Auto Ignition Temperature Test Chamber Fire Investigation

Based on Report DAA-33855

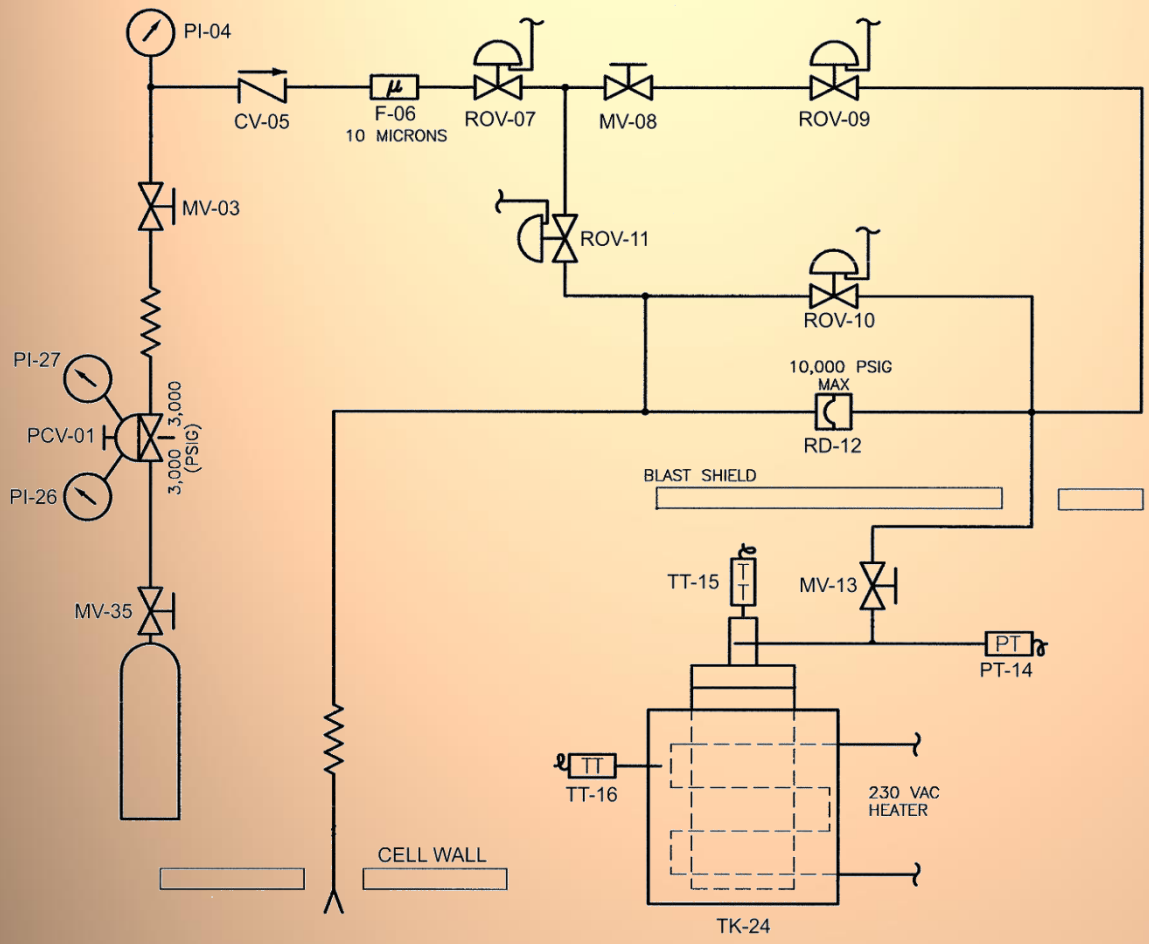
Exploration Space Suit

- 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.

