1980 | 1530 | Flight Archive - Windows Internet Explorer
D:\Documents and Settings\jcorte\Desktop\1980 1530 Flight Archive.mht
File Edit View Favorites Tools Help
NASA - Search Results 1980 | 1530 | Flight Archive
Home Premium Archive Video Images Forum Blogs Jobs Shop
You are in: Home » Aviation History » 1980 » 1980 - 1530.PDF
RSS Email Newsletters

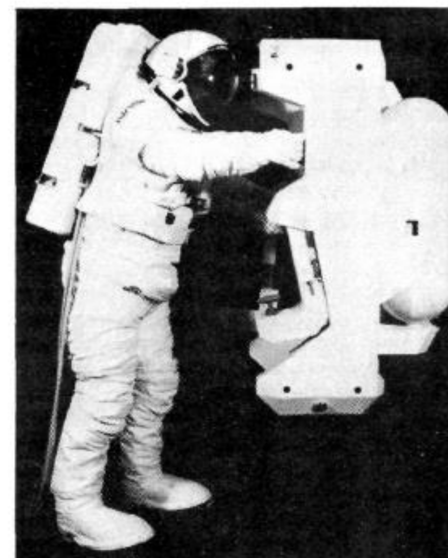
Spacesuit flash-fire provokes minor alterations

NASA has revealed that an unoccupied astronaut's spacesuit was destroyed in a flash fire on April 18. The fire started during routine performance testing in the crew systems laboratory at Johnson Space Centre. A technician employed by Hamilton Standard, manufacturer of the Shuttle spacesuit, was badly burned in the incident, but has since left hospital.

The flash fire started when the technician switched from the spacesuit's main oxygen supply to a 30min emergency supply. Ignition took place in a chamber between the high-pressure (200bar) oxygen supply and the regulator which reduces it to a breathable 240 millibar. The resulting fire burned through the regulator which is mounted in the backpack attached to the suit, as well as the lower torso of the spacesuit.

A review board was unable to duplicate the flash fire in subsequent tests, or to pinpoint the cause of ignition. But it did list four probable causes, most of them involving shock-heating, in which the sudden flow of high-pressure gas against an obstruction rapidly raises its temperature.

To prevent a recurrence, the board made several recommendations. These included redesign of high-pressure oxygen valves and regulators to avoid stagnation zones and lessen the chances of internal contamination; replacement of silicone-rubber seals with a material of greater ignition-resistance and the clarification of Nasa specifications. The board also asked Nasa to consider making regulator bodies out of monel instead of the more easily ignited aluminium alloy, more detailed inspection during manufacture and further testing of the modified parts.



A spacesuited astronaut reaches for a manned manoeuvring unit. The back-pack on the spacesuit contains oxygen, cooling and other life-support systems

Internet 100%

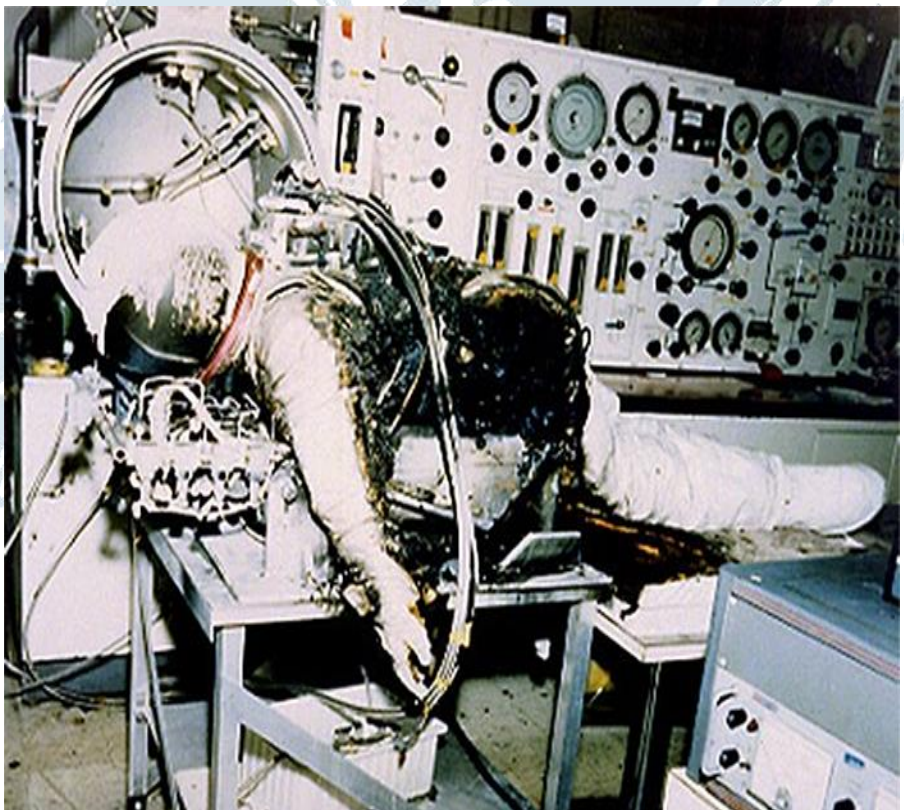
Lessons Learned From the EMU Fire

"All men make mistakes, but only wise men learn from their mistakes."

Winston Churchill

We are a team that is "re-directed" by our failures, not defined by them.

We are a Learning Organization.

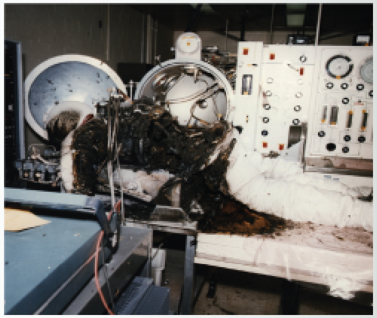


The Story Line

A Space Shuttle Extravehicular Mobility Unit *(pressure garment and life-support backpack)* was destroyed in a flash fire during a functional test in the Johnson Space Center's crew systems laboratory. A technician standing next to the suit received second-degree burns over his upper body during the accident.

- What happened?
- Safety message?
- Did we learn from our mistakes?
- Leveraging earned knowledge.

