Federal Aviation Administration

International Aircraft Materials Fire Test Working Group

Update on Flammability Testing of Magnesium Alloy Components

Presented to: IAMFT WG, Cologne, Germany

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Date: June 17, 2009

Magnesium Alloy Flammability

Preliminary lab scale oil burner testing

Handheld extinguisher testing

Additional lab-scale flammability experimentation

Identify critical elements of preliminary testing

Conduct full scale test using mag-alloy seat frames

Develop lab scale test based on full-scale results

Proposed Mag-Alloy Testing at FAA Tech Center

Conduct 4 full-scale tests, postcrash fire scenario

~~Baseline using OEM aluminum frames, FB seat cushions~~ *problem*

~~Baseline using OEM aluminum frames, FB seat cushions~~ *problem*

Baseline using OEM alum frames, new seat backs, FHF seat cushions

Substitute good-performing mag alloy in primary structural components

Substitute poor-performing mag alloy in primary structural components

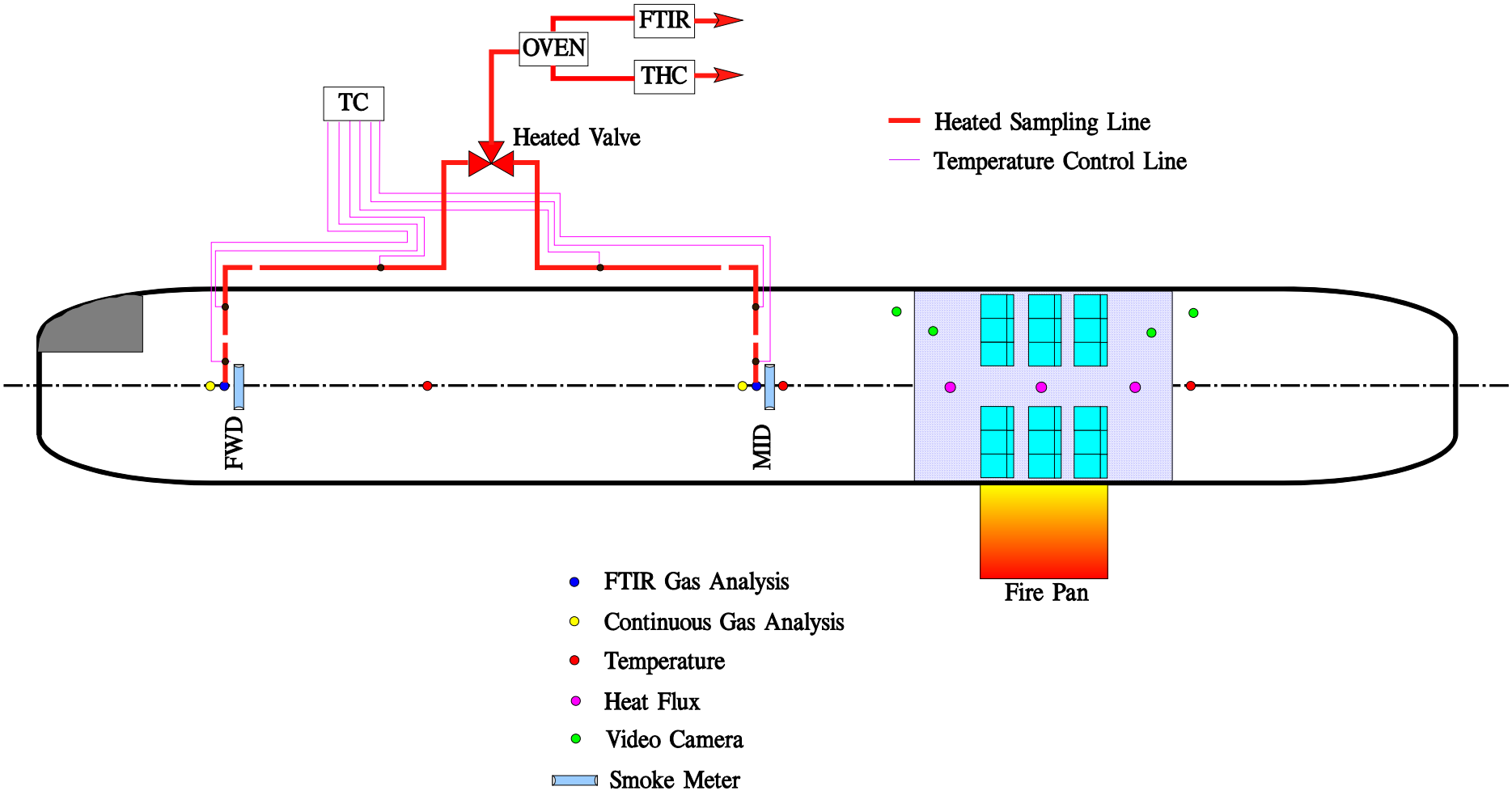
Substitute good-performing mag alloy in all structural components

