



Glovebox/WEP Fire Tests

**Conducted August 2007
by
Southwest Research Institute**

**Presented
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Conditions Leading Up to Tests

- Maximum Fire Event
 - Post Seismic Fire
 - Peak Heat Release: 12.2 MW;
 - Peak Temperature: ~650 °F
 - Fire Duration: 130 + min
 - Controls – CVS/Fire Barriers/Combustible amounts
 - Met DOE STD 3009 criteria



Key Assumptions

- WEP & shield windows de-rated by 90%
 - Little qualified data on WEP and shield window performance
- Fire testing of WEP shielding/glovebox assemblies conducted to understand material performance and make observations on de-rating assumptions

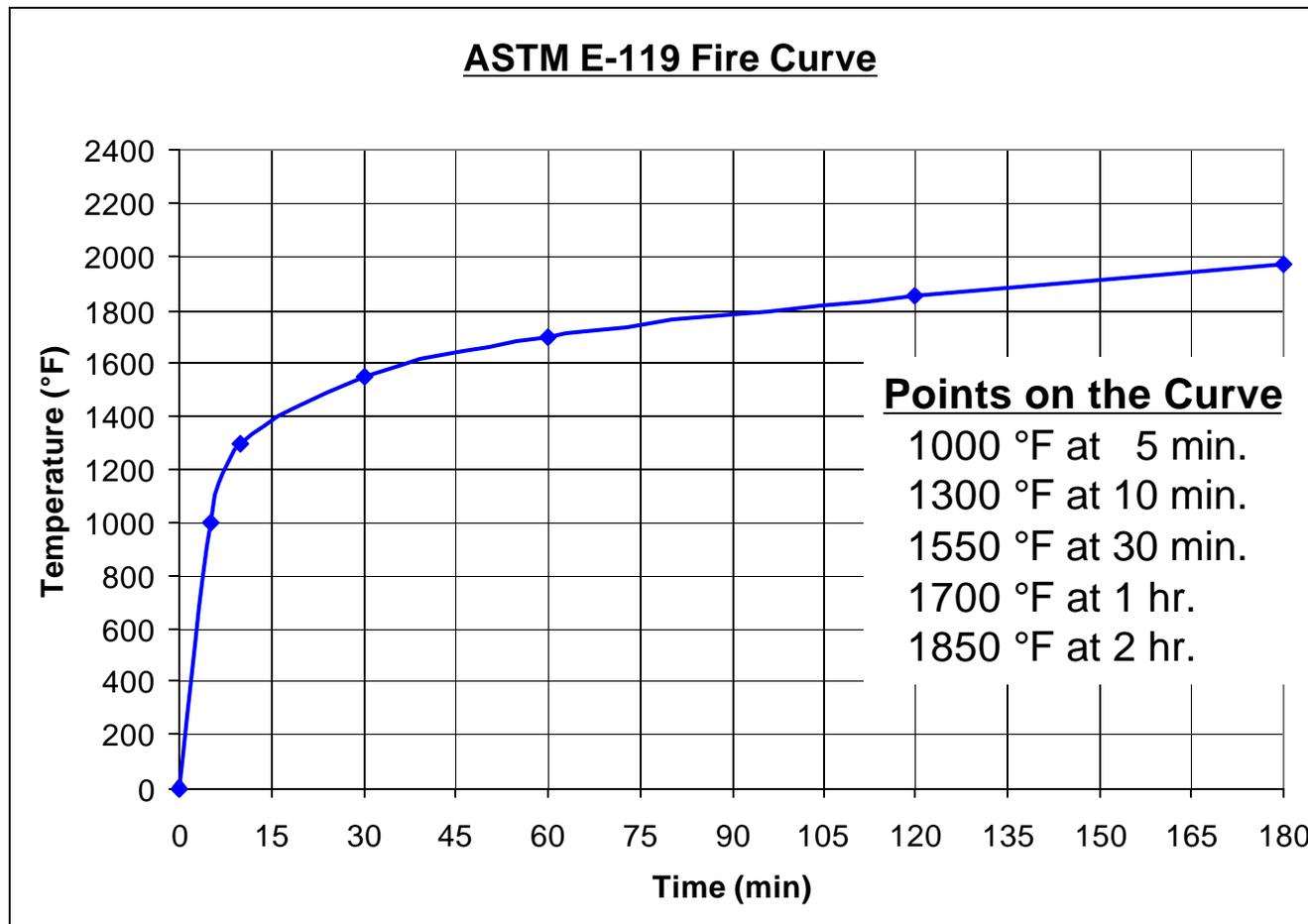


Objectives of the Tests

- Validate assumptions in fire analysis
- Support assessment of increased combustible loading
- Provide better understanding of fire behavior of metal clad WEP and glovebox assemblies



Fire Test Curve





Scope of the Fire Tests

- 800 °F for 2 hours with thermocouples
- ASTM E-119 Fire with no venting of WEP confinement
- ASTM E-119 Fire full Glovebox with venting of WEP confinement