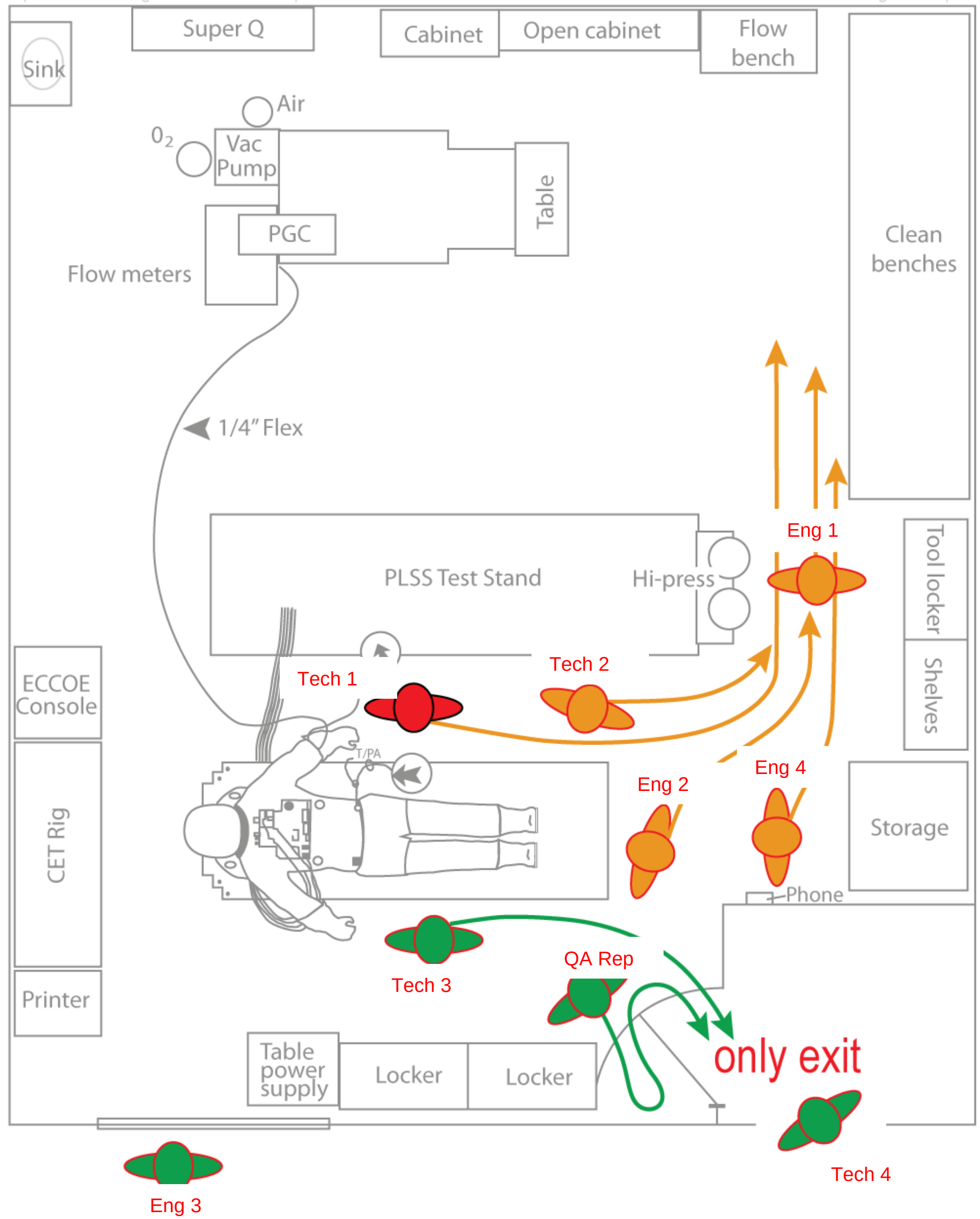
Excerpt From the Accident Investigation Report



On the afternoon of April 18, 1980, Hamilton Standard personnel were conducting an Extravehicular Mobility Unit (EMU) Performance Record Test in room 121 of building 7. The test involved the use of 900 psi O2 and 6200 psi O2. At 1:22 p.m., a flash fire occurred. One technician suffered first and second degree burns over 32% of his body and was taken to the hospital. Another technician got his hand burned, requiring first aid. The fire actuated an overhead sprinkler; two CO2 extinguishers were used. The Houston fire department responded and assured the extinction of the fire.

- Regulator vaporized in less than 1 second
- O_2 availability allowed for metal to burn
- O_2 depress less than 2 seconds
- Softgoods burned until extinguished - ~1-2 minutes

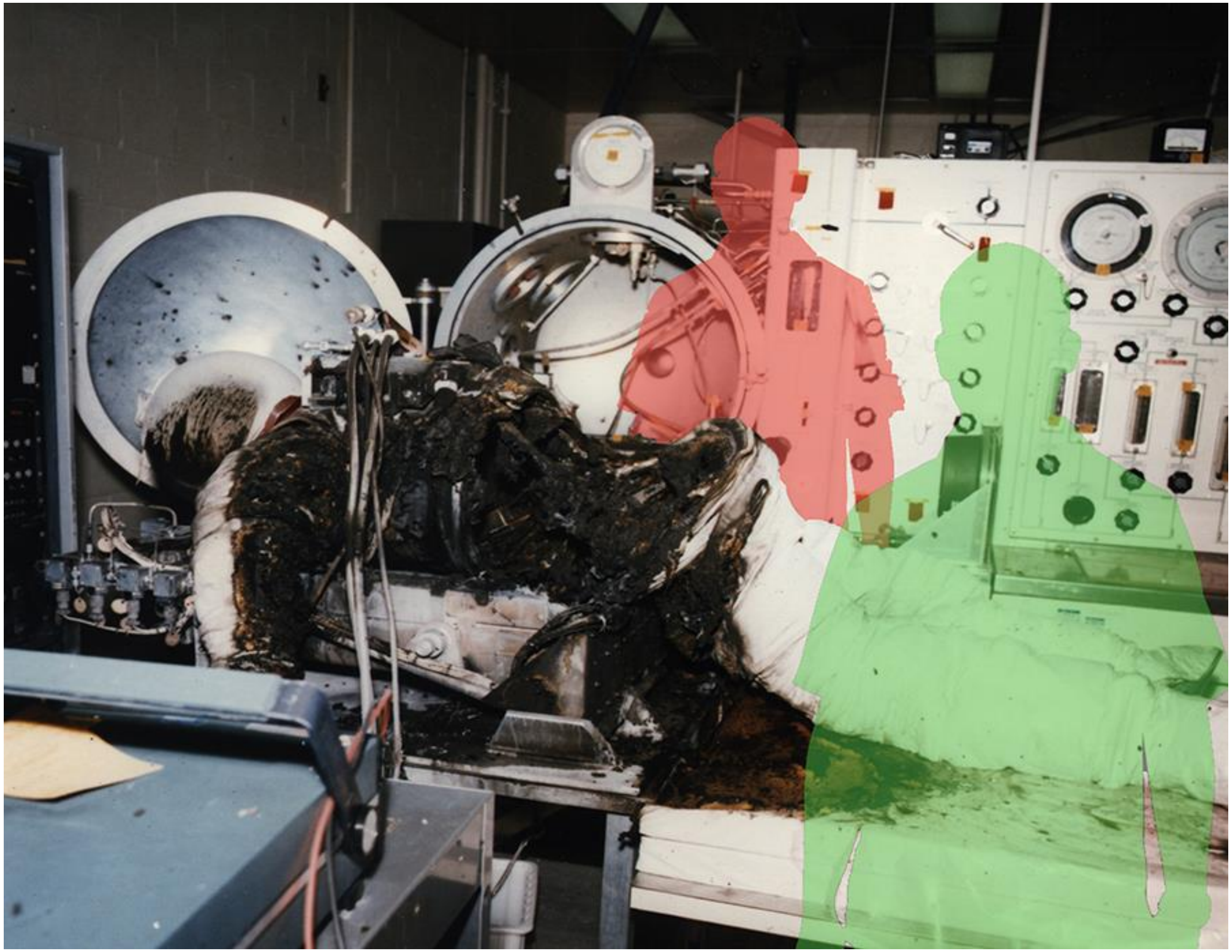
reproduction of "figure A - Location of personnel and initial reaction to the accident" from the official accident investigation report