Expected Outcomes

Determine if any additional hazard results

Determine if any difference exists between mag alloys

Full-Scale Test Apparatus

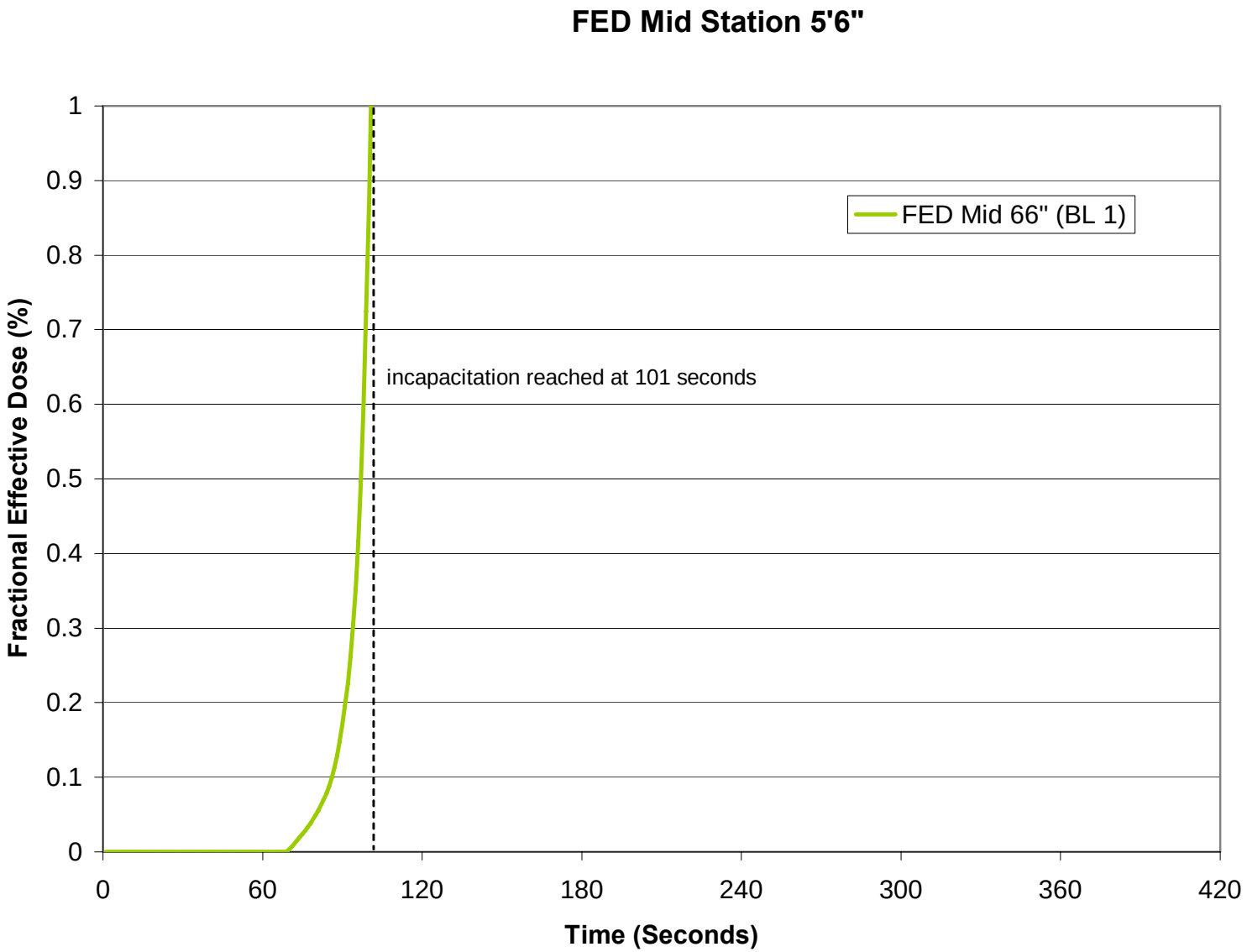


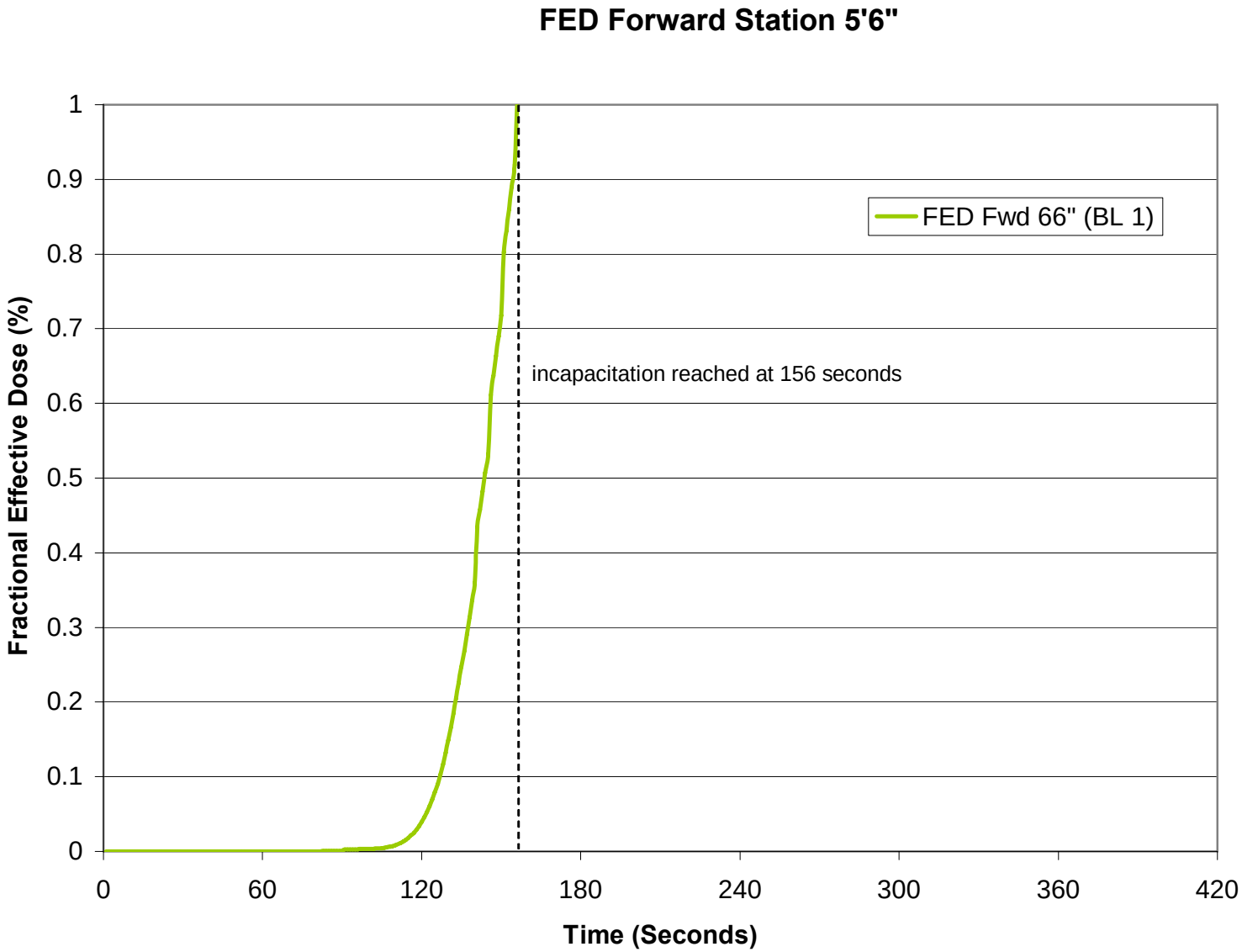
Baseline 1 Test Configuration

Baseline 1 Test Configuration

Baseline Seat Test 1 Conducted on Oct 7, 2008

Baseline 1 Test Result


FED Mid Station 5'6"
Fractional Effective Dose (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
60
120
180
240
300
360
420
Time (Seconds)
FED Mid 66" (BL 1)
incapacitation reached at 101 seconds


FED Forward Station 5'6"
Fractional Effective Dose (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
60
120
180
240
300
360
420
Time (Seconds)
FED Fwd 66" (BL 1)
incapacitation reached at 156 seconds

