Auto Ignition Temperature Test
Chamber Fire Investigation

Based on Report DAA-33855
Design of new exploration space suit is underway at NASA.

There has been a history of unanticipated contamination of space suit hardware from:
- Gas Supply Cleanliness
- Test rig Cleanliness
- Procedural Control Limitations

To anticipate future contamination issues, the Primary Oxygen Regulator (POR) was designed to tolerate and quench contamination events.

POR was then deliberately contaminated and subjected to rapid pressurization cycles.

For the suit analysis, the AIT of the contaminate needed to be known in oxygen.
Test Materials and Test Conditions

- **Test Materials**
  - Dodecane (C12) low AIT Hydrocarbon

- **No applicable WSTF historical data**
  - For Dodecane AIT in Oxygen
  - 19 preliminary AIT tests with Dodecane were run at ambient conditions weights between 0.2g and 2.0g

- **ASTM G72**

- **Newport Scientific 41-12555 Vessel**

- **Test Conditions before AIT in Oxygen**
  - Temperature: ~178°C, Pressure: ~15.7 Mpa
Test System Layout

Reaction Head/Sample Holder
Incident

Pressure (psia) vs. Time [minutes]

Temperature (F) vs. Time [minutes]
Evidence

• Chemical Analysis
  – Sample weight of dodecane insufficient to cause full pressure rise alone.
  – Gordon-McBride Model
    • After 0.2g sample consumption, predicted chamber pressure 41.4 Mpa
    • Near sample 3,126 °C flame temperature @ 139 Mpa
      – Melting point of 304 SS 1400-1455 °C\(^1\)
    – ~3.5 g of SS would have to burn to increase chamber to 69 Mpa
    – ~28 g of SS was missing from inside of the reaction head

• Temperature rise happened before pressure rise.

• Secondary fire in RV-10 may have been due to rapid pressurization of contamination from previous testing.

\(^1\)http://asm.matweb.com/search/SpecificMaterial.asp?bassnum=MQ304A
Pressure Rise

- TJE Type Transducer
  - Published Overpressure (Burst)
    - 172 Mpa (20 ksi)
- Data indicated large pressure rise between samples ~1 Hz
- Sufficient to mechanically rupture pressure transducer
- Fine Solidified Metal Spray found throughout system increasing reaction rate. (Line dia 3.125 mm)
## Proposed Series of Events

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<th>Test Configuration</th>
<th>Dodecane Ignition</th>
<th>Thermocouple Ignition</th>
<th>Bushing Ignition</th>
<th>System Breech</th>
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</table>

1. **Test Configuration**
2. **Dodecane Ignition**
3. **Thermocouple Ignition**
4. **Bushing Ignition**
5. **System Breech**
Findings

• The stainless busing was replaced with brass to quench possible TC ignition events in the future.
• Contamination found down stream needs to be evaluated for cross contamination issues.
• Fire risks related to unexpected overpressure from contained sprayed metal fires is not well understood.
• The space suit POR was extremely robust.