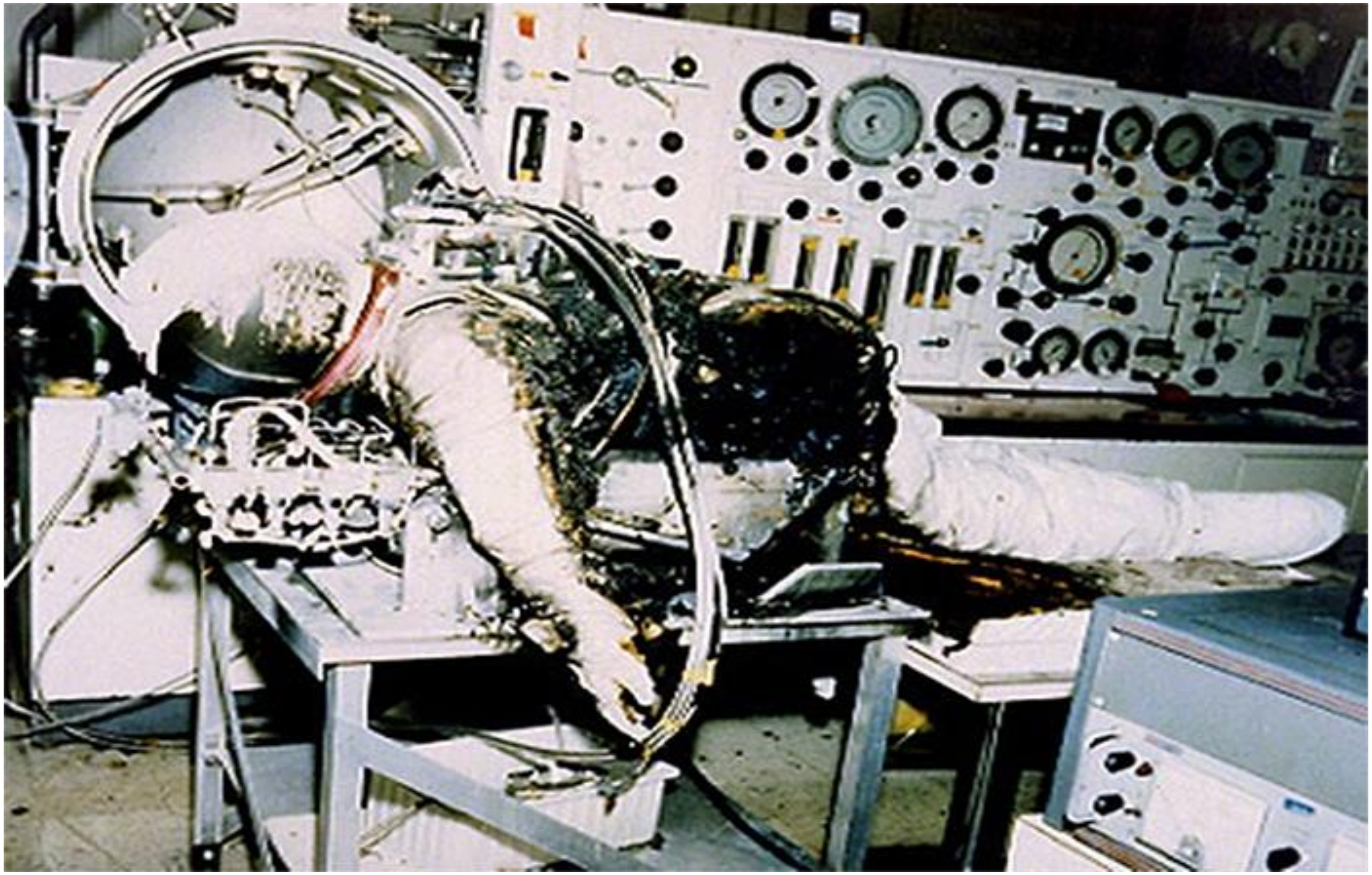
Suffered severe injuries - hospitalized

Improper reaction – could have resulted in injury or death

Proper reaction – individuals exited the room to safety

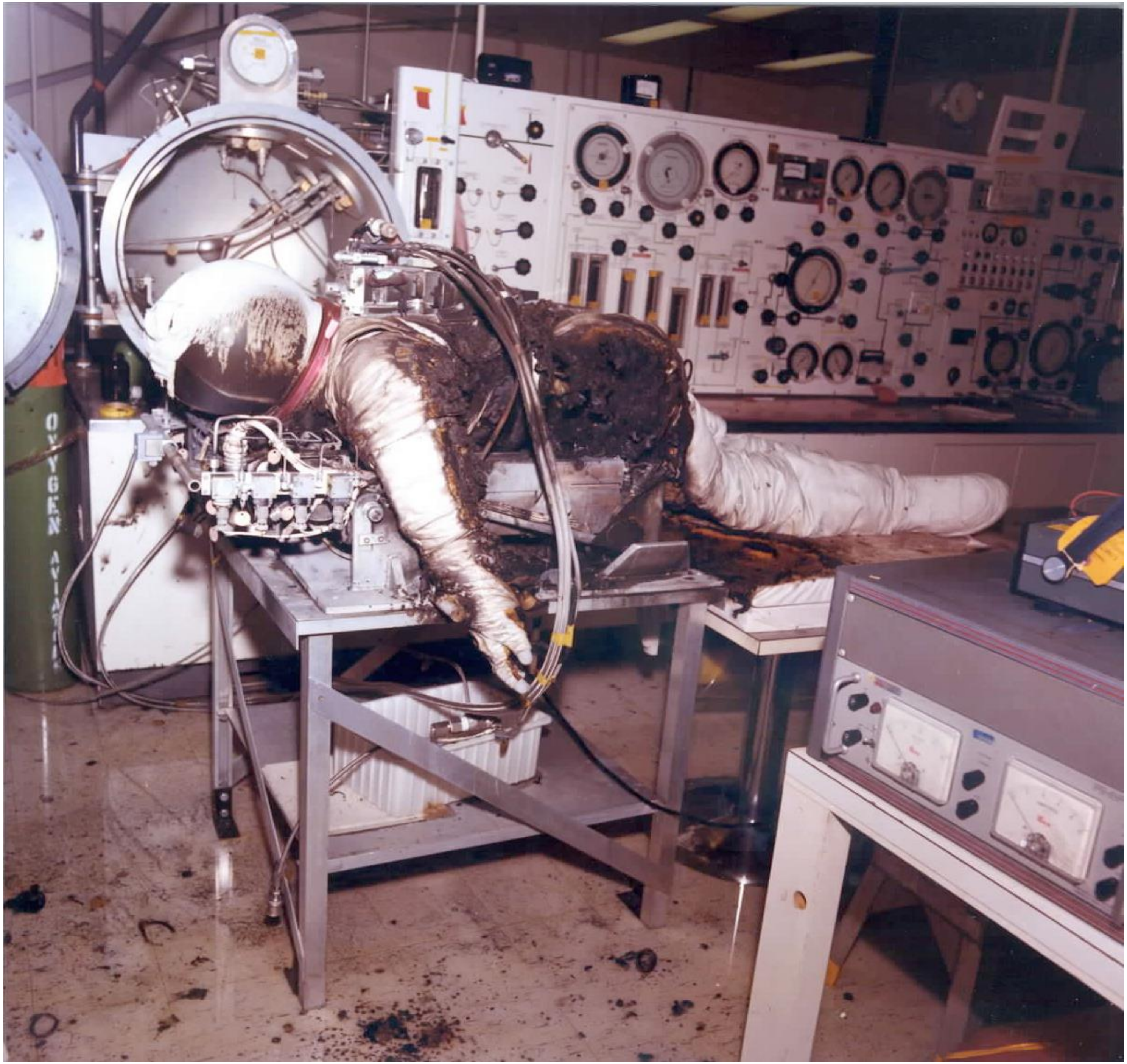


A technician was standing between the suit and test stand

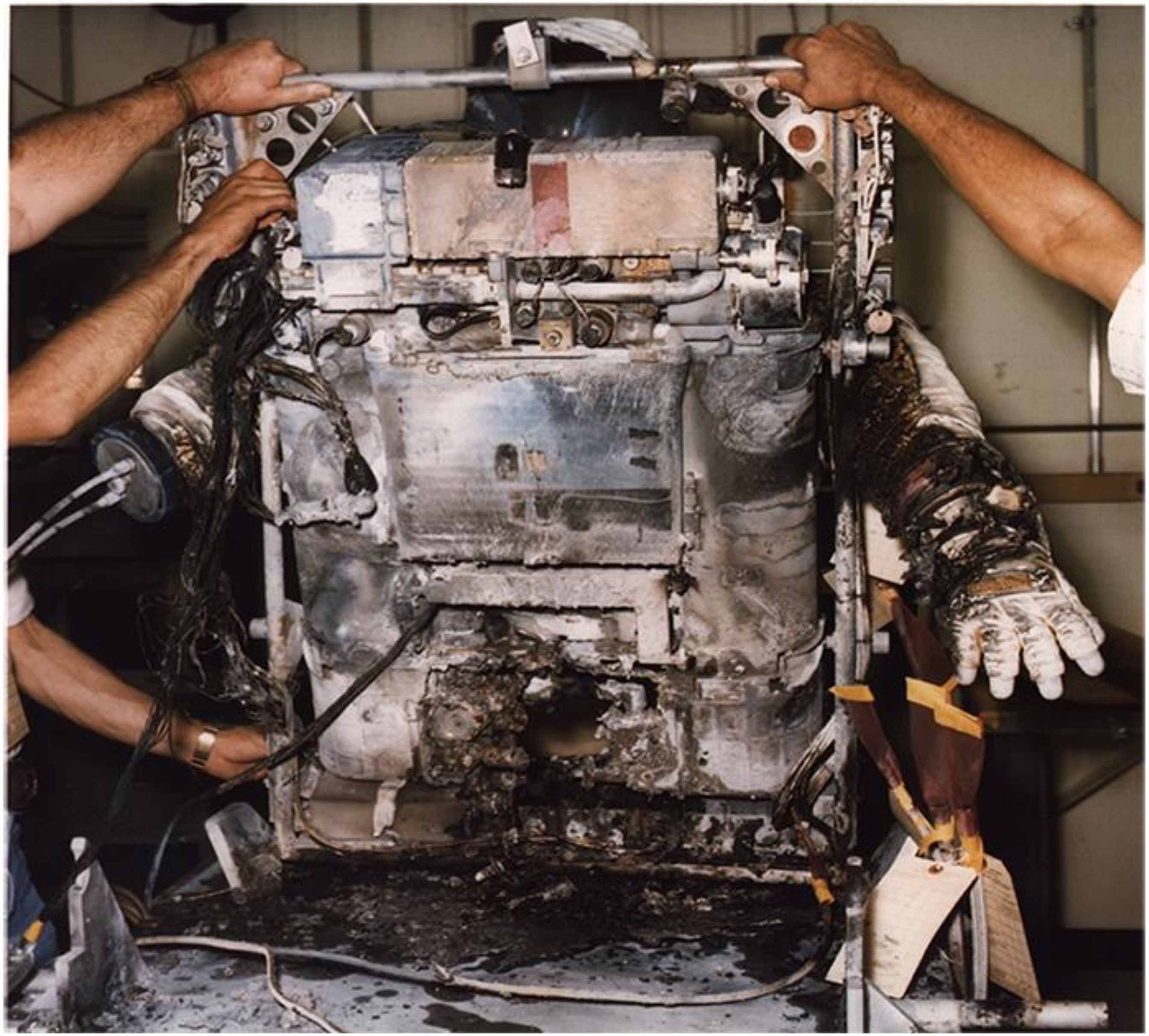


~2 million dollars worth of damage

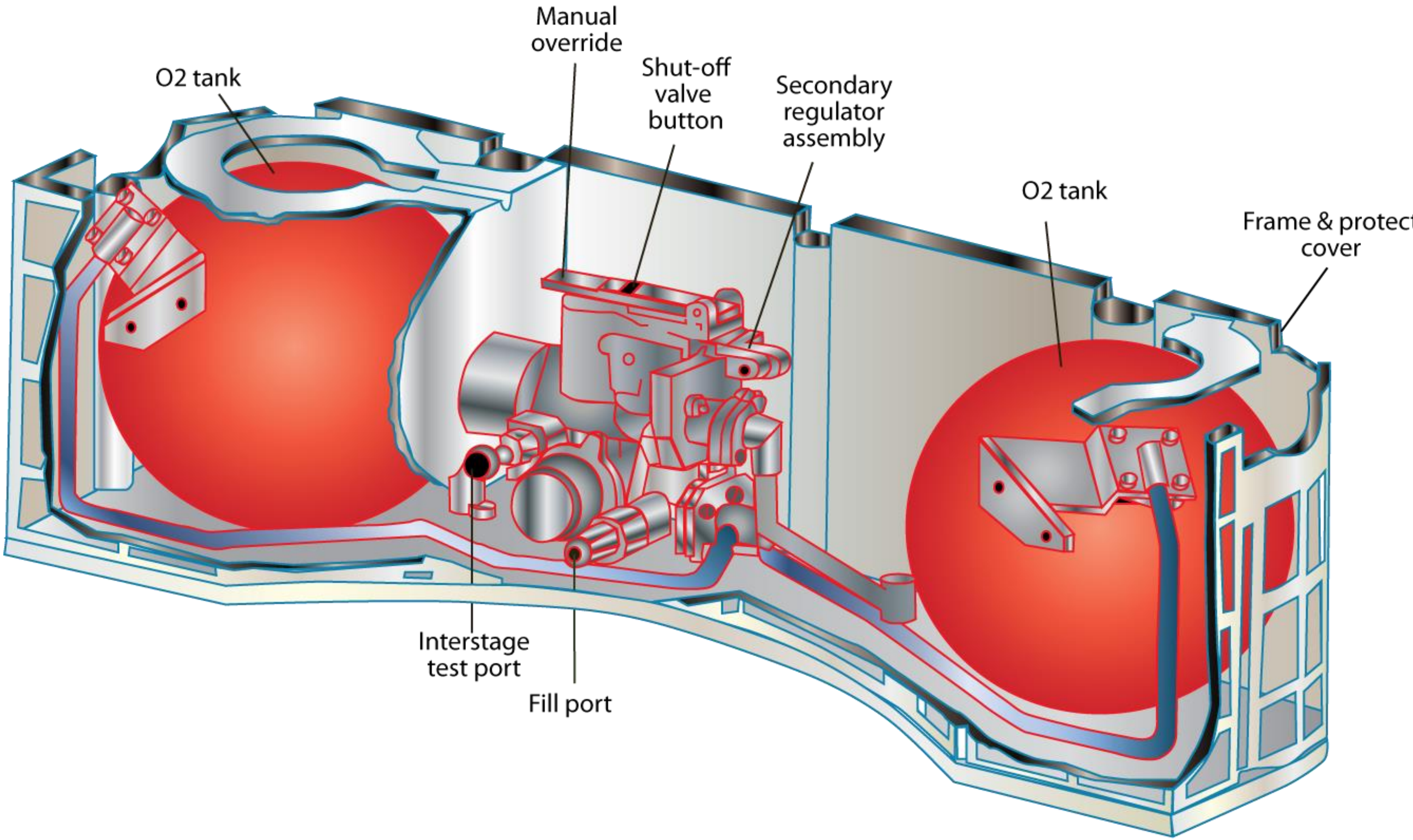
EVA SYSTEMS