Fire Test Conditions

- **Why 800°F?**
 - Representative of expected bounding PDCF fire
 - Previous analysis of “three-room fire” predicted 670°F
 - Temperature below IEEE 383 cable insulation auto-ignition.
 - Temperature below Acrylic (PMMA) auto-ignition (868°F).
 - Below flashover temperature

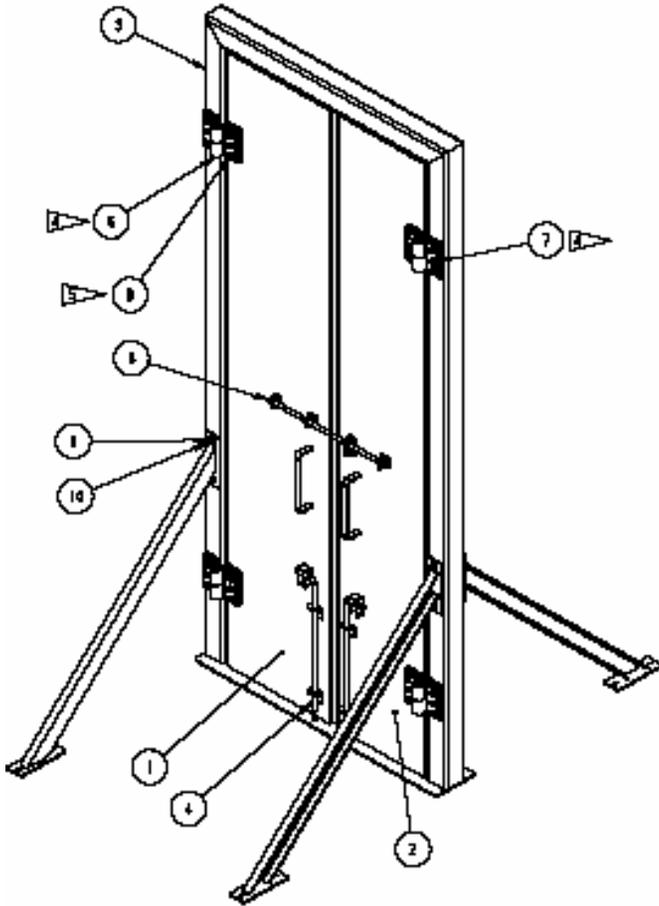


Fire Test Conditions

- **Why ASTM E-119?**
 - Recognized standard for Time Temperature Curve for ordinary combustibles and evaluating building performance
 - Represents a fire without suppression
 - Represents a severe fire scenario for most facilities



Shield Doors



Fully Assembled Glovebox –Fire Test Ready

1722 lbs without WEP

2078 lbs with WEP





Observations from Fire Test #1

- 5 min - WEP began weeping out of penetrations (800°F)
- 43 min - Panel bulges and small hole relieves pressure
- 68 min - WEP deposits on floor ignite
- 97 min - WEP consumed and flames die down
- 109 min - WEP re-ignites and burns; flames climb up panel
- 116 min - Flames die out from lack of fuel
- 124 min - Vapors visible from panels as they start to cool