Baseline 1 Test Result

Summary of Findings

Test terminated at 3 minutes

Incapacitation reached in less than 3 minutes

Seat backs (cushions, covers, plastics) completely consumed

Seat bottom cushions on LHS heavily involved in fire

Minimal melting of primary seat structure

Baseline 2 Test Configuration

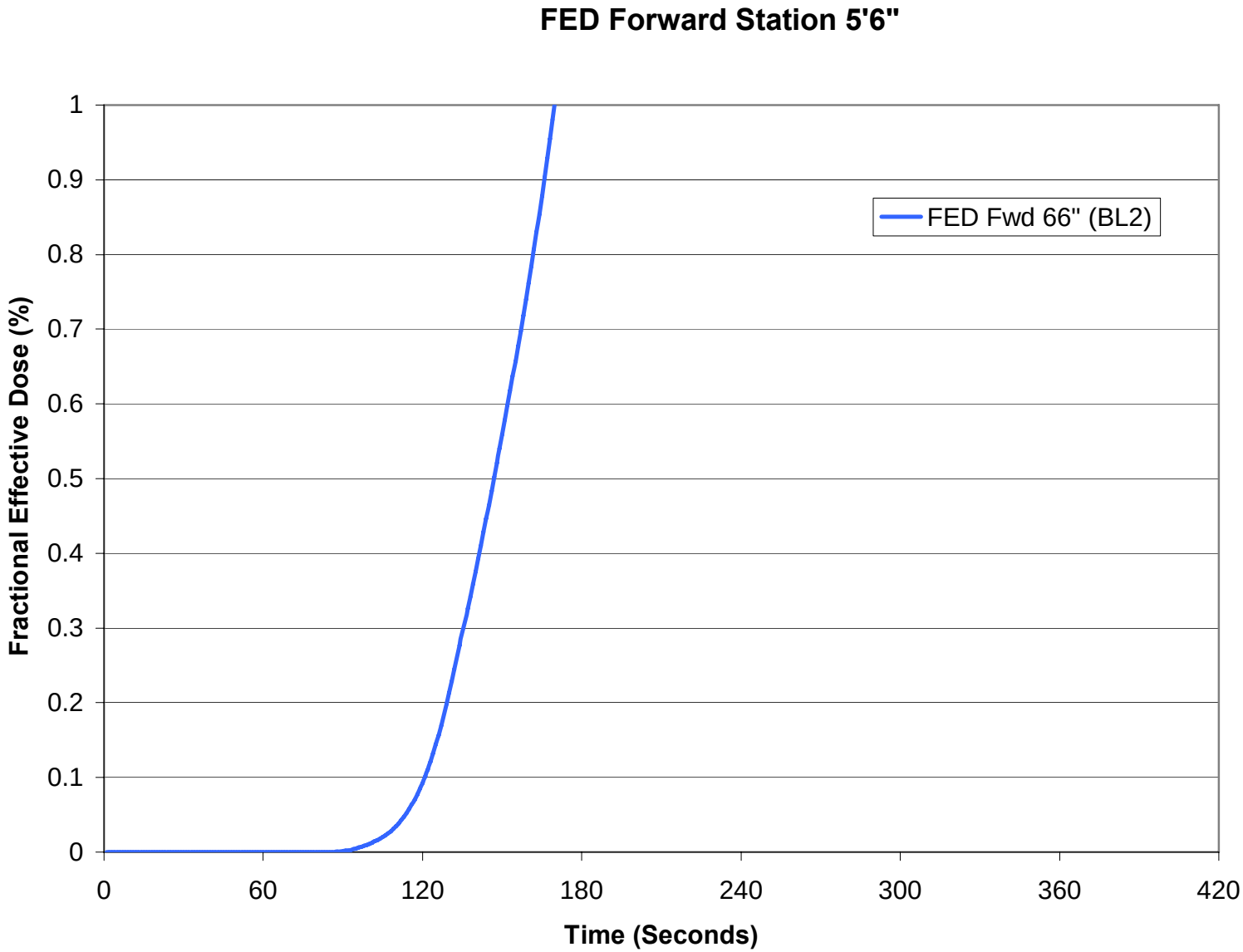
Baseline 2 Test Configuration

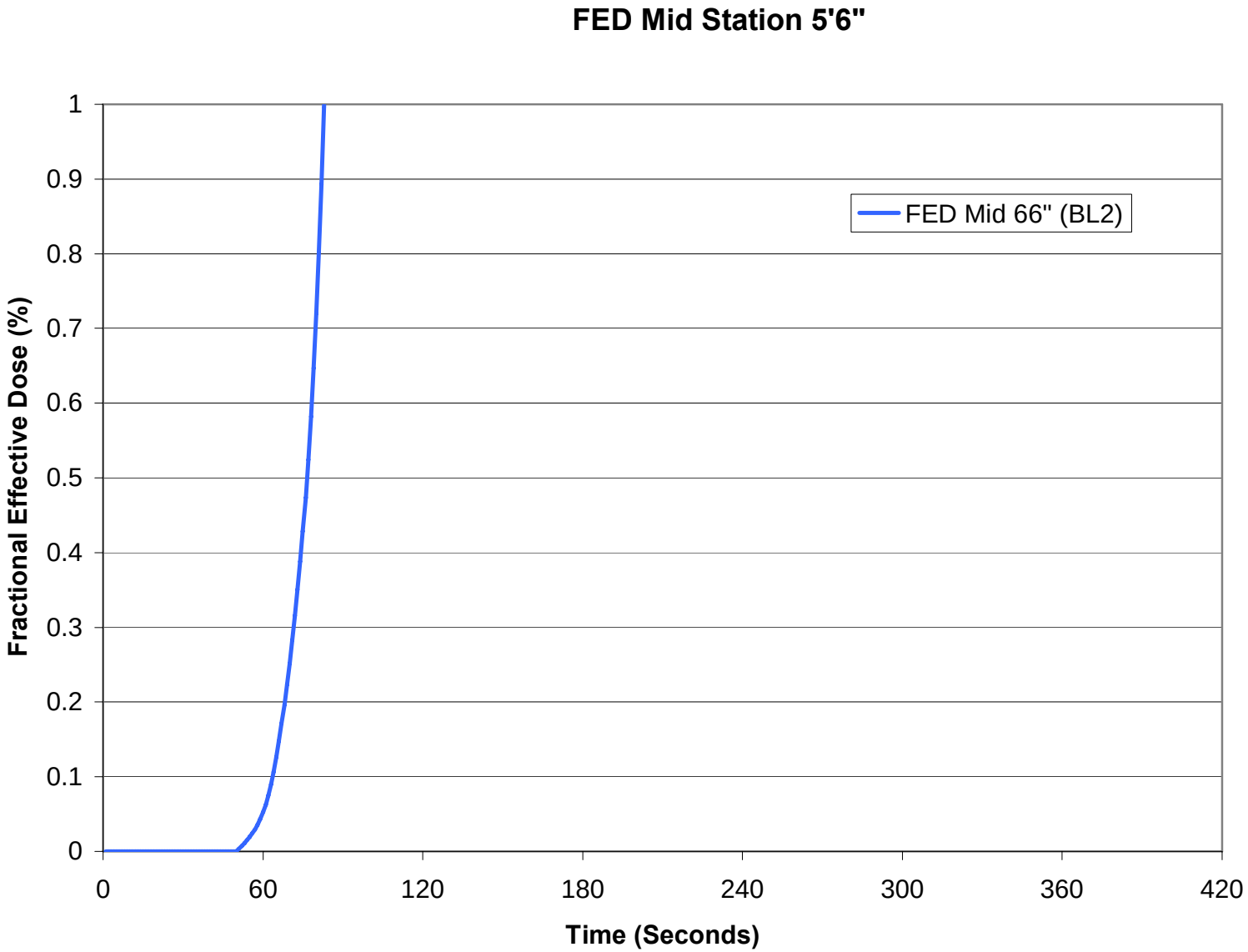
Baseline Seat Test 2 Conducted on Dec 18, 2008

