

**Tires, Tiles, Light Bulbs, Corrosion, and Pat:**  
**Reflections of five years of life in the Materials Testing Laboratory at NASA/KSC**

Find out what tires, tiles, light bulbs, corrosion, and Pat have in common... Ed Dumas will share his experiences while working for NASA's Materials Science Laboratory at the Kennedy Space Center. He worked there as a co-op student between 1987 and 1993 and will show some of the more interesting studies he participated in while at KSC.



Liftoff of the Space Shuttle Challenger, STS-51L, January 28, 1986

## **Kennedy Space Center Materials Science Laboratory**

Primary function: To provide independent, non-biased analysis of materials and their performance in various systems to support manned space flight activities for NASA. The laboratory was organized into three branches, the Microchemical Analysis Branch, the Failure Analysis Branch, and the Materials Testing Branch.

### **Microchemical Analysis Branch**

- X-Ray Diffraction Lab
- Scanning Electron Microscopy Lab
- Wet Chemistry Lab

Primary function: To analyze the chemical makeup of materials.

### **Failure Analysis Branch**

- Electronics Failure Analysis Lab
- Fluids & Mechanical Failure Analysis Lab
- Metallurgical Analysis Lab
- Metrology Analysis Lab
- Video Documentation and Production Lab

Primary function: To analyze the failure mode of mechanical and electrical systems on various types of spacecraft and ground support equipment.

## Materials Testing Branch

- Mechanical Testing
- Thermal / Vacuum Testing
- Vibration Testing
- Electrostatic / Triboelectric Testing
- Corrosion Testing
- LOX compatibility (impact) testing

Primary function: To test materials and systems to determine performance under various environmental conditions.



This is the Operations & Checkout Building where the MSL and branches are located. This building is home to the astronauts while they live at KSC in preparation for Shuttle flights.

## **Shuttle tire test project – October to February, 1988**

Objectives: To provide correlation data between the actual tire pressure and the output of strain gages used to measure the tire pressure in flight as a function of temperature. It was also desired to determine the ability of the strain gage sensors to adequately detect a leaking tire in the middle of extreme temperature excursions.

Method: Both nose and main tires were tested in a Thermotron environmental chamber while temperature, pressure, and strain gage output measurements were taken. The tires were exposed to both static and dynamic temperature changes that simulated exposure to the thermal environment while the tires are in flight.

During the dynamic temperature test, a deliberate leak was introduced into one of the main tires to see if a leak could be detected in the strain gage data. Data were collected automatically during the 72-hour test using a near-state-of-the-then-art Keithley System 570 data acquisition system. And we even backed that system up with a video camera trained on the computer screen, just in case!

Fun facts: The Shuttle nose and main tires are made by B.F. Goodrich and are filled with 100% gaseous nitrogen. The nose tires are 32 x 8.8 (tire diameter x wheel diameter), pressurized to 345 PSI, and rated for 23,700 pounds static load. The main tires are 44.5 x 16 (tire diameter x wheel diameter), pressurized to 365 PSI, and rated for 123,000 pounds static load.