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Fire Test #1—Panel @ 40 min 800°F



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Fire Test #1—Panel @ 68 min 800°F



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Fire Test #1—Panel @ 120 min 800°F





Fire Test #1—WEP Behind Top Fill Port





Fire Test #1—WEP at Top Fill Port After Test





Fire Test #1—The Only Vent Found





Observations from Fire Test #2

- 11 min - Panel bulges; relieves some pressure (1340°F)
- 14 min - Panel ruptures at bottom; relieves pressure (1400°F) and flames appear at bottom of panel
- 20 min - WEP material burns to end of test (2 hrs)
- 131 min - Flames die out from lack of fuel

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Fire Test #2—Panel @ 11 min 1340 °F



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Fire Test #2—Support Welds Failed





Test #2—Bottom of Panel



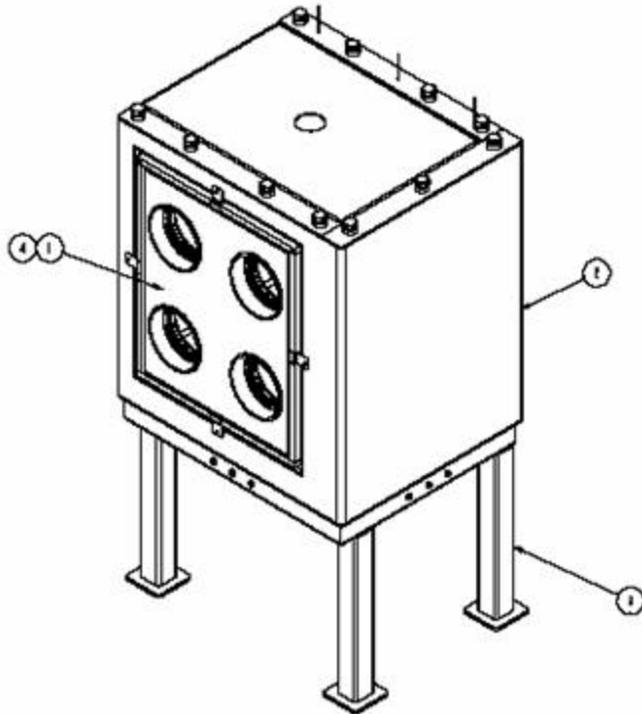


Glovebox/WEP Fire Test #3

- Glovebox exposed to ASTM E119 Time Temperature Curve
- Burners turns off after 42 minutes, but allowed to burn for 60 minutes.
- Nominal Maximum Test Temperature of 2200° F
- Significant venting occurred at top of glovebox