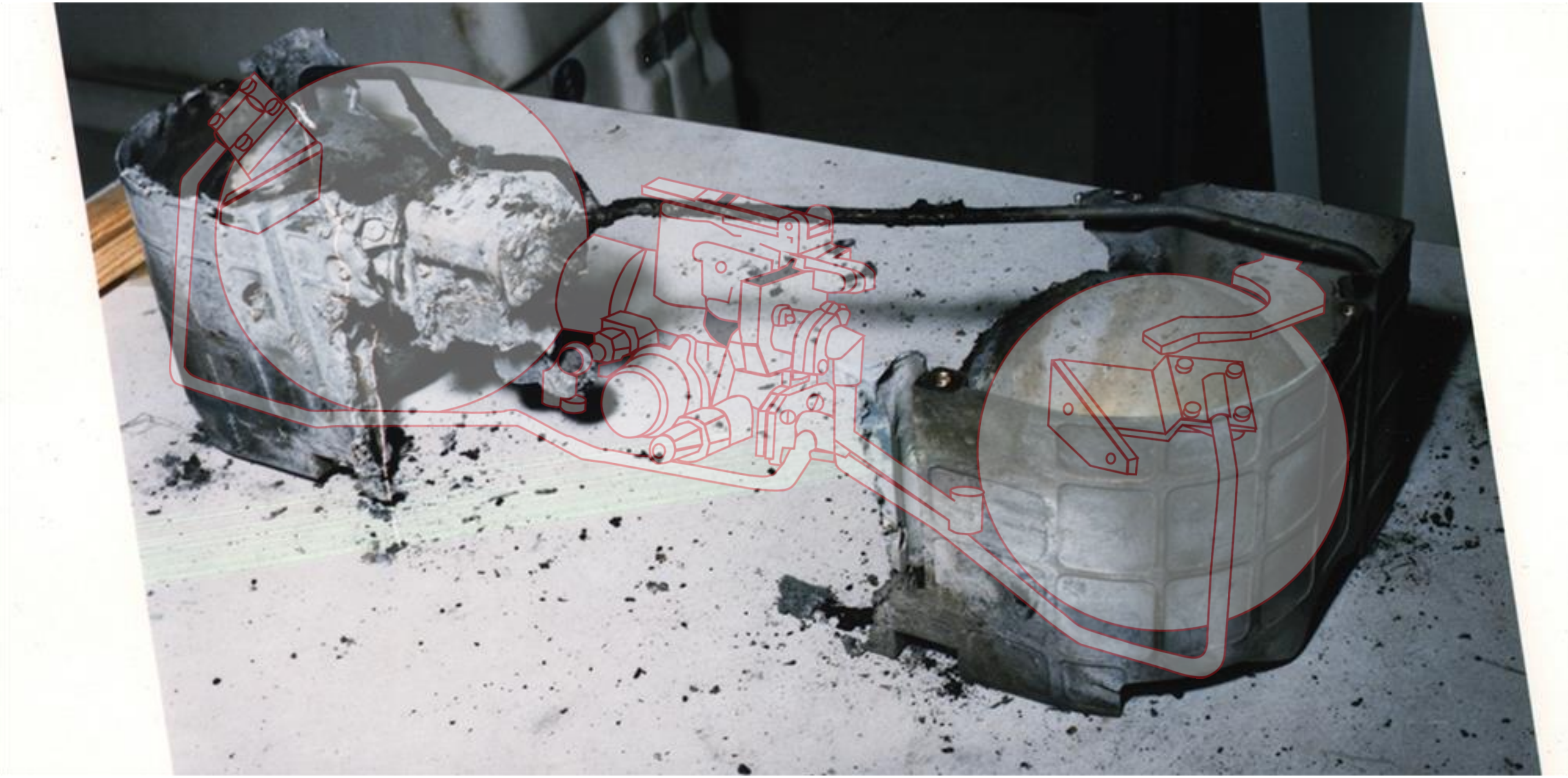
SEMU 3002 /PLSS 1002



Rear View of SOP/PLSS Regulators


Manual override
Shut-off valve button
Secondary regulator assembly
O2 tank
O2 tank
Frame & protect cover
Interstage test port
Fill port

Not Much Left!



Probable Causes

- The fire originated in an aluminum bodied regulator and valve assembly when 6000-psi oxygen was released through the valve into the regulator. It was