# MWA THERMAL PROFILE TEST

WHEEL TEMPERATURE VS. TIME

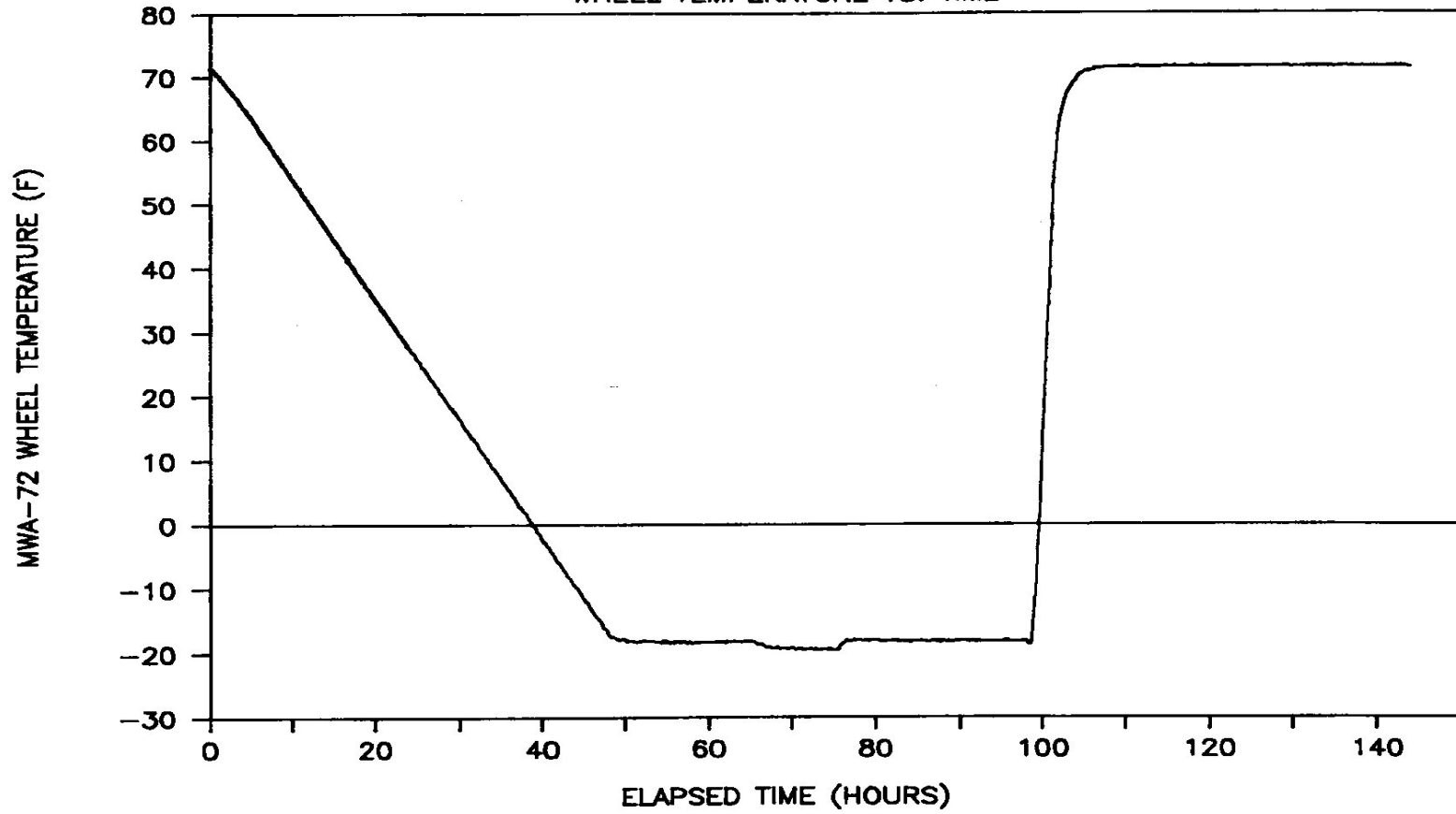


FIGURE 5

Main wheel ramp test temperature profile.