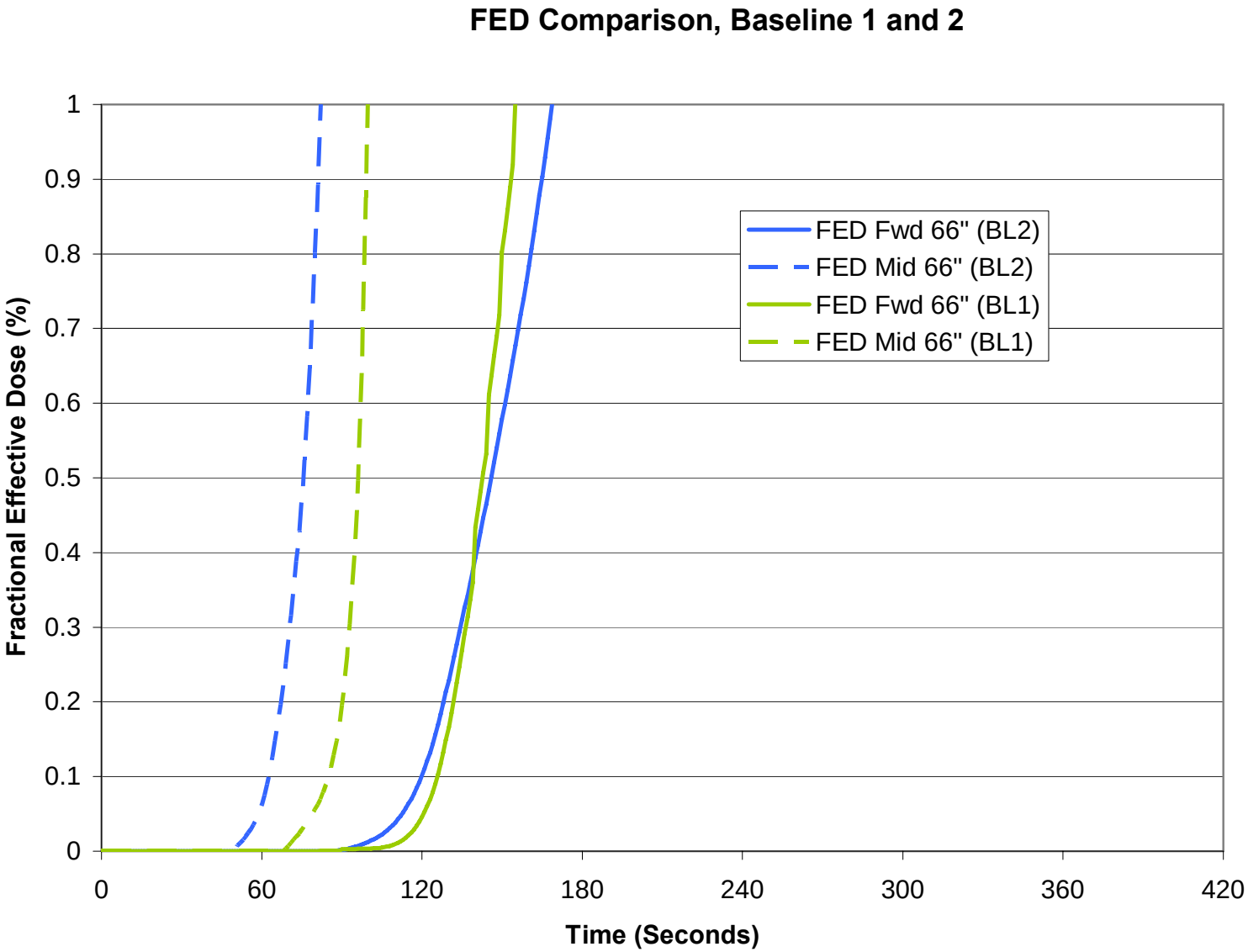
Baseline 2 Test Results (untouched)

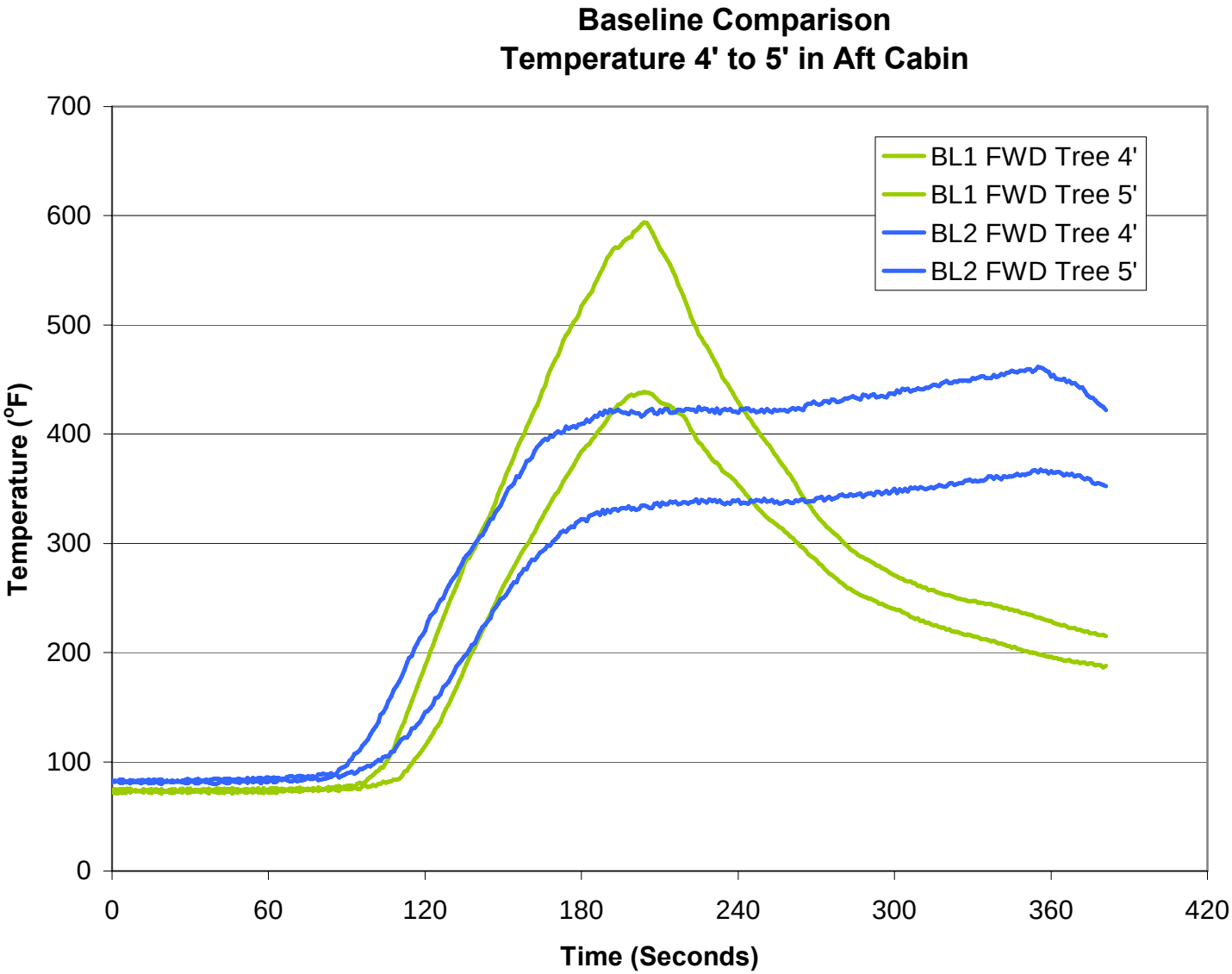
Baseline 2 Test Results (panels removed)