Glovebox

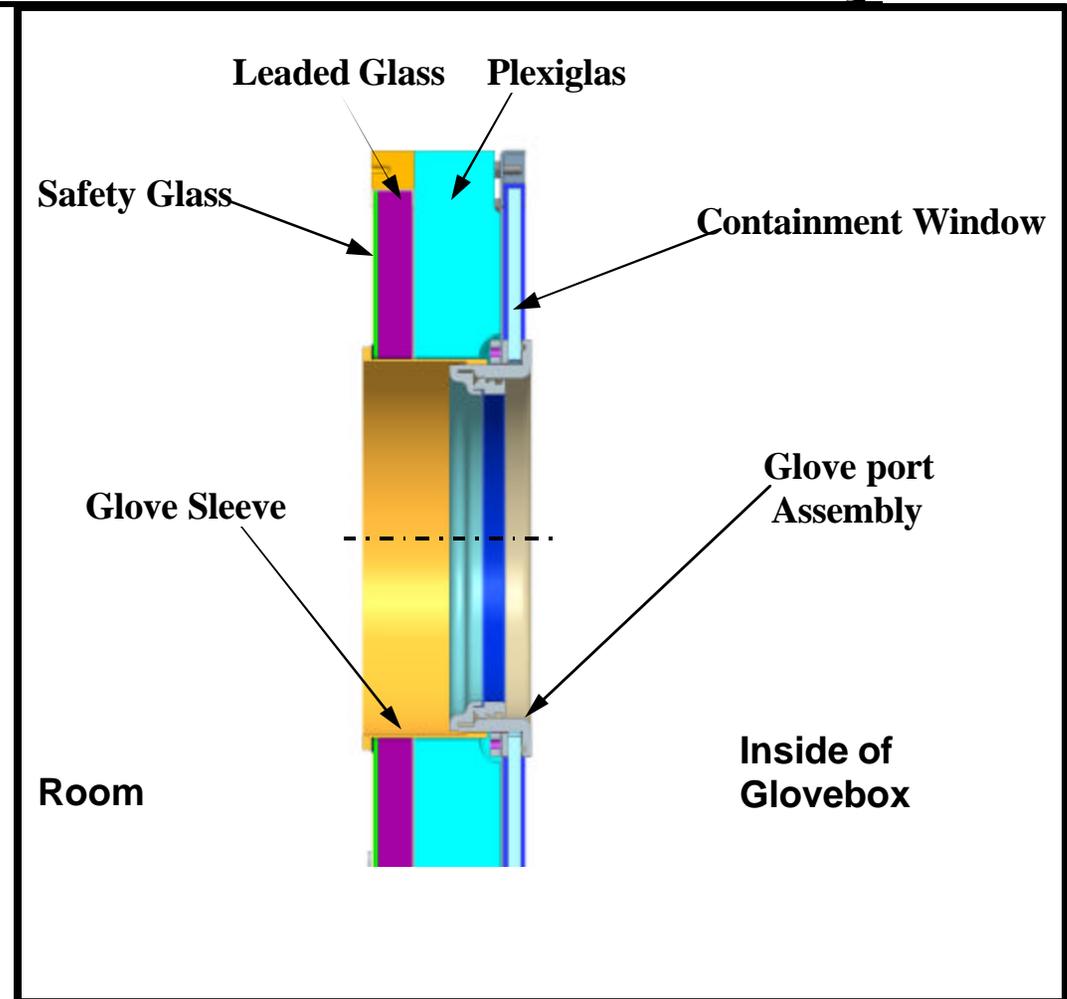


Fully Assembled Glovebox - Fire Test Ready

- 2478 lbs without WEP
- 3222 lbs with WEP



Glovebox - WEP - Window/Glove Assembly





Observations — Test #3

- 1 min One glove ring ignites and is consumed
- 2 min Glove ring is consumed and flame goes out
- 4 min Remaining gloves and plastic sleeves ignite, safety glass fails (868°F)
- 6 min Exposed acrylic around glove ports ignites (1155°F)
- 13 min Lead glass fails—flames spread across face of glovebox window (1380°F)
- 16 min Flames & smoke fill the oven (1580°F)
- 22 min Temperature exceeds fire curve (1840°F)
- 33 min Temperature well above fire curve (2200°F)