# MWA THERMAL PROFILE TEST

TIRE PRESSURE VS TIME

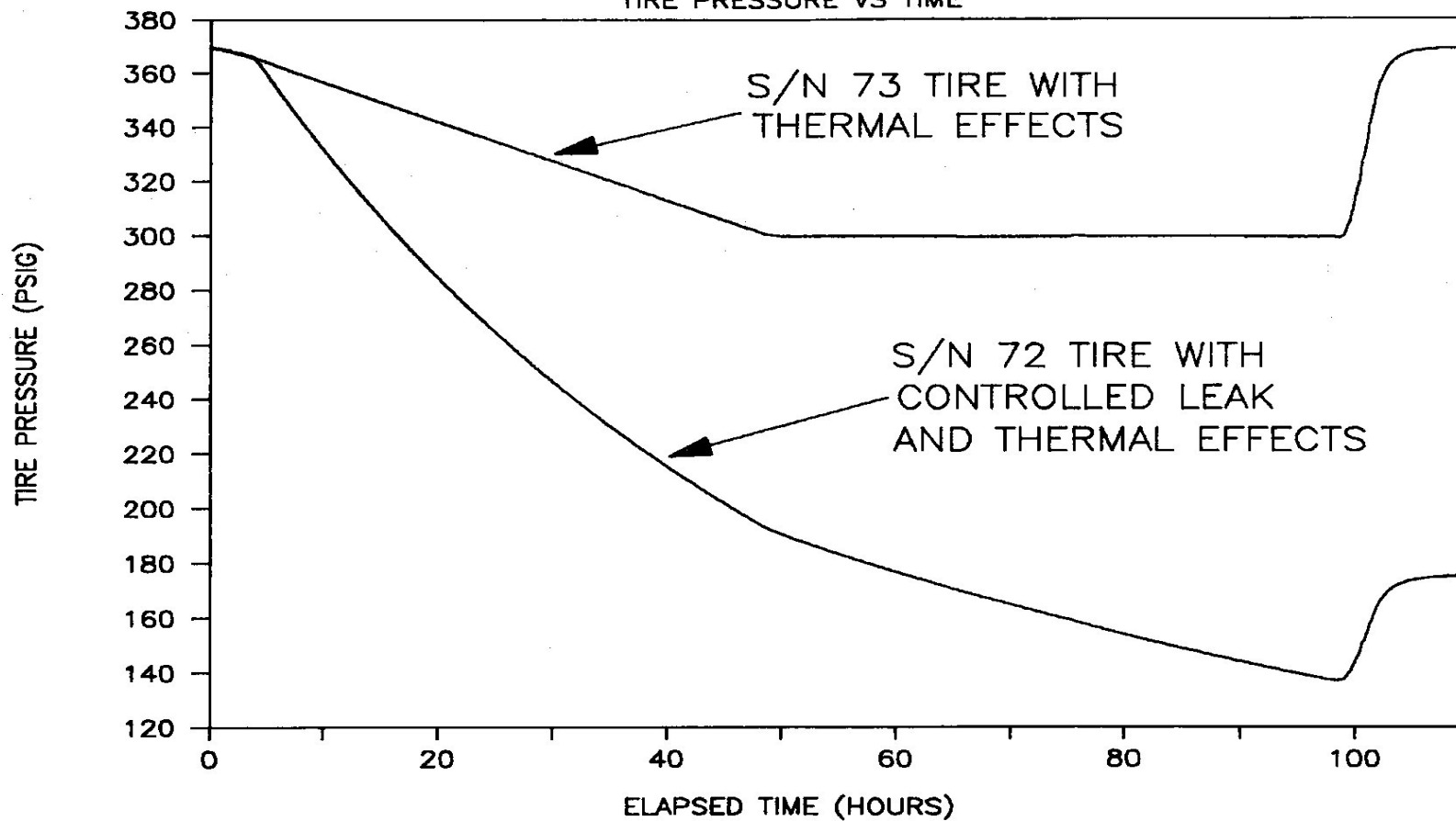


FIGURE 6

Pressure vs. time curves for main wheel assemblies  
S/N 72 and S/N 73.