postulated that the fire was probably caused by one or combination of the following:
  - Rupture of a thin, internal section of the aluminum body
  - Ignition of a silicone O-ring by compression heating of the oxygen
  - Particle impact

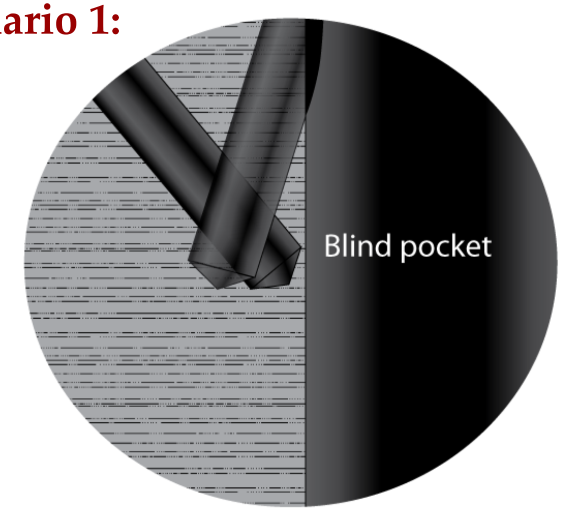
As a result of the post-fire investigation, the regulator and valve assembly was redesigned, and the aluminum in this assembly was replaced with Monel®.