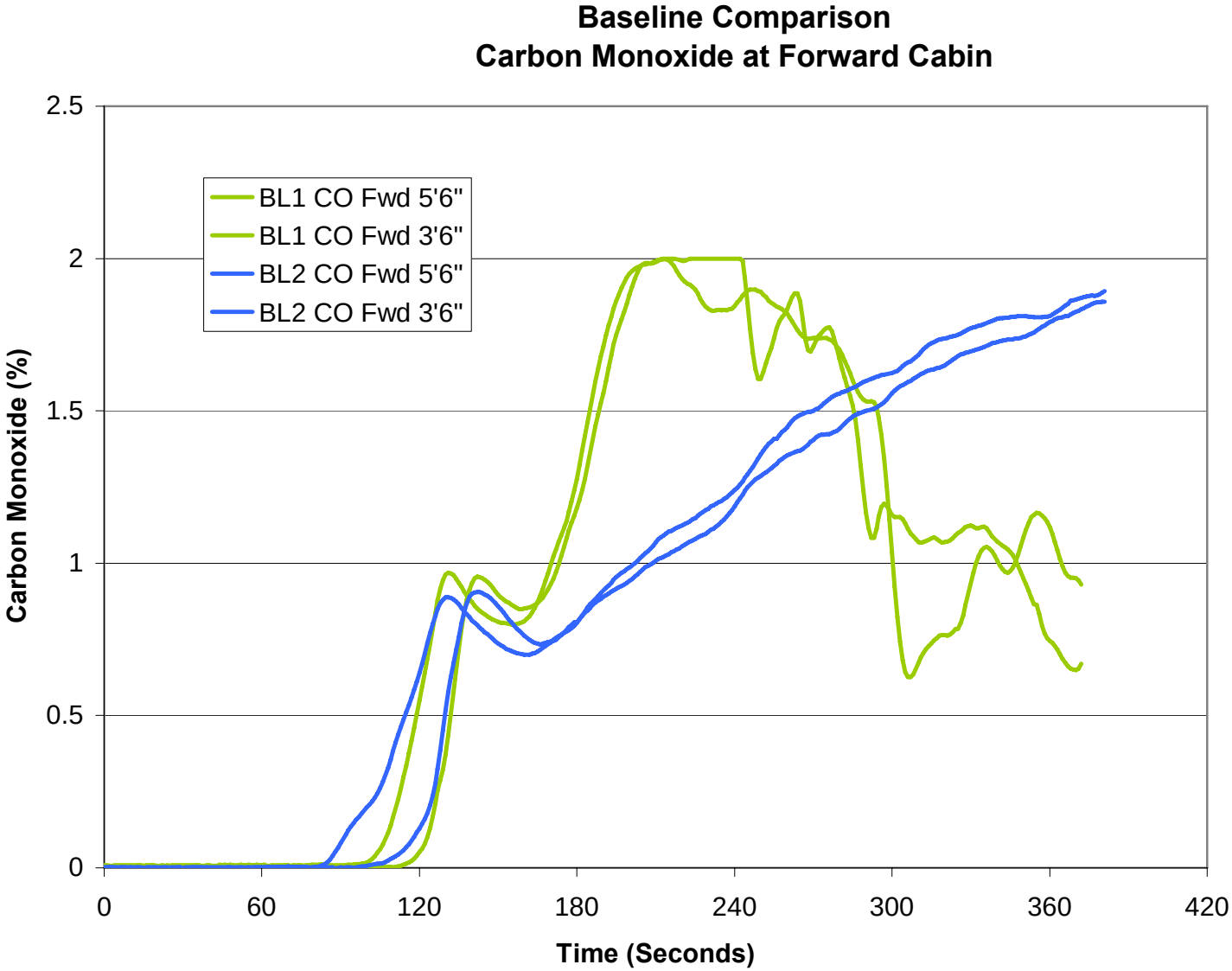
Baseline 2 Test Results (panels removed)

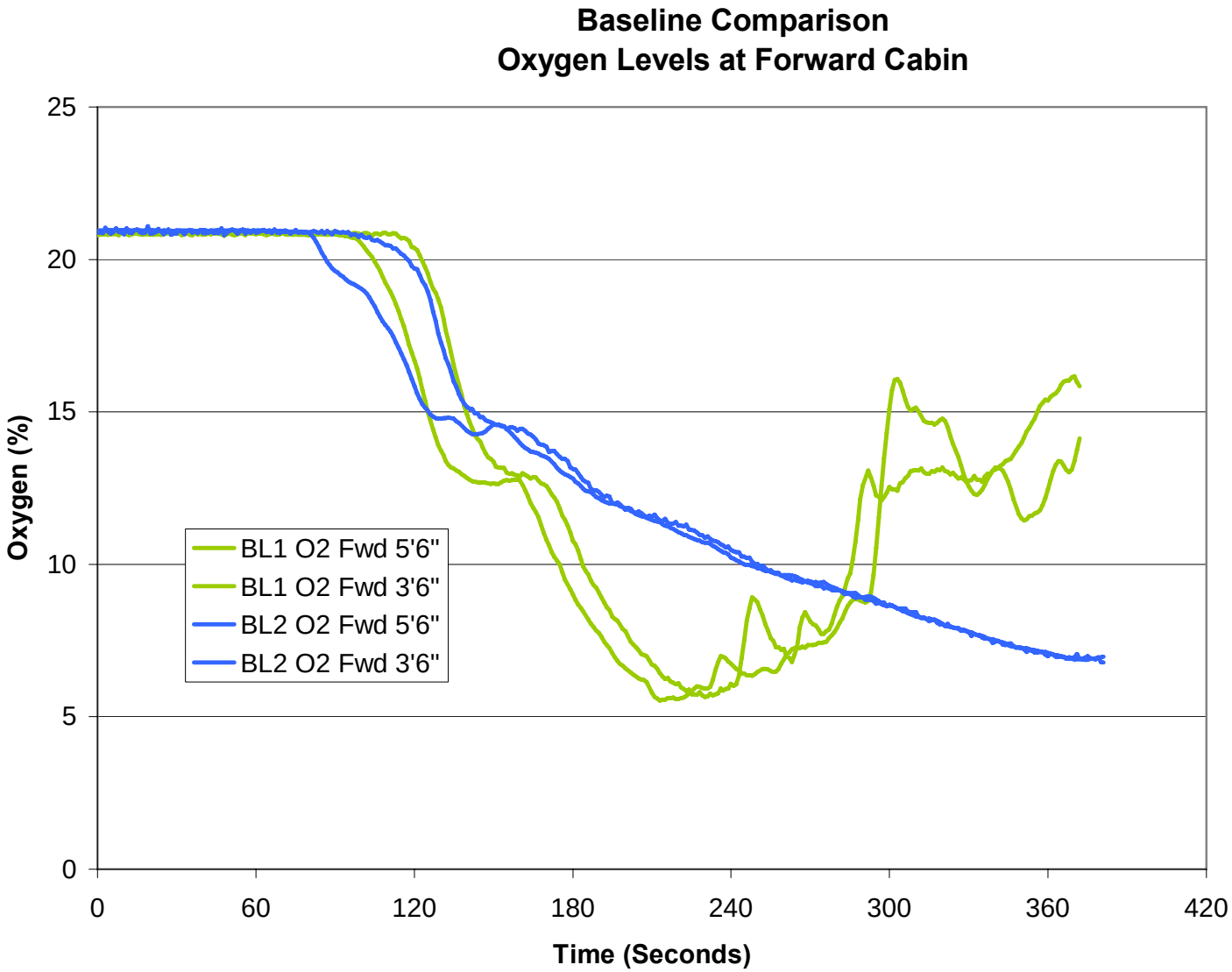

FED Forward Station 5'6"
Fractional Effective Dose (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
60
120
180
240
300
360
420
Time (Seconds)
FED Fwd 66" (BL2)


FED Mid Station 5'6"
Fractional Effective Dose (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
60
120
180
240
300
360
420
Time (Seconds)
FED Mid 66" (BL2)


FED Comparison, Baseline 1 and 2
Fractional Effective Dose (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
60
120
180
240
300
360
420
Time (Seconds)
FED Fwd 66" (BL2)
FED Mid 66" (BL2)
FED Fwd 66" (BL1)
FED Mid 66" (BL1)


Baseline Comparison
Temperature 4' to 5' in Aft Cabin
Temperature (°F)
Time (Seconds)
0
100
200
300
400
500
600
700
0
60
120
180
240
300
360
420
BL1 FWD Tree 4'
BL1 FWD Tree 5'
BL2 FWD Tree 4'
BL2 FWD Tree 5'


Baseline Comparison
Carbon Monoxide at Forward Cabin
BL1 CO Fwd 5'6"
BL1 CO Fwd 3'6"
BL2 CO Fwd 5'6"
BL2 CO Fwd 3'6"
Carbon Monoxide (%)
2.5
2
1.5
1
0.5
0
0
60
120
180
240
300
360
420
Time (Seconds)


Baseline Comparison
Oxygen Levels at Forward Cabin
Oxygen (%)
25
20
15
10
5
0
0
60
120
180
240
300
360
420
Time (Seconds)
BL1 O2 Fwd 5'6"
BL1 O2 Fwd 3'6"
BL2 O2 Fwd 5'6"
BL2 O2 Fwd 3'6"

Baseline 2 Test Results
(seats removed from fuselage)

What is the extent of damage to the primary components?