# MWA THERMAL PROFILE TEST

MILLIVOLTS VS. TIME

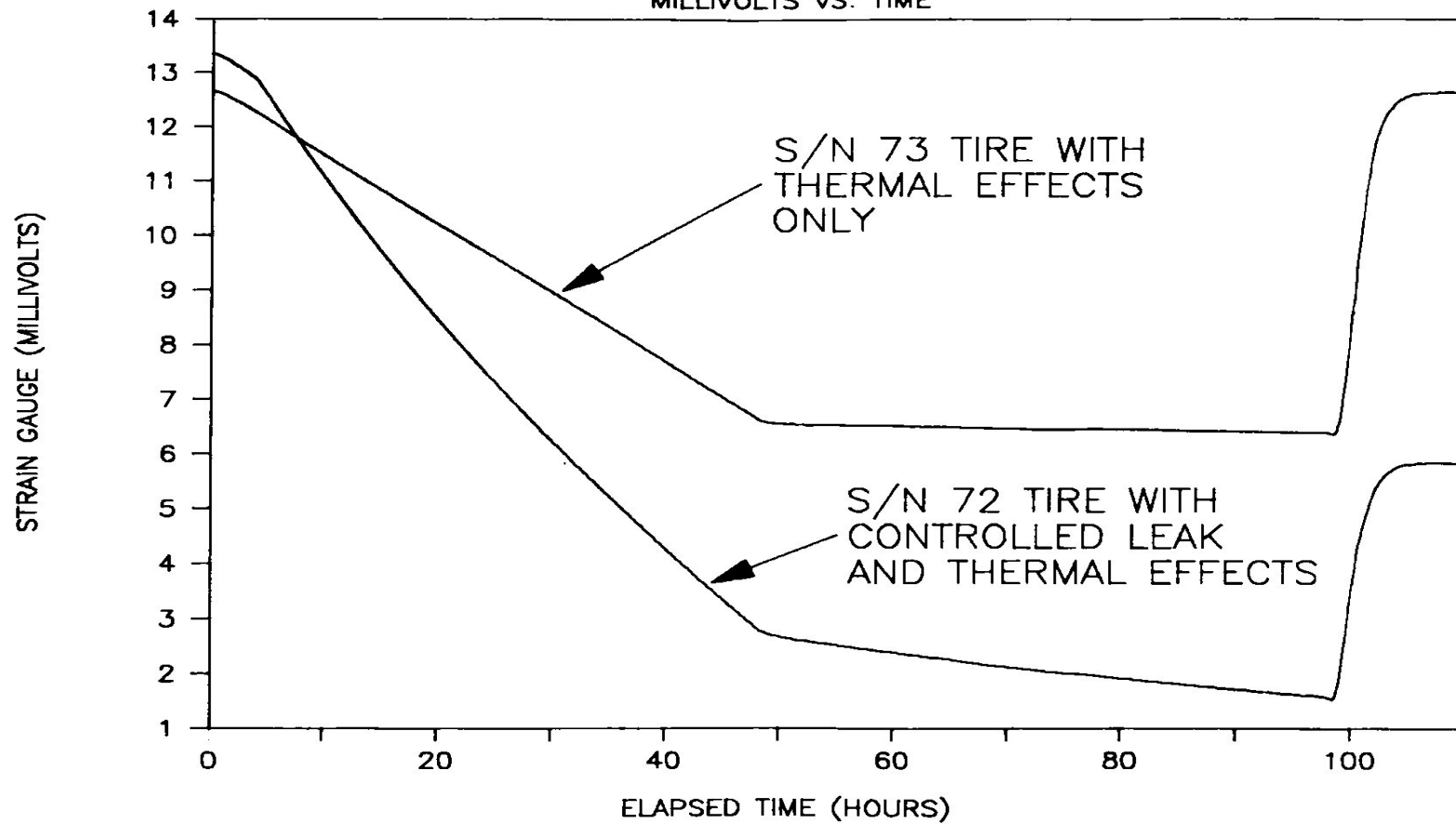
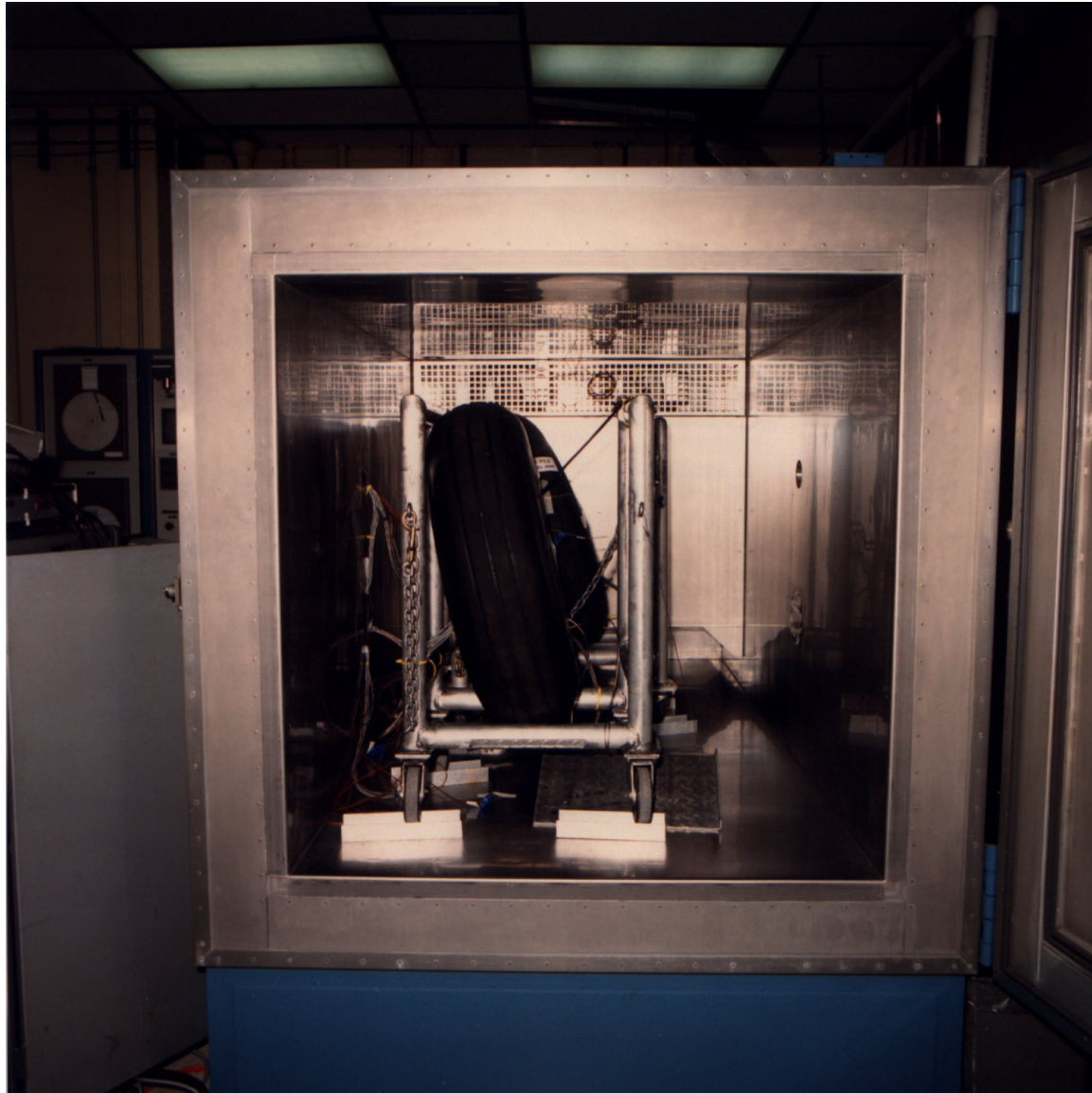