This change and several others were implemented in the version of the EMU suit that is used today.

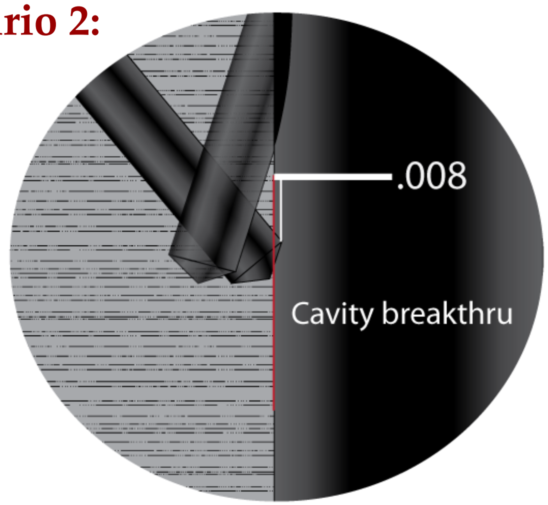
Trade names and trademarks are used in this report for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

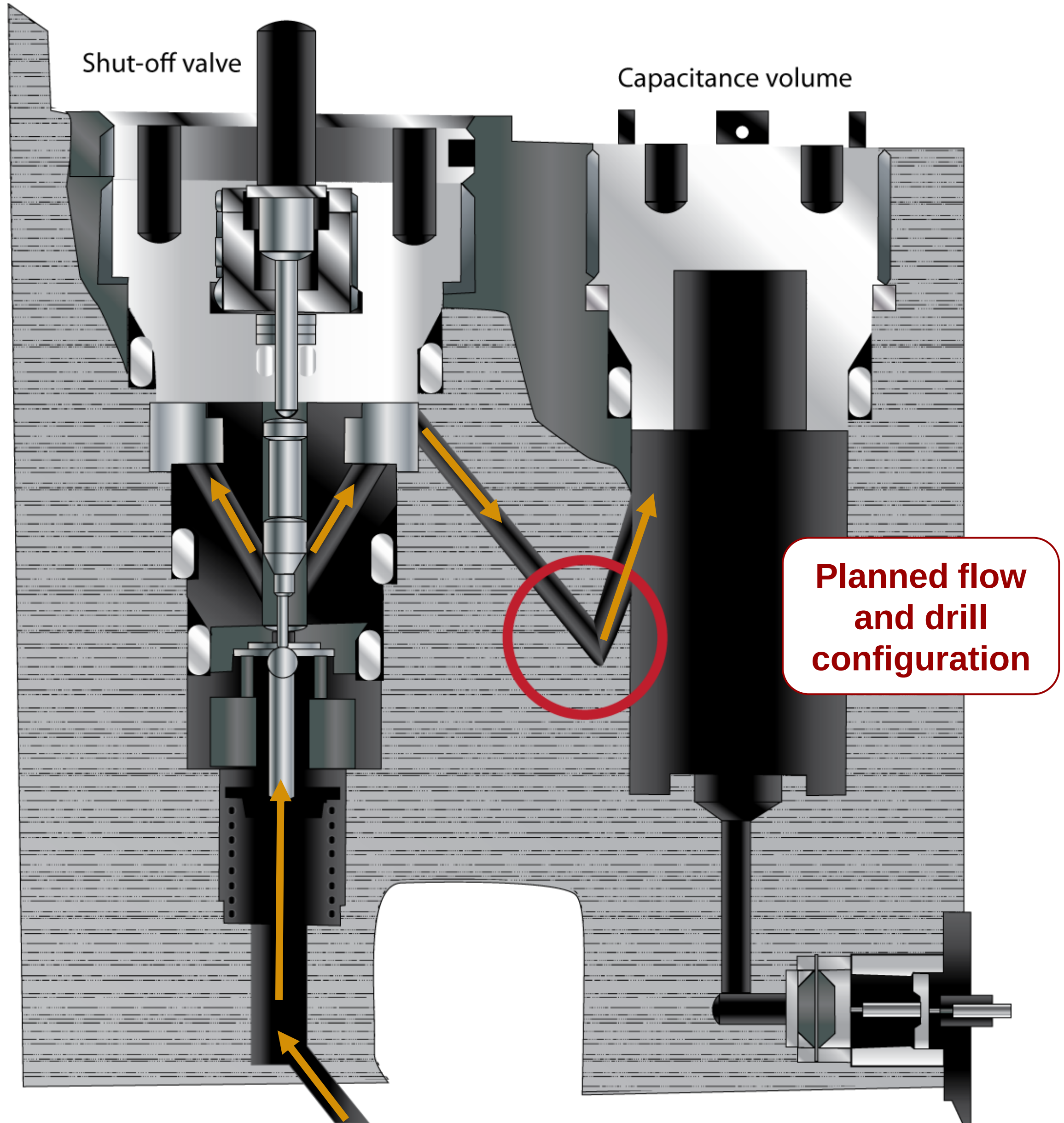
Secondary Regulator

Scenario 1:



Scenario 2:





Accident Investigation Report Recommendations

1. Nylon smocks tend to melt into the skin with a fire. An alternate material should be worn (Durret/ Chemstat).

2. All test personnel were wearing safety glasses, a requirement when operating a high-pressure O_2 system. This requirement protected the injured technician from serious eye damage. This regulation should be rigorously followed during testing.

3. This accident highlights the necessity of proper procedures while working with equipment of this type. Specifically, safety glasses and the proper type of protective clothing should be worn *(PPE)*. Cleanliness rules should be followed, and technicians should be familiar with all corrective measures indicated in case of a system failure.