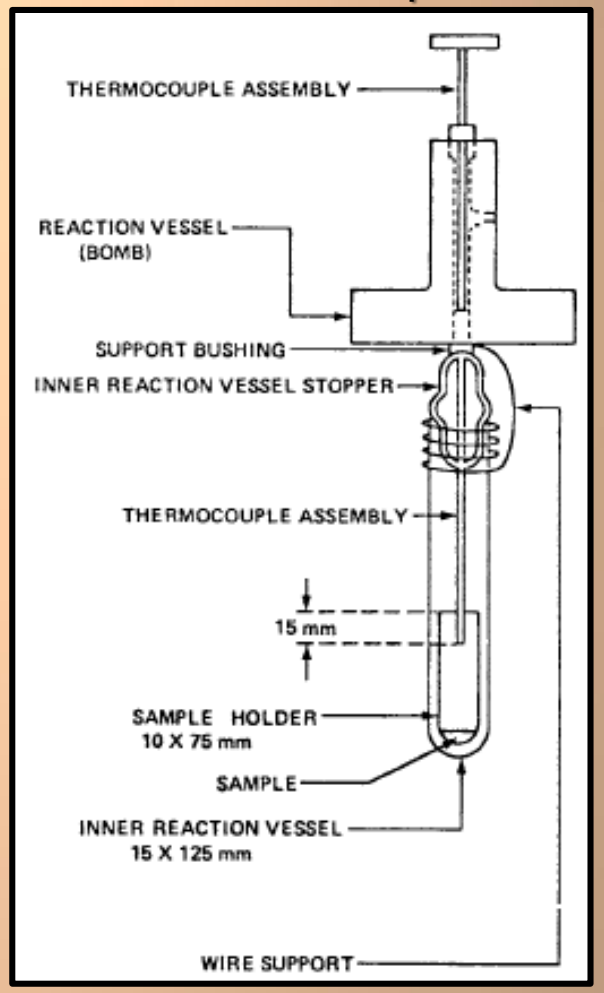
Test Materials and Test Conditions

- 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

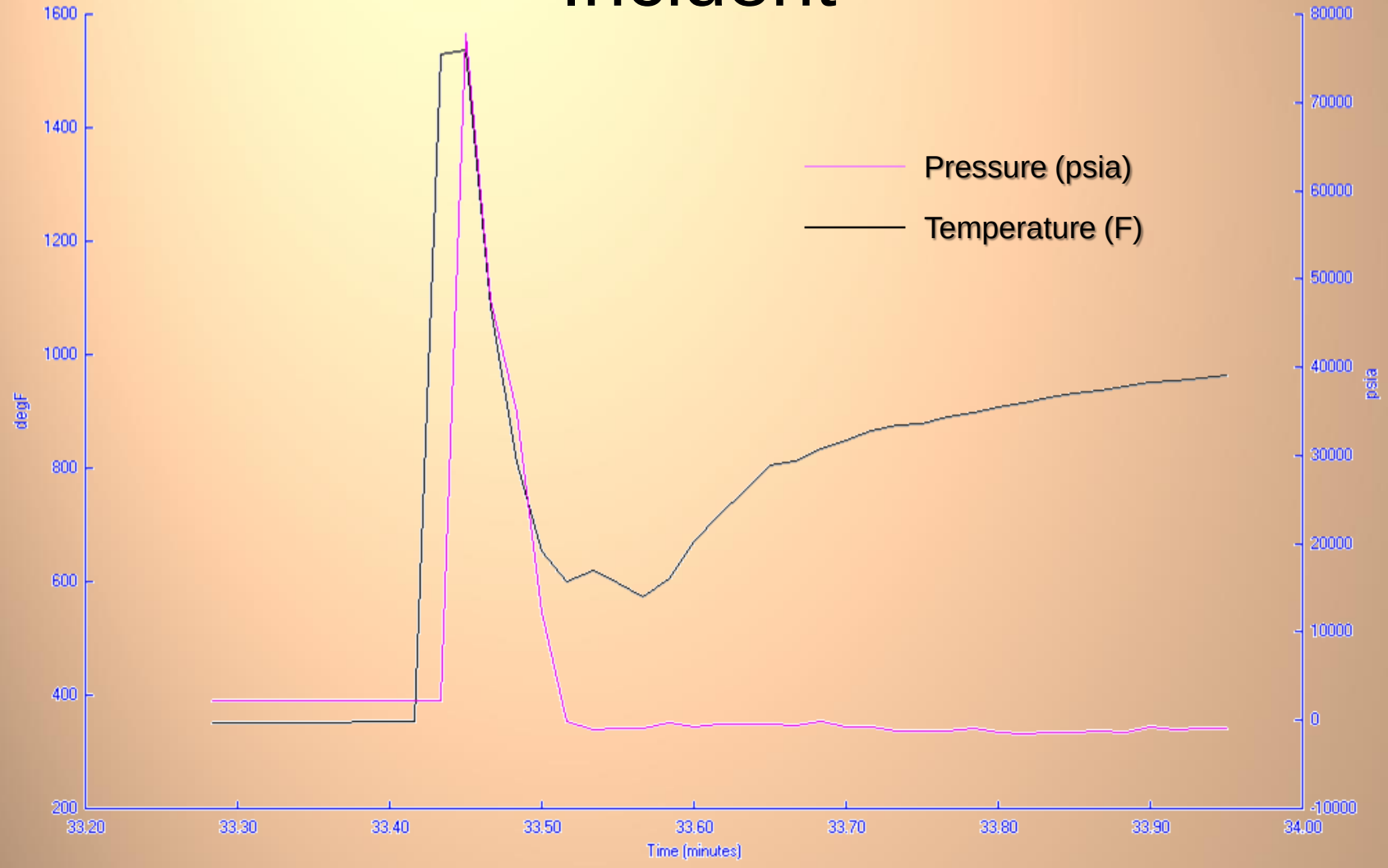
Test System Layout



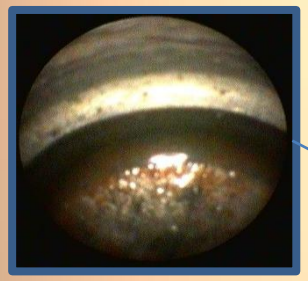
Reaction Head/Sample Holder