FIGURE 7

Millivolt vs. time curves for main wheel assemblies S/N 72 and S/N 73.







## **Light Bulb Test – March 1990**

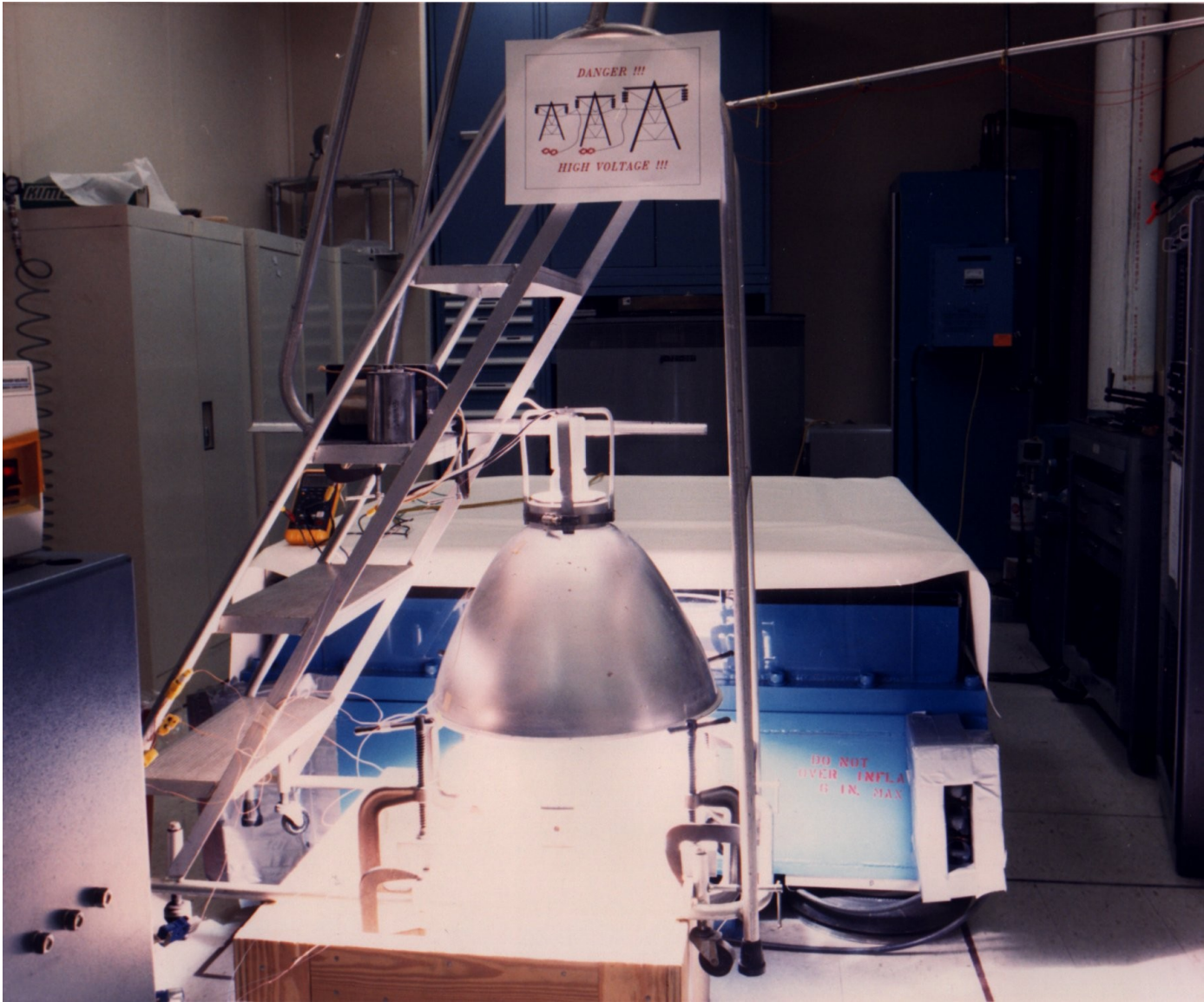
Objective: To test a proposed glass lens cover for high-power multi-vapor lamps in the high bay of the O& C building. The test was done in the wake of a bulb that did shatter and shower debris over a spacecraft that was inside the high bay for processing. The high bay has a 60-foot ceiling, the bulb tube normally operates at 2100° F, so it is imperative that the bulb fragments be contained if the bulbs were to shatter.