Lessons Learned that Changed the Way We Do Business

- **Documentation**
- **Procedures**
- Proper **PPE** enforced, management held responsible to make sure it is available to everyone (Voluntary Protection Program (VPP))

Lessons Learned that Changed the Way We Do Business: Documentation & Reviews

- TPS was put into use, stopped working from service instructions:
  - Warnings and Safety notes are on the TPS and a procedures **Hazard Analysis** is required
- Perform a **TRR** as required
- Hardware should be designed with safety in mind. Follow the **design requirements** and get the right people involved during PDR, CDR

Lessons Learned that Changed the Way We Do Business: Procedures

- Procedures were written and a signature list developed:
  - We now have a S.P., which includes a checklist review of all procedures
- **Restrict the number of people in the area**, set up a test area and allow only the test team members access
- Perform a **safety briefing** and all members should know how to secure and evacuate the area and set up test such that **safe and rapid evacuation is possible**
- Stress **Safety** – the person who will use the hardware, your friend or a co-worker's LIFE may depend on it

Lessons Learned that Changed the Way We Do Business: PPE

- PPE provided at entry of lab
- No one is allowed to enter without wearing the proper equipment

Conclusion

- All Must be educated on the topic so that:
  - **Design** of systems both flight and ground with ignition mechanism mitigation incorporated
  - **Maintain** systems so that contaminants and leaks do not occur
  - **Operate** systems, both flight *(crew training and procedures)* and ground *(tech training and procedures)* to minimize risk by maintaining cleanliness, thus mitigating adiabatic compression

Lessons Learned

- A short EMU fell out of a fixture in August 2000:
  - JSC Building 7
  - Procedural issue
- A close call occurred in January 2001 when a flowmeter was over pressurized:
  - No personnel nor flight hardware was damaged
  - JSC Building 7
  - Skill and roles/responsibility issue

Initial Assessment

- Safety Team and Quality Team:
  - Members from NASA, HS, USA, ILC
- Consisted of site tours and interviews
- Assessed for adequacy, compliance, and values
- NASA representatives briefed at final out-briefing
- Corrective actions approved by team leaders and tracked

Initial Assessment Findings, Root Causes, Corrective Actions

- Over 50 Corrective Action Plans (CAPs) developed
- 6 categories of CAPs:
  - Skills assessment and training records
  - Document revision, procedure deviation, and release
  - Contract requirements flowdown
  - JSC hardware control requirements
  - EH&S program flow down
  - Corrective actions closure tracking
- Root Cause and Corrective Action competed for each CAP

Assessment

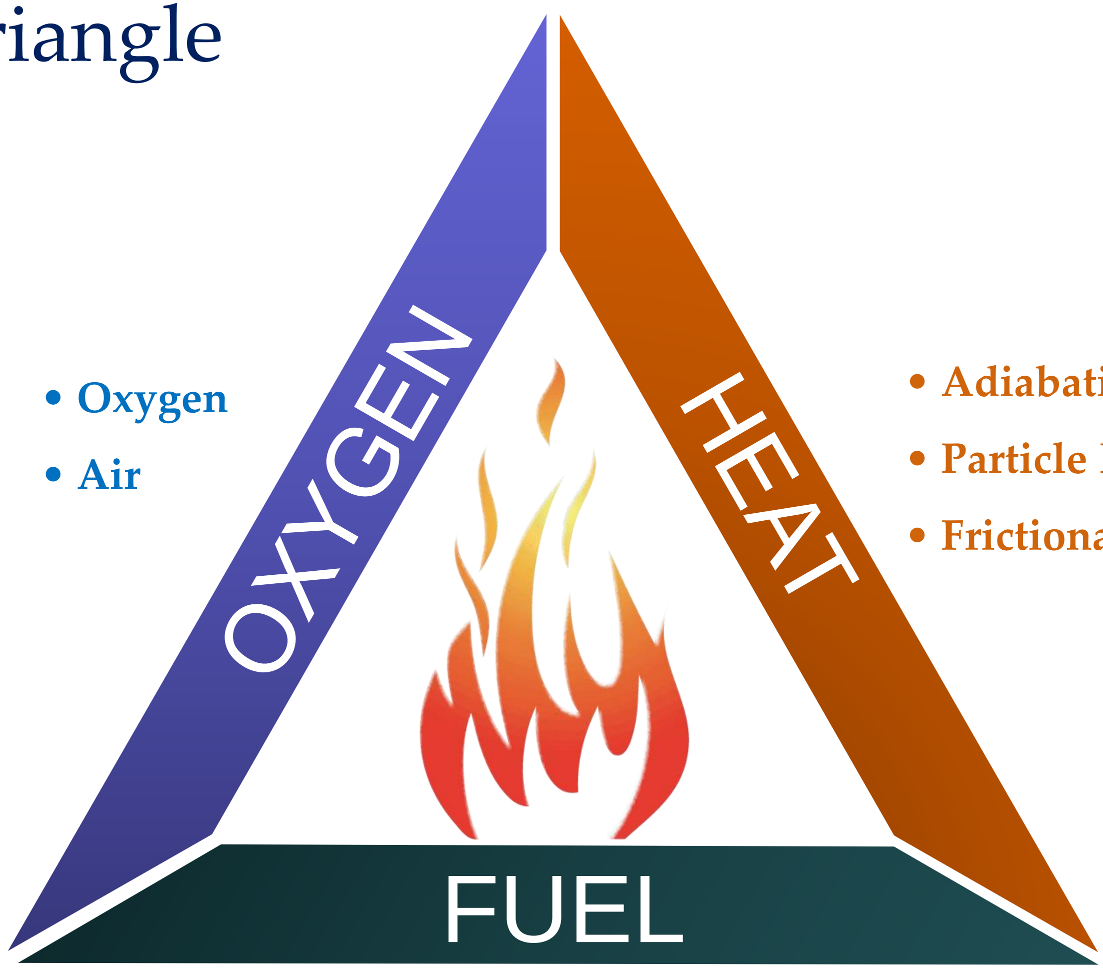
- Completed CAP Closure effectiveness audit November 2001
- Validation of every Quality-related CAP audited for closure

Finding	Example	Root Cause	Corrective Action
Skills assessments & training records not complete for all employees	Electrostatic Discharge Control certificate not on file with data base coordinator	Administration of skills assessment & training system needs improvement	Utilize HSWL Training Management System at HSMS
Practices for document revisions, procedure deviations and release of documents do not consistently provide good process control	Procedure deviation didn't have number assigned, missing signatures, use of redlines	Processing document management process needs improvement	Modify standard procedures to improve processing documentation control based on HSWL practices
Some contract requirements were not flowed down	No evidence of flowdown of TRR process and maintaining shop and laboratory processes at JSC	Lack of procedure for flowing down contract requirements	Establish a procedure for contract requirements flowdown Establish an EMU contract requirements matrix Distribute the requirements matrix to associates
Some hardware was not controlled per JSC requirements	Uncontrolled copies of procedures and rig schematics, hardware on flow bench was not 911 tagged	Skill assessments do not include all the JSC material control requirements	Add JSC material control requirements to skill assessments
Requirements of UTC EH&S Program not fully in place	NMT did not have MELT training and consequently did not know the SP001 through SP0012 requirements	Lack of procedure for flowing down requirements of UTC EH&S Program	Train HSMS management in UTC EH&S Program requirements Develop standard procedure for implementing UTC requirements based on HSWL procedure
HSMS standard procedures do not include a means for tracking corrective action (such as an audit database for tracking corrective actions of audit findings)	Internal audit findings only addressed specific deficiency, not root cause and corrective action	Management was not aware of the requirement for tracking corrective actions	Train HSMS management in UTC EH&S Program requirements Update standard procedures to incorporate safety actions into the Problem Investigation Tracking (PIT) system

Backup

Fire Triangle

- Oxygen
- Air



- Adiabatic Compression
- Particle Impact
- Frictional Heating

- System Components
- Non-metals
- Metals

What Do We Do About It?