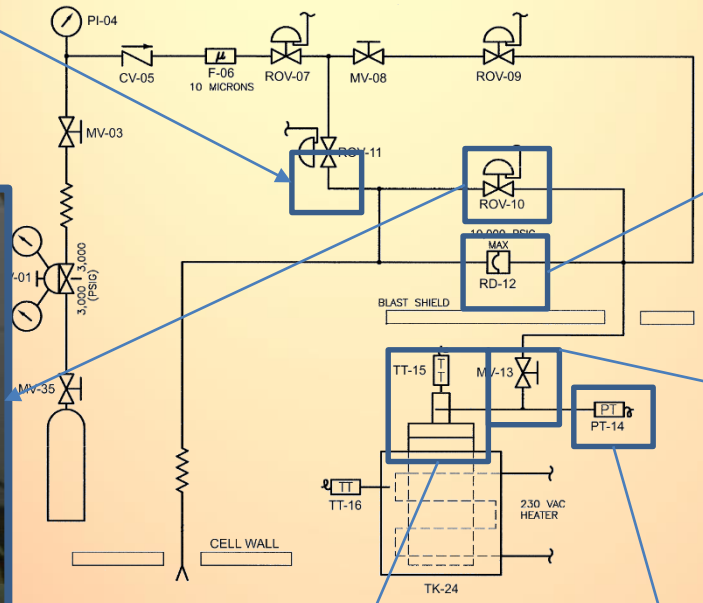


Incident


Pressure (psia)
Temperature (F)
degF
psia
Time (minutes)
1600
1400
1200
1000
800
600
400
200
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
33.20
33.30
33.40
33.50
33.60
33.70
33.80
33.90
34.00