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Fire Test #3 @ 1 min ~140°F



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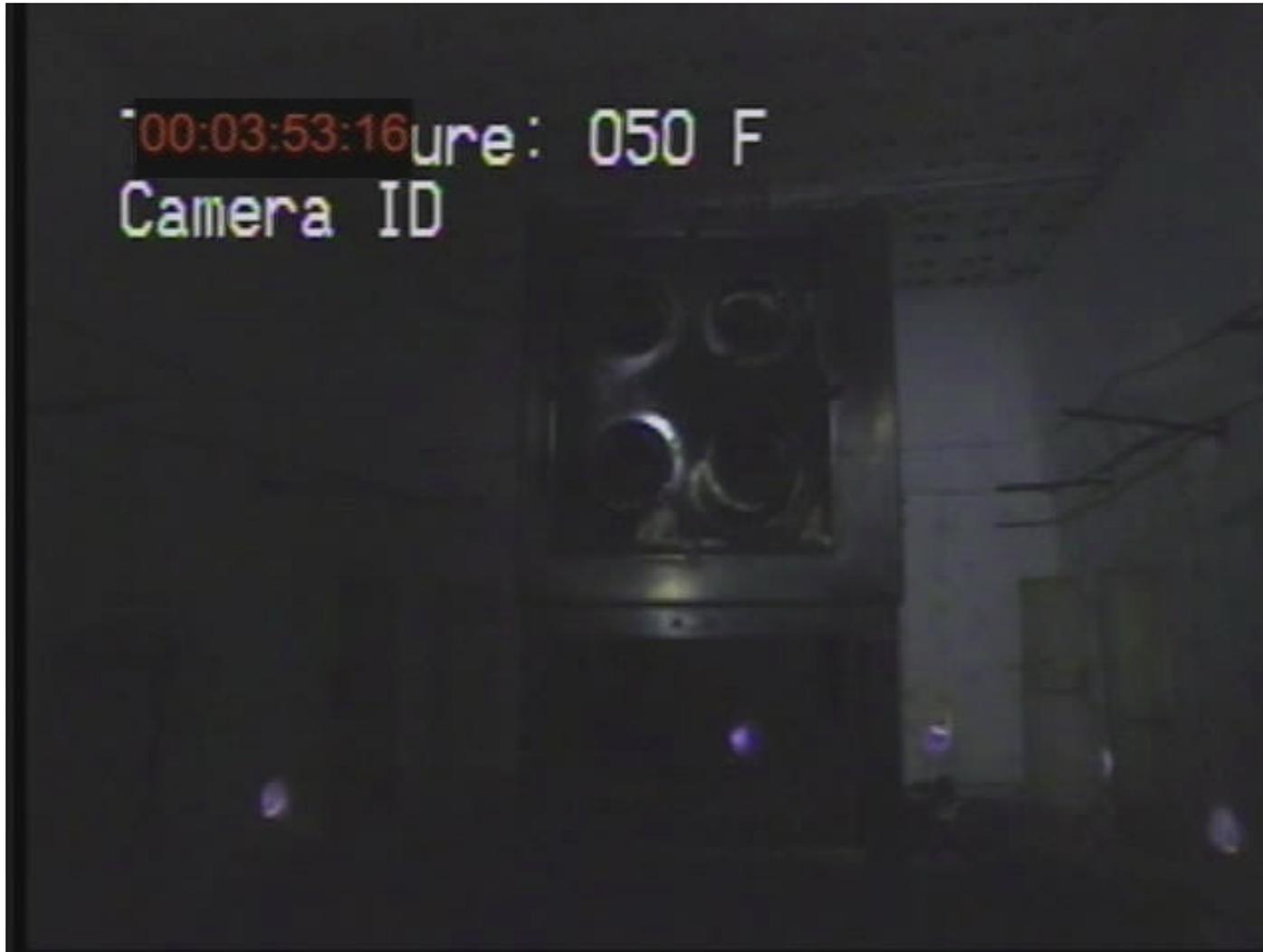


WEP Panel Test #3 @ 2 min ~300°F





WEP Panel Test #3 @ 4 min ~850°F





WEP Panel Test #3 @ 6 min 1155°F



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WEP Panel Test #3 @ 6 min 1155°F





WEP Panel Test #3 @ 11 min 1300°F



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WEP Panel Test #3 @ 13 min 1380°F



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WEP Panel Test #3 @ 16 min 1580°F