- Spacesuits will always have all 3 hazards present
- Risk mitigation efforts:
  - Lower potential activation energy sources
  - Pick materials with higher activation energy requirements that are not propagation promoters
  - Keep the system clean so that you do not get unwanted, “bad” materials
  - Mandatory training on oxygen system hazards and safety measures
- Use a systematic approach to identify and analyze the ignition mechanisms resulting in the safest possible design and operation of the system

Ignition Mechanisms

EVA SYSTEMS

Particle Impact

- Heat generated when small particles strike a material with sufficient velocity to ignite the particle and/or what it hits
- Most common ignition source in metallic systems

Adiabatic Compression

- Heat generated when a gas is compressed from a low to a high pressure
- Most common when exposed non-metal close to a dead-end
- Most efficient direct igniter of non-metals and contaminants

Flow Friction

- Oxygen leaking across a polymer in such a way that enough heat is generated within the polymer to cause ignition
- Requires a high pressure drop and an exposed non-metal in a flow path

Ignition Mechanisms

Galling, Friction, or Mechanical Impact

- Heat generated by the rubbing of two or more parts together
- Compressors, chattering RVs, check valve barely opening

Promoted Ignition

- Heat from the ignition and combustion of a more flammable material igniting a less flammable material
- Contamination is a very common, unplanned start for this

Static Discharge

- Accumulated static charge on a non-conducting surface discharging with enough energy to ignite the receiving material
- Most severe in a dry environment

Electrical Arc

Resonance - Acoustic source

NASA News

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058
AC 713 483-5111

For Release

Terry White

RELEASE NO: 80-039

June 10, 1980

ALSO RELEASED AT NASA HEADQUARTERS

INVESTIGATORS FILE REPORT ON CAUSE OF SPACESUIT *BACKPACK FIRE*

A NASA board investigating the April 18 Flash Fire in a spacesuit backpack Found where the fire started and recommended 11 mays to improve safety and reliability of Lhe system.

While Lhe exact cause was not found, the Four most probable causes of igniLion were cited in the board's reporL to Johnson Space Center Director Christopher C. Kraft, Jr., after Five meeks of engineering deLective work that included more Lhan 2,000 unsuccessful aLtempts to reproduce the Fire.

The accident destroyed an unoccupied Space Shuttle spacesuit and life support backpack. A HamilLon S%andard Lechnician, Robert A. Mayfield, was severely burned but is recovering and has been released from Lhe hospital.

- more -

these tests are conducted to assure that such malfuncitons are discovered prior to flight, since such an accident during a mission might well cause serious injury or fatality, or require premature termination of the mission.

The fire apparently started when the technician switched the secondary oxygen pack to the "spaeewalk" position during a per-Formance test in a clean room in the Crew Systems Laboratory.

The secondary pack is attached to the bottom of the main backpack and provides 30 minutes of emergency oxygen For breathing and to maintain suit pressure i¢ the main oxygen source fails.

Ignition took place in a V-shaped passage which serves to restrict the flow of oxygen betmeen a shut-off valve and a chamber in the pack's regulator module, the investigating board determined.

It said the four most probable causes were:

1. Heating by compression or shock of a thin section of aluminum betmeen the flow restrictor passage and the adjacent cavity.
2. Heating by compression or shock of contaminants in the Flow restrictor.
3. Heating of internal surfaces through mechanical shock of incoming high-pressure oxygen, or heating of particles.
4. Similar heating of shut-off valve o-rings.

The board found that all procedures followed during the April 18 test mere proper. The regulator module had 19 cycles mith high-pressure oxygen prior to the accident.

- more -

Technicians mere unable to duplicate the Failure in tests at Johnson's White Sands Test Facility, Las Cruces, New Mexico. Four regulator modules of the same Factory batch mere cycled 2,228 times. Post-test disassembly revealed significant contamination mikhin the modules.

A regulator module is machined From a single block of aluminum and is Fitted mith valves, a pressure gauge and tmo step-domn regulators that reduce oxygen supply pressure From 6,000 Lo 3.5 pounds per square inch. The Flom restrietor consists of kmo 1/16-inch diameter drilled passages that intersect. IL is betmeen the high pressure inlet and the First stage regulator.

AFter ignition on April 18, the regulator module burned through and an oxygen-rich jet of Flame burned the lomer torso of the attached spacesuit.

The board ruled out backpaek and clean room electrical systems as ignition sources. It said all clean room support Feed lines mere pure.

The i1 recommendations of the board are:

o Redesign high pressure oxygen valves and regulators so that debris eannot be trapped and eliminate "stagnation points" mhere healing by compression and shock can occur.

o Redesign regulator modules Lo lessen chance of internal contamination, mhile improving manufacturing inspection techniques.

- more -

o Reviem Lhe design of all Space ShuLtle high pressure valves and regulaLors For debris Lraps and unproLeeLed o-rings.
o Replace existing silicone o-rings miLh silicone o-rings having improved ignition resisLanee.
o Machining regulator module body From monel instead of aluminum mould reduce ignition potential.
o Inspect completed regulator modules miLh X-rays.
o Consider using neutron radiography Lo confirm thaL o-rings and oLher non-meLallic componenLs miLh significant hydrogen contenL are properly installed.
o Machine a dummy regulaLor module body from a block of clear plastic to verify mall thicknesses and oLher passagemay machining tolerances.
o Consider comparison impact igniLion tesLing of Teflon or Kel-F backup rings as a means of reducing shock healing of silicone o-rings.
o Clarify inLernal NASA specificaLions.
o Consider esLablishing a commiLtee consisLing of NASA and non-NASA personnel Lo collect existing high-pressure oxygen data_ review and clarify existing design standards and requirements, recommend any necessary supplimenLs to presently available information and publish a comprehensive standard for the design and use of high-pressure oxygen equipment used in Lhe space program.

- more -

The investigating board mas headed by Chester A. Vaughan, propulsion engineer. Members were: Noel Willis, Jr., crew systems engineer; George D. Nelson, astronaut; Joseph Degioanni, flight surgeon; and James B. Chappee, safely engineer. Andrew J. Hoffman of Hamilton Standard served as ex-officio member, and R. L. Johnston, materials engineer, served as advisor.

###

Trade names and trademarks are used in this report for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

Acronyms & Abbreviations

CAP	Corrective Action Plan
CDR	Critical Design Review
CO_2	Carbon Dioxide
EH&S	Environmental Health and Safety
EMU	Extravehicular Mobility Unit
HSMS	Hamilton Standard Management Systems
HSWL	Hamilton Standard Windsor Locks
JSC	Johnson Space Center
MELT	Management Environment Leadership Training
NMT	No More Than
O_2	Oxygen
PDR	Preliminary Design Review
PIT	Problem Investigation Tracking
PLSS	Portable Life Support System
PPE	Personal protective equipment
PSI	Pounds per Square inch
RV	Relief Valve
SEMU	Short Extravehicular Mobility Unit
SOP	Secondary Oxygen System
S.P.	Standard Procedures
TPS	Thermal Protection System
TRR	Technical Requirements Review
UTC	United Technologies Corporation
VPP	Voluntary Protection Program