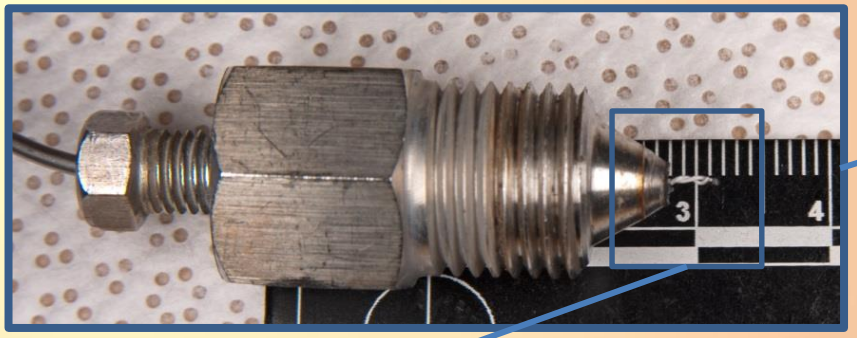
Incident

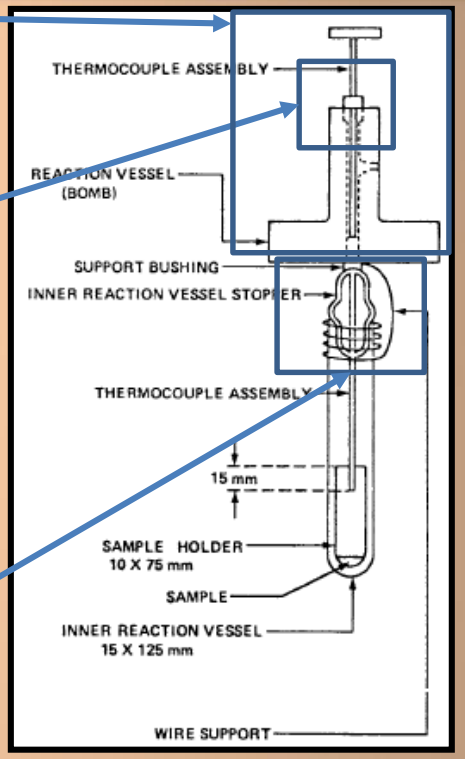


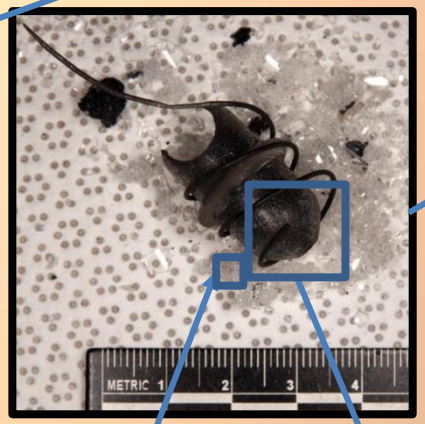

PI-04
CV-05
F-06
10 MICRONS
ROV-07
MV-08
ROV-09
MV-03
ROV-11
ROV-10
MAX
RD-12
BLAST SHIELD
3,000
(PSIG)
MV-35
TT-15
MV-13
PT
PT-14
TT
TT-16
230 VAC
HEATER
CELL WALL
TK-24

