International Aircraft Materials Fire Test Working Group Meeting

Task Group Session on New Flammability Test for Magnesium-Alloy Seat Structure

Presented to: International Aircraft Materials Fire Test Working Group, Toulouse

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Date: June 20-21, 2012

Federal Aviation Administration

Evolution of the Test Configuration

Horizontal Bar

Spring 2007

Vertical Cone

Spring 2011

Various Shapes

Shorter cones

Taller cones

Stepped cones

Rectangular stepped shape

Horizontal cylinders

Rectangular tubing horizontal

Rectangular tubing vertical

I-Webs horizontal

T-Webs horizontal

Inverted cones

Cylindrical tubes horizontal

Cylindrical tubes vertical

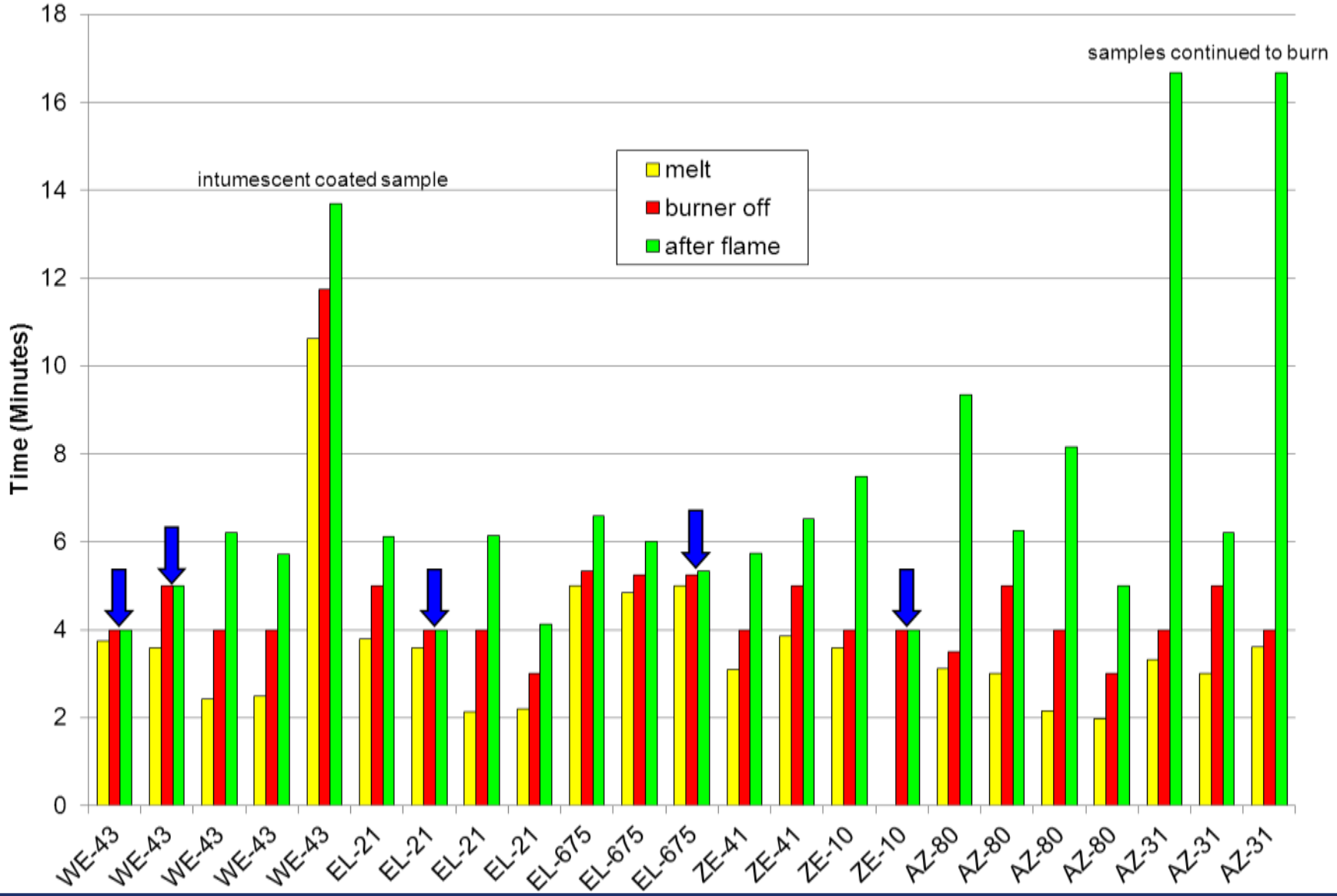
Hollow Cylinder

Summer 2011

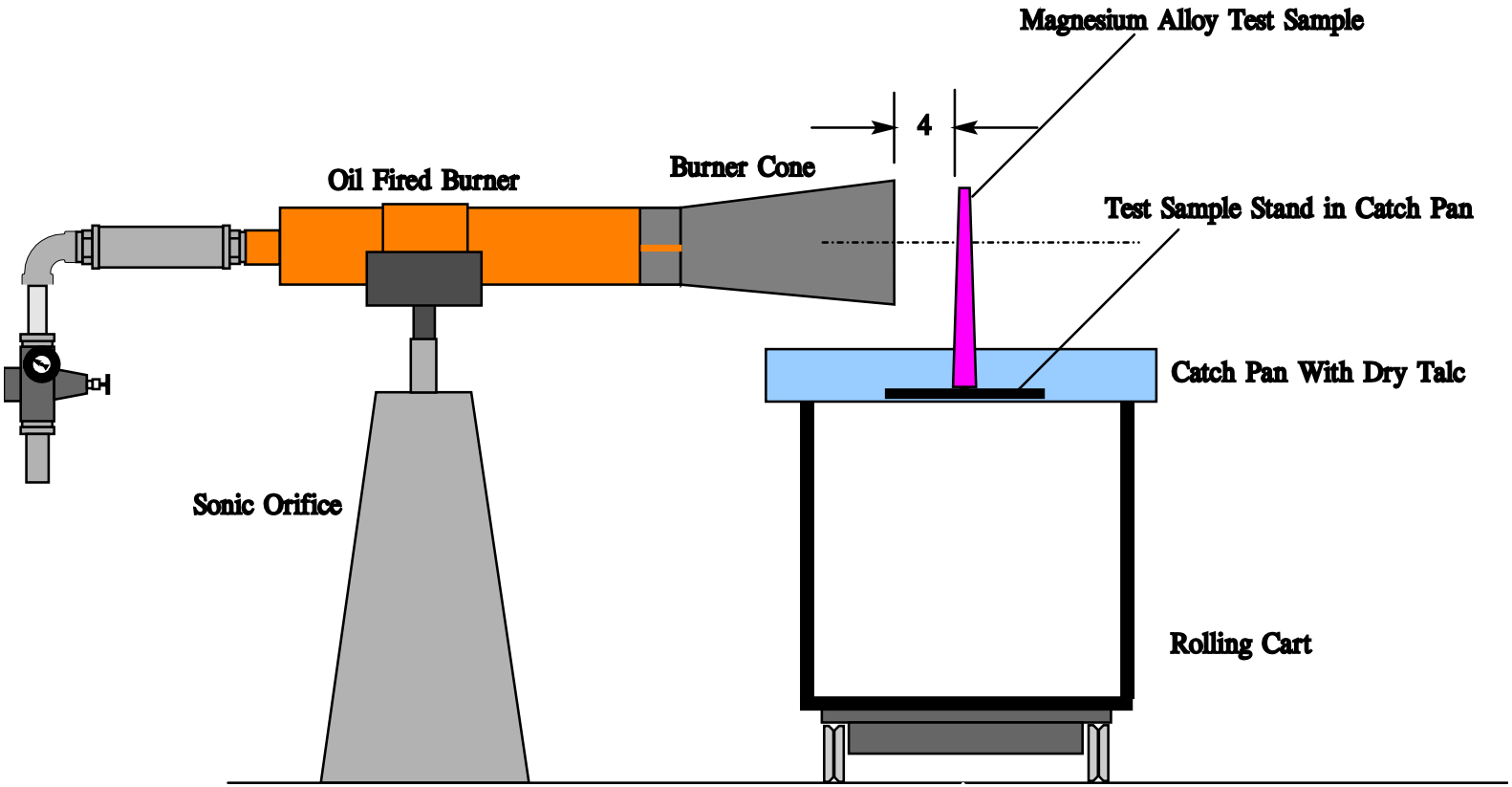
Horizontal Bar

Spring 2012

Initial Magnesium Alloy Horizontal Bar Test Results (2007)