Baseline 2 Test Results

Inspection of primary structure

Baseline 2 Test Results

Baseline 2 Test Results

Comparison of Two Baseline Tests Conducted in 2008

Full-Scale Tests Highlighted Seat Back Flammability

Full-Scale Tests Highlighted Seat Back Flammability

Full-Scale Tests Highlighted Seat Back Flammability

Full-Scale Tests Highlighted Seat Back Flammability

Task Group Minutes 3/4/2009

Repeat baseline test, or move ahead??

Procure Additional 990 Seats, fabricate new seat backs

Test Details

Application of Water

Seat Thermocouples

Camera Location

Oil Burner Testing

Procurement of Additional 990 Seats

24 triple 990 seats procured from Universal Asset Management for $10,000

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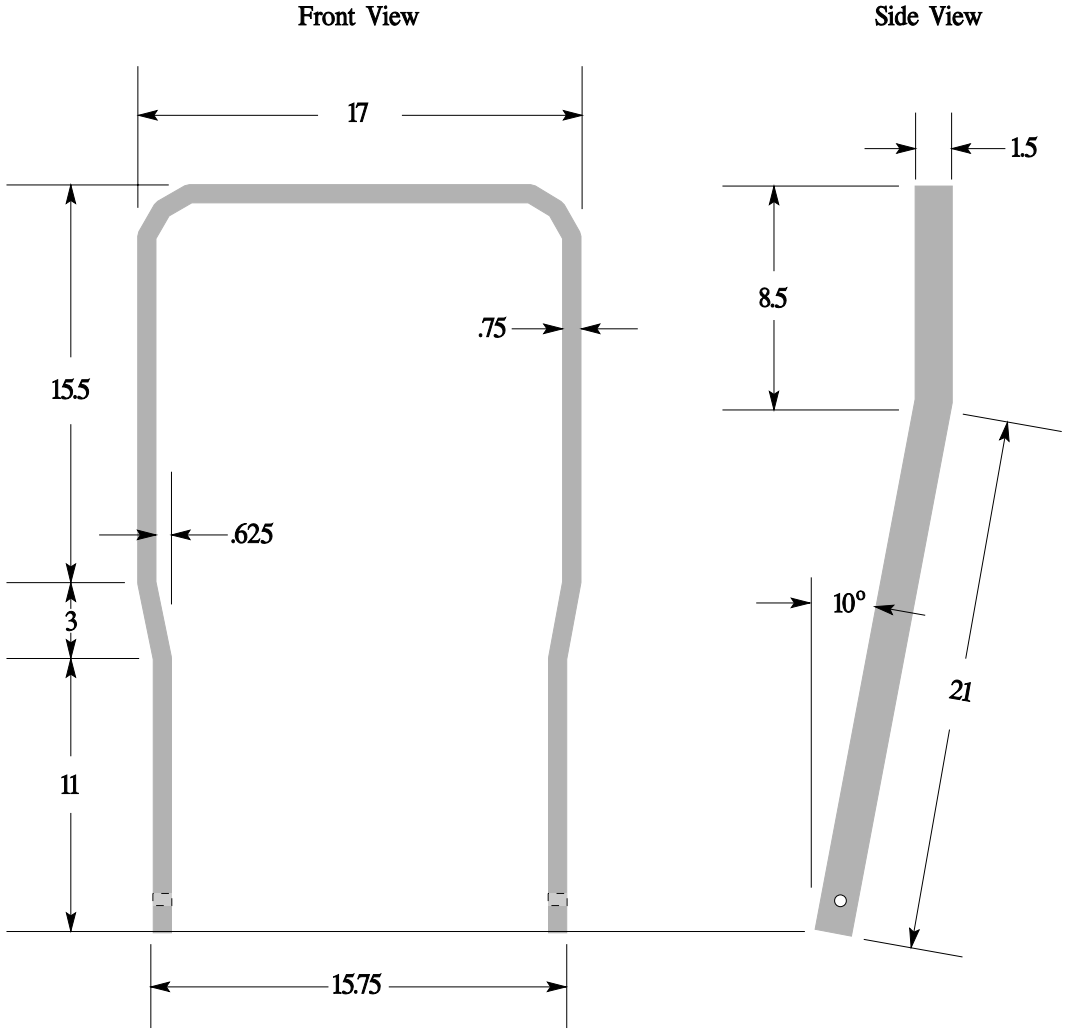
Fabricate New Seat Backs

New Frame, Foam, and Dress cover



Fabricate New Seat Backs

New Frame, Foam, and Dress cover

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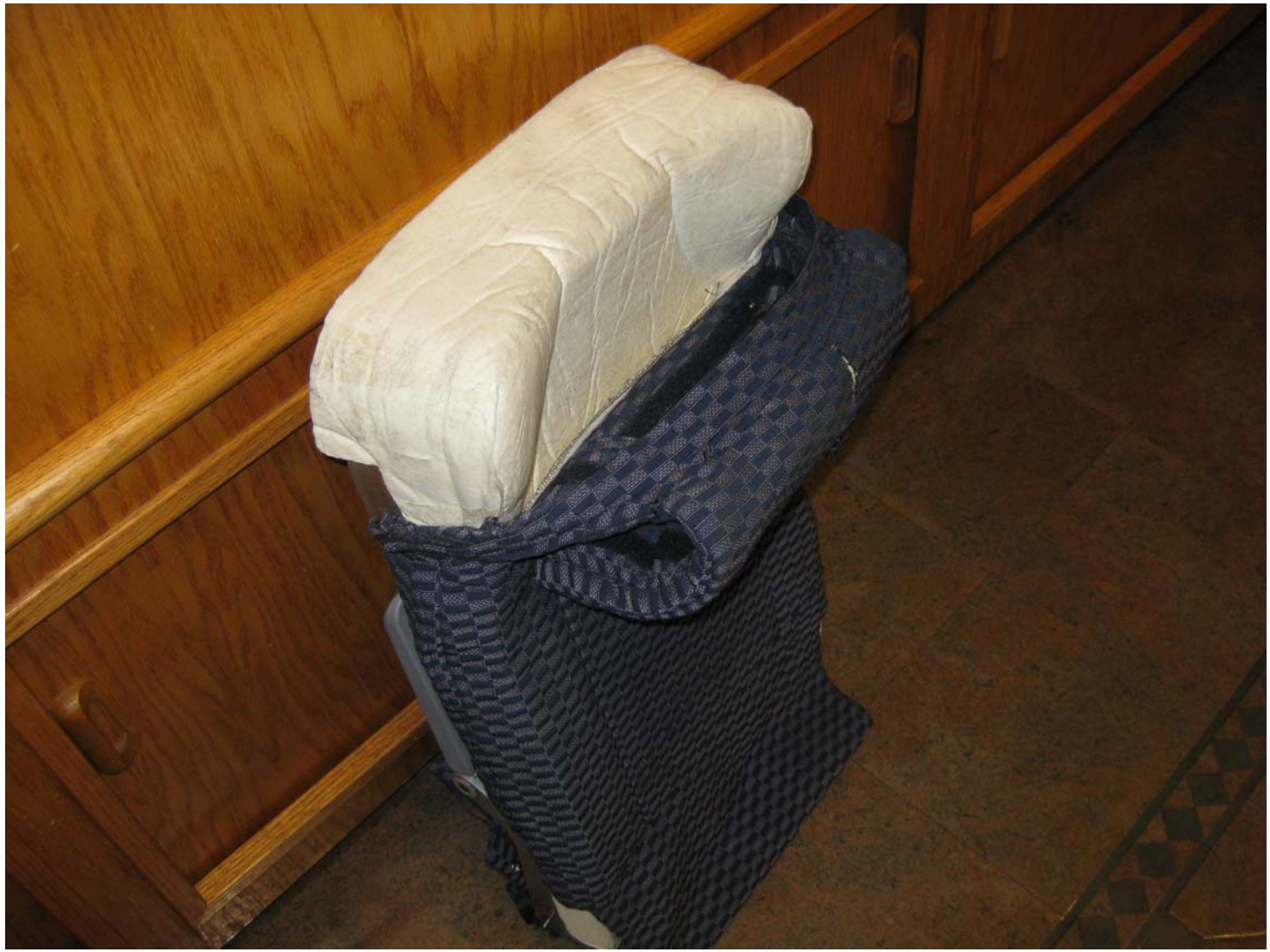