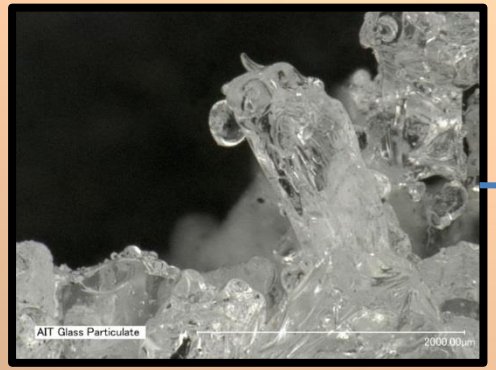
NASA

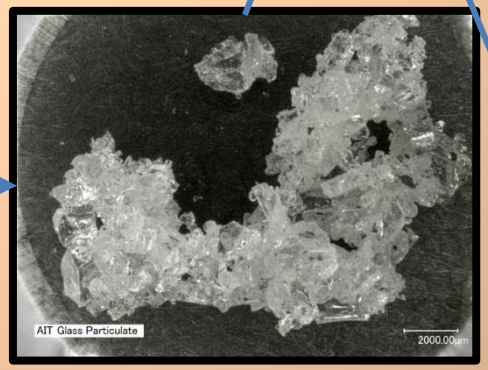
White Sands Test Facility











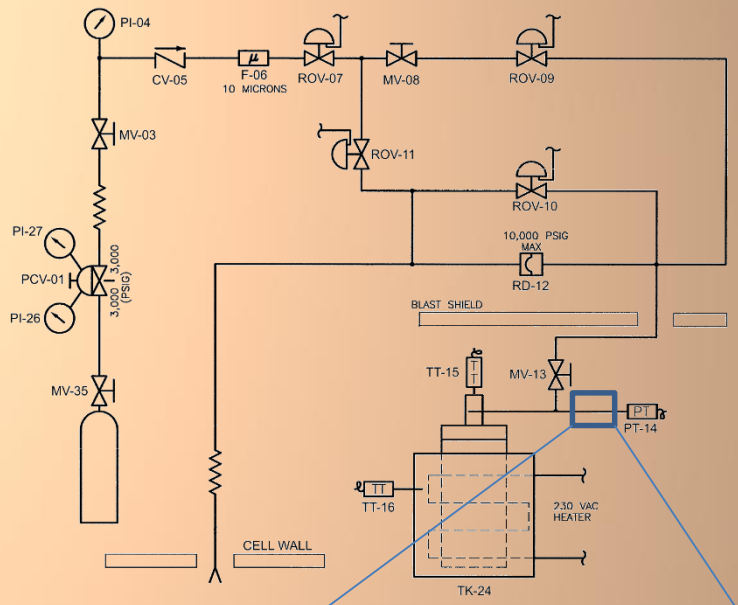
Evidence

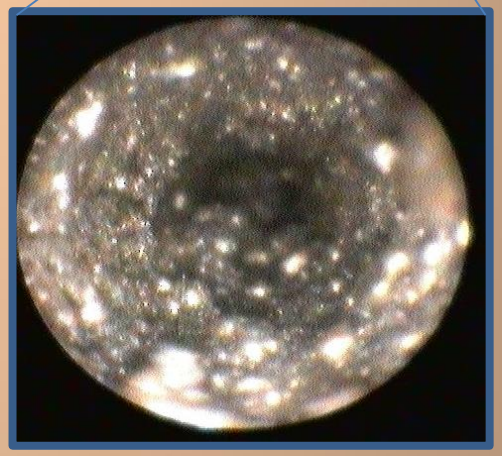
- Chemical Analysis
  - Sample weight of dodecane insufficient to cause full pressure rise alone.
  - Gordon-McBride Model
    - After 0.2g sample consumption, predicted chamber pressure 41.4 Mpa
    - Near sample 3,126 °C flame temperature @ 139 Mpa
      - Melting point of 304 SS 1400-1455 °C[1]
  - ~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

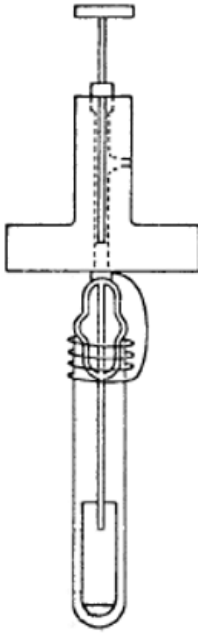
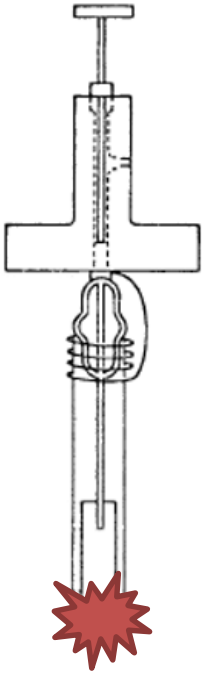
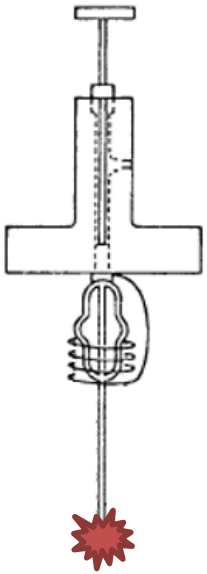
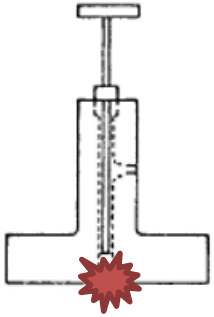
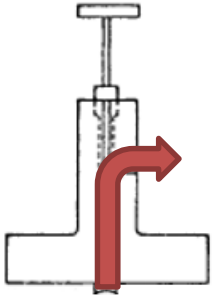
Pressure Rise

- 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 through out system increasing reaction rate. (Line dia 3.125 mm)





Proposed Series of Events

				
Test Configuration	Dodecane Ignition	Thermocouple Ignition	Bushing Ignition	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.