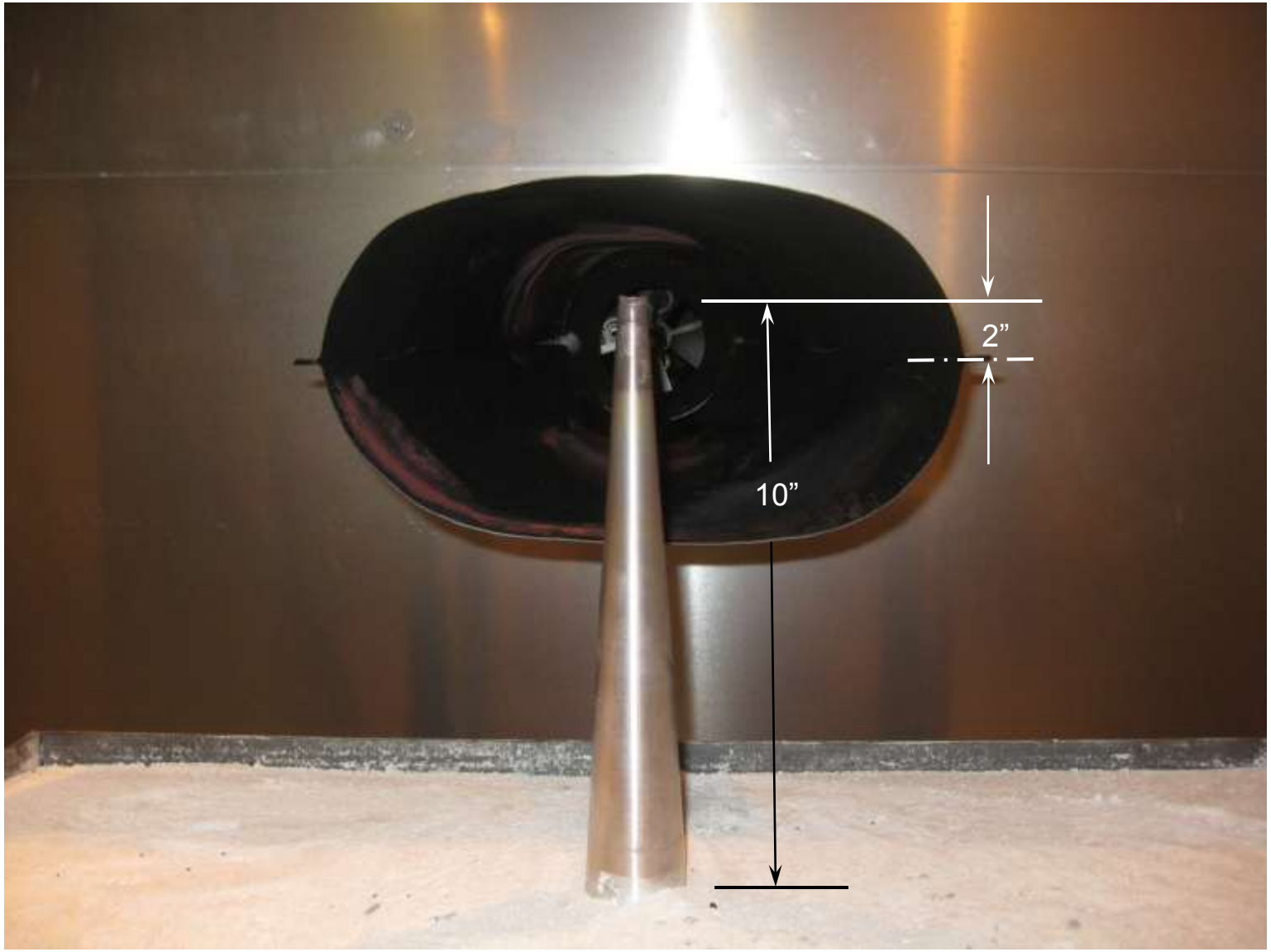
(Gen II) Proposed Magnesium Alloy Flammability Test



Objective: reproduce results obtained in full-scale tests

WE-43: After several minutes of exposure, remove burner, sample burns for approx 1 minute

Truncated Cone Test Sample of Magnesium Alloy



Problems Encountered with Truncated Cone