Method: Duplicate the high bay lamp setup in the lab, turn the bulb on and let it equilibrate, and then place a heated quartz tube onto the lens cover to simulate the bulb element. I bet you can guess the joke in this one!

Results: The test was successful in showing that the lens cover could indeed contain the hot quartz tube. The only hitch with the whole thing was the amount of time and people it took to setup and run the test... It took a total of four NASA engineers 2 1/2 hours to turn on a light bulb!







## **Accelerated Corrosion Testing for Shuttle Fuel Systems Materials – 1987-Present**

Background: The area around the Kennedy Space Center is naturally among the most corrosive in the world and the environment around the launch pad is even more so due to the 18M hydrochloric acid and alumina powder fallout that rains on the launch pad 30-45 minutes after every Shuttle launch. The extreme launch environment poses a variety of problems for Shuttle ground support equipment.

The fuel lines that are used to deliver cryogenic LOX and LH<sub>2</sub> fuel from the holding tanks some ¼ mile away from the launch pad to the orbiter are made from stainless steel and have an inner and outer sheath. A vacuum is maintained between each sheath to keep the cryogenic fuel from boiling off on its way from the holding tank to the Shuttle. Naturally, the fuel lines must have flexible joints to accommodate the demands of fueling the orbiter. Bellows joints are formed in the inner and outer sheaths and it is in the tight radius corners of the outer bellows that stress corrosion cracking occurs that can lead to vacuum loss and boiling of the cryogenic fuel.

Objective: To identify candidate materials for Shuttle fuel line jackets that have maximum resistance to corrosion and good mechanical properties to allow them to be formed into bellows to accommodate flexing of the fuel lines.

Method: The accelerated corrosion testing was performed in a salt-fog chamber that would simulate the corrosive environment the materials would be exposed to in approximately 1/10 of real-time. In addition to the salt-fog, a mixture of 18M HCl and alumina powder was squirted on every sample each week to simulate exposure to fallout from a Shuttle launch.

Results: The jury is still out, as far as I know... The test is probably still going on to push the materials to their limits. It became clear as the test progressed, however, that standard 304L stainless steel was almost no match for the relentless salt-fog and the weekly soakings of HCl and alumina. It was gone within a month...

The best alloy of the 50 or so that were tested turned out to be Hastelloy, a very high nickel content metal that seemed to keep going and going and going... It also had adequate formability and workability that allowed the bellows joints to be formed satisfactorily. Using data from the stress-corrosion cracking samples, the early estimations were that a set of bellows made from Hastelloy would last well over 100 years in the KSC launch environment.

## **The PAT Project – A Criminal Investigation to Help Identify the Perpetrator of a Crime Involving the Shuttle Columbia**

Objective: To determine who defaced the FRCS (Forward Reaction Control System) thruster of the Space Shuttle Columbia by scratching the letters “PAT” into the Inconel FRCS panel.

Method: A Questar long-range microscope was used to make magnified photographs of the area in question. Because the Shuttle was in the Orbiter Processing Facility with work stands placed all around, the area where the destruction had occurred was inaccessible to typical microscopic observation techniques. The Questar long-range microscope provided approximately 10X magnification from a distance of 30 feet, thus enabling detailed observation of the area in question.

Observations: The scratch mark appeared to have been made by a sharp object, possibly a dental pick or roller-ball type of pen. There was a whitish residue from the solid rocket separation motors that had flowed in the groove left by the pen, indicating that the marks had been made prior to at least the last flight. The lettering also appeared to have been made by a person who was left-handed.

By using a list of all technicians who had access to the Orbiter’s FRCS area during the time period prior to the Shuttle’s last mission, a list of approximately 200 people was developed. Unfortunately, the perpetrator of the crime was never caught.



I saw this on the way home to Titusville from work one day so I stopped and took a picture.



Another view of the 747 and carrier aircraft and the Shuttle...