Fabricate New Seat Backs

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Fabricate New Seat Backs

Additional Test Details

Length of Test, Incapacitation, etc.

What is the most appropriate time to terminate the test?

Test Should be Terminated When Incapacitation is reached

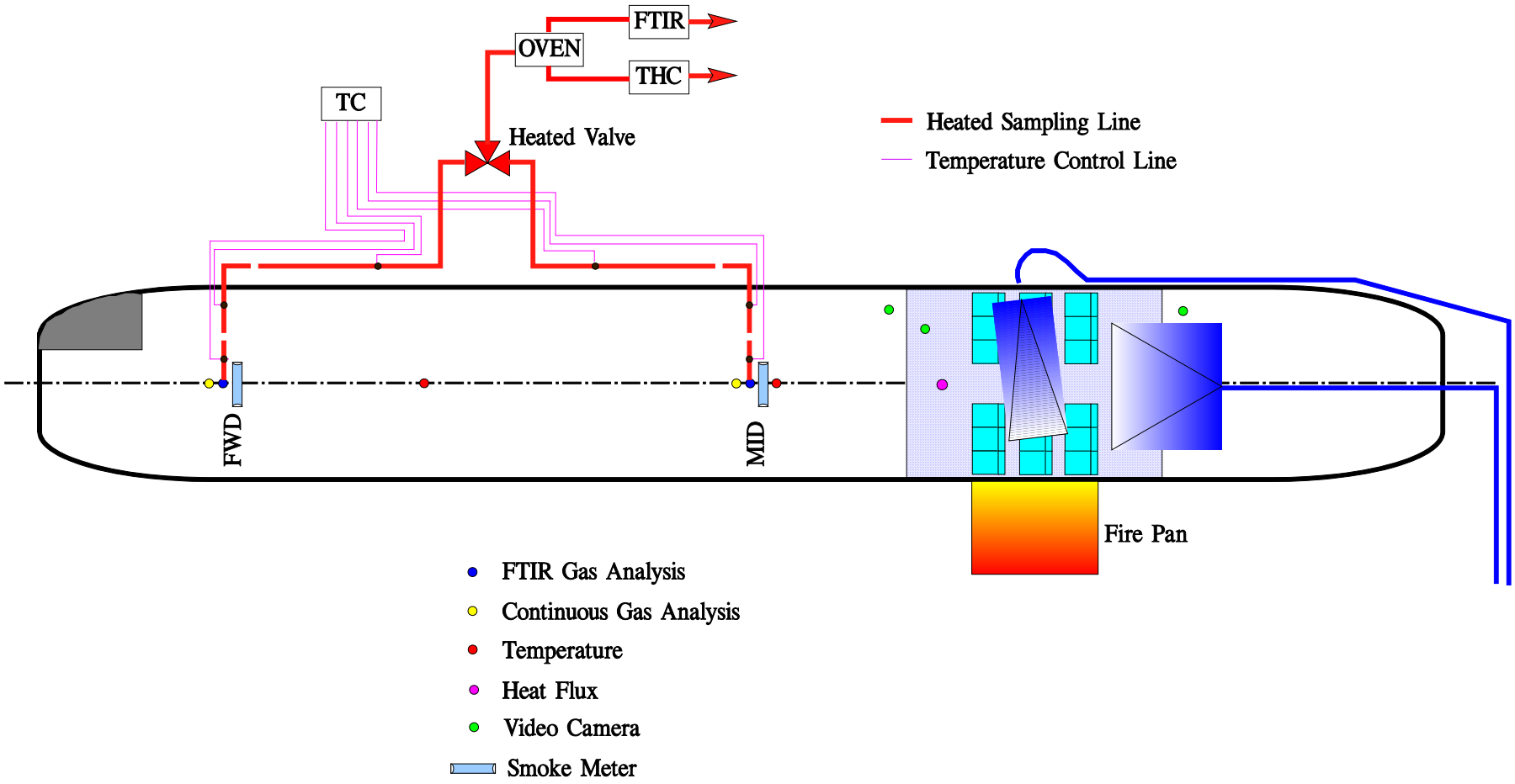
Incapacitation model not capable of "real-time" calculation

