S CPC
4. ACTIONS & RECOMMENDATIONS

- TREAT MORE CONNECTORS ON F-16
- INCREASE BASE PARTICIPATION
- INCORPORATE IN SOME T.Os = REQUIRE USE.
- TREAT CONNECTORS INSIDE LRUs
- TEST ADDITIONAL CPCs IN USE
- TEST MITIGATING CIRCUIT BOARD CORROSION
- PRAM FUNDED TO TEST ON OTHER WEAPON SYS
  - F-15 TESTING APPROVED; APPLICATION STARTING
  - ADDITIONAL ACFT COULD BE INCLUDED IN TESTS

BELL LAB'S CPC

- F-16s FLY BETTER WITH ELECT CONNECTORS LUBED

BELL LAB'S CPC

- **F-111s WILL FLY BETTER WITH LUBED CONNECTORS**

BELL LAB'S CPC

- THE RELIABILITY OF EVERY U.S. WEAPON SYSTEM THAT USES ELECTRONIC PARTS MAY BE INCREASED BY USING THIS CORROSION INHIBITING LUBE IN THEIR CONNECTOR SETS
- MANY OTHER USES FOR THIS CPC COULD BE BENEFICIAL
- COST IS SHOWN AS PRIMARY BENEFIT BUT EFFECTIVENESS & SAFETY FOR OUR TROOPS IS EVEN MORE IMPORTANT

BELL LAB'S CORROSION PREVENTIVE COMPOUND

BELL LAB'S CORROSION PREVENTIVE COMPOUND

- **ANY QUESTIONS?**