Glovebox After Fire Test



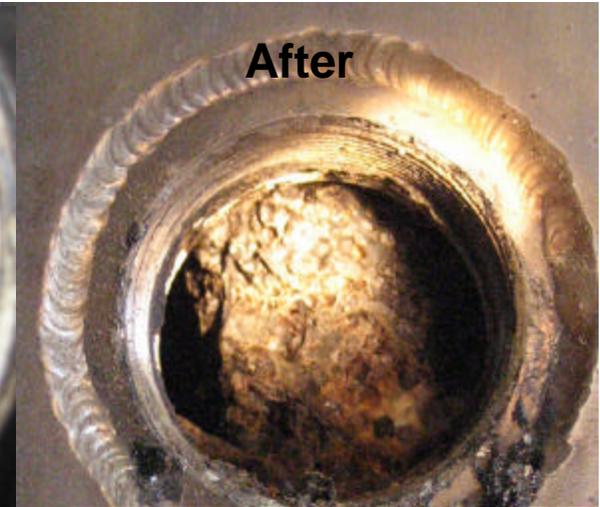
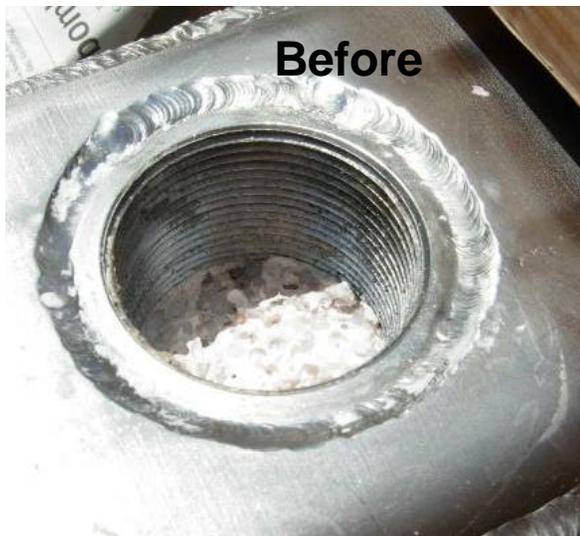


Initial Conclusions

- No Big surprises
 - The vaporization of moisture in the WEP maintains WEP temperatures well below exposure temperature conditions while moisture off gassing occurs
 - WEP off gassing rate is sensitive to the exposure temperature
 - WEP that became exposed to flame burned, but did not cause fire propagation internal to the metal cladding
 - Off gassing from unvented WEP over pressurizes metal cladding to failure
 - WEP metal cladding failure is not catastrophic and does not eject large quantities of WEP material that burn
 - Venting of metal clad WEP effectively maintains cladding integrity
 - Combustible vapors are released from WEP at high temperature
 - WEP Vapors ignite at elevated temperatures [expected]
 - After the exposure testing, residual WEP material remains in the metal cladding



WEP Testing Supports De-rating



- **WEP Material still in GB confinement after 2hr 800°F fire**
- **Vented confinement intact after full fire (Test 3)**





Basis for Considering WEP De-rating

- Enclosed materials are typically derated for fire analysis based on enclosure design

Design	De-rating (%)
Cabling in conduit	100
Cabling in enclosed cable tray	80
Combustibles in metal bookcase	75
Combustibles in metal file cabinet	90

- Shipping cask testing has shown at elevated temperature (930°F)
 - Water & combustibles are released
 - Residue remaining is combustible
- SwRI testing showed ~ 60% weight loss



Fire Tests – Initial Conclusions – Window Assembly

- Gloves contribute to the fire loading at a relatively low temperature, but extinguish quickly due to low fuel quantity and do not fail the shield windows
- Mechanism for fire involvement of PMMA is failure of glass barriers
- Once a PMMA shield window becomes exposed to ignition temperatures, it behaves like a high heat flux hydrocarbon fire
- De-rating shield windows may be a problem



WEP & Window Fire Performance Data

- Complete Post Fire Evaluation
 - Characterize amount of WEP remaining
 - Determine moisture content of residual material
 - Determine combustibility of remaining WEP



Summary

- Fire is a key safety issue for all DOE facilities
- PDCF has developed fire data that may be useful in the complex
- We will share the fire test information within the complex