Real-time approximation of incapacitation using CO and Temperature data

CO and temperature monitored every 30 seconds to determine test duration

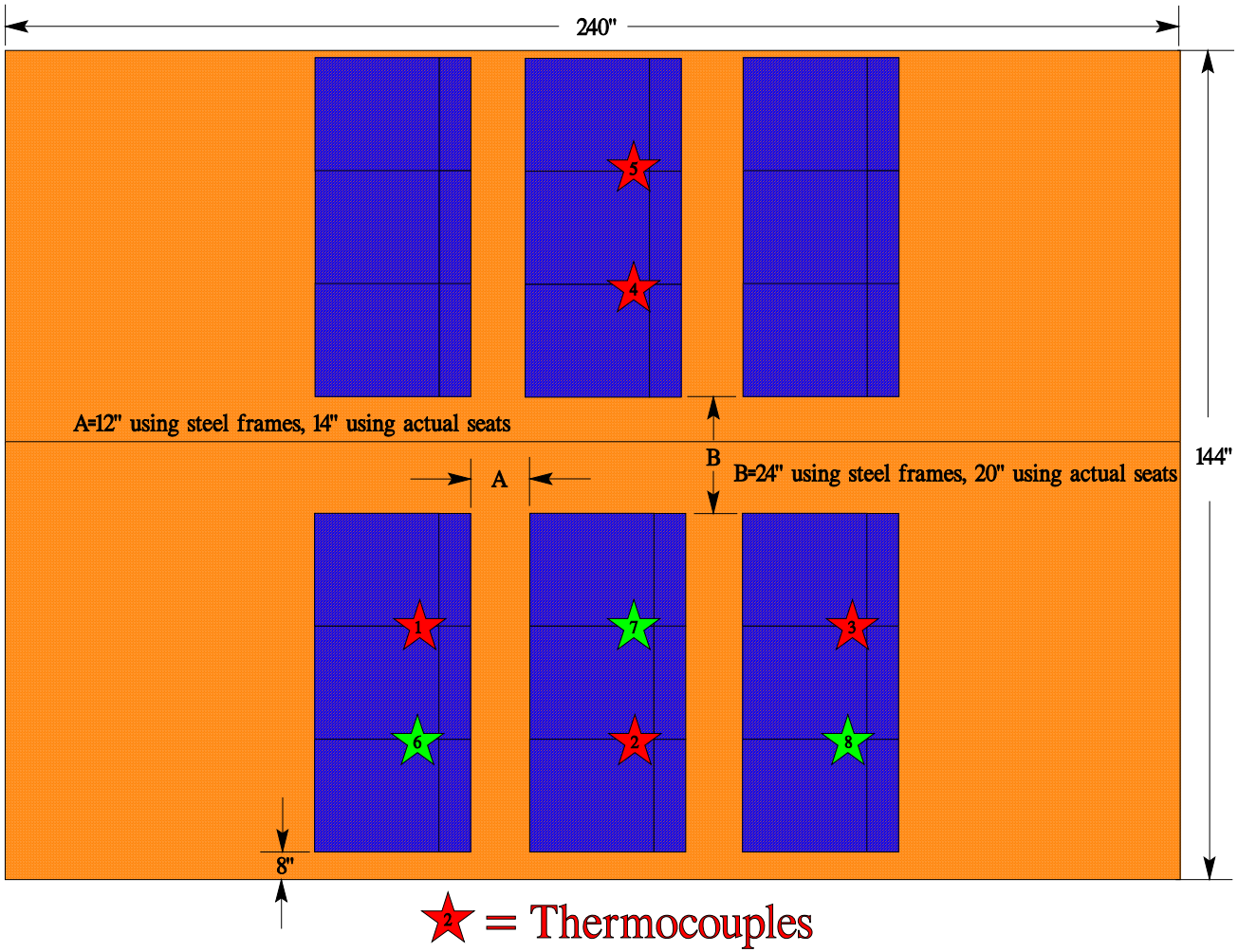
Application of Water Post-Test

Group Consensus: apply water at end of all tests (not just magnesium), for similarity.



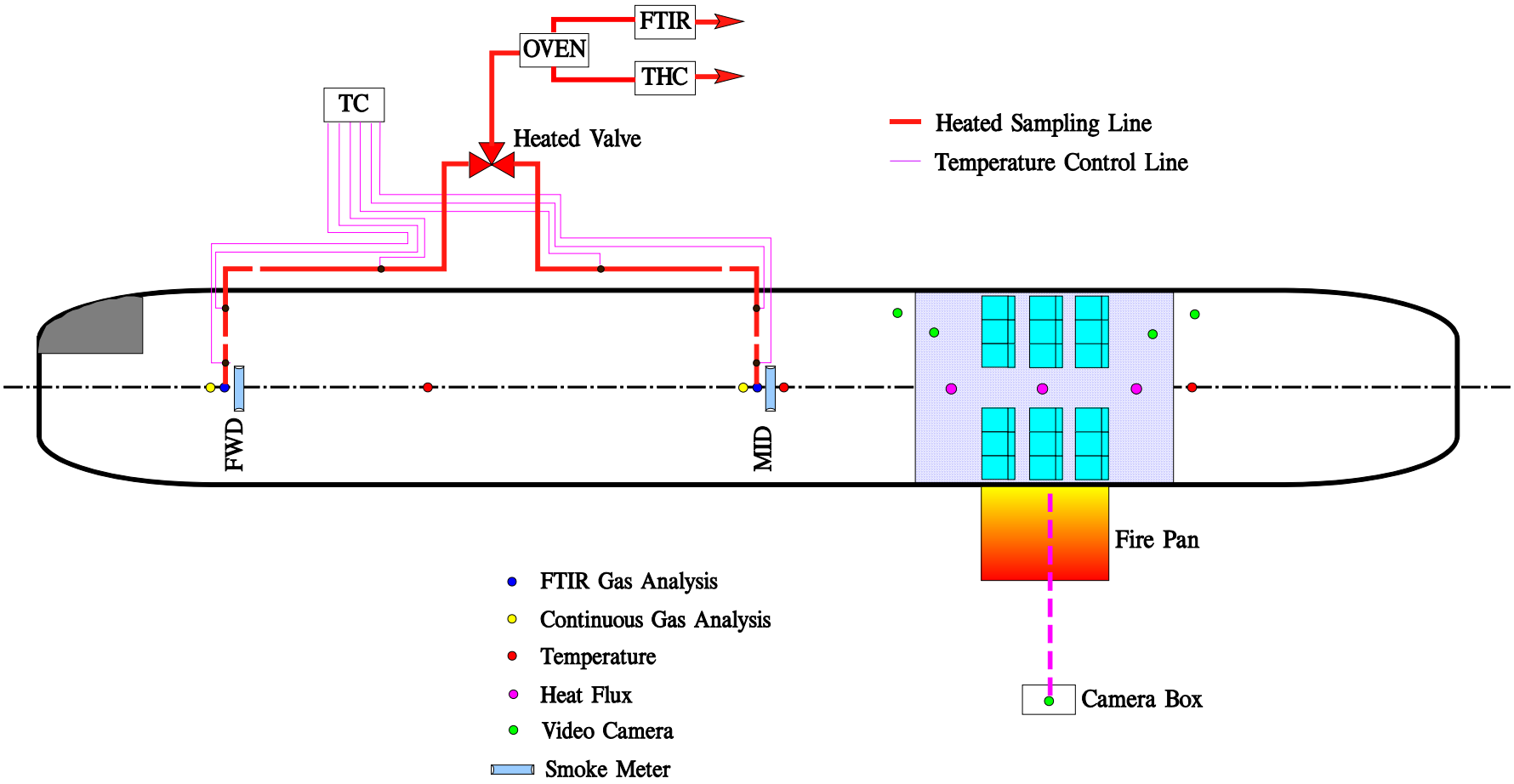
Seat Thermocouples

Group consensus: Additional T/C's needed in seat legs.



Camera Location

Group consensus: Clear video needed for accurate application of water post test



Oil Burner Testing

Group consensus: Need accurate lab-scale test results of new cushion seat flammability

FAATC: Test blocks will be supplied with new seat back cushions for lab-scale testing

Next Steps

Continue with assembly of seats using new back cushions/covers

Conduct new baseline test with upgraded seat back materials

Prepare for test using WE43 mag-alloy components

If good-performing mag-alloy results in elevated hazard level:

Terminate?

If good-performing mag-alloy does not result in elevated hazard level:

Proceed with test of poor-performing mag-alloy

Status of Mag-Alloy Machining

Future Considerations

All full-scale test results would help define an appropriate lab-scale test method or methods, which is the primary goal of the research.

Although post crash full-scale test results will help in determining the safe application of magnesium in seat frames, other scenarios and testing will also be used.

If magnesium alloys are determined safe for use in seat frames, a lab test/tests will be developed.

Industry Welcome to “Look Over Our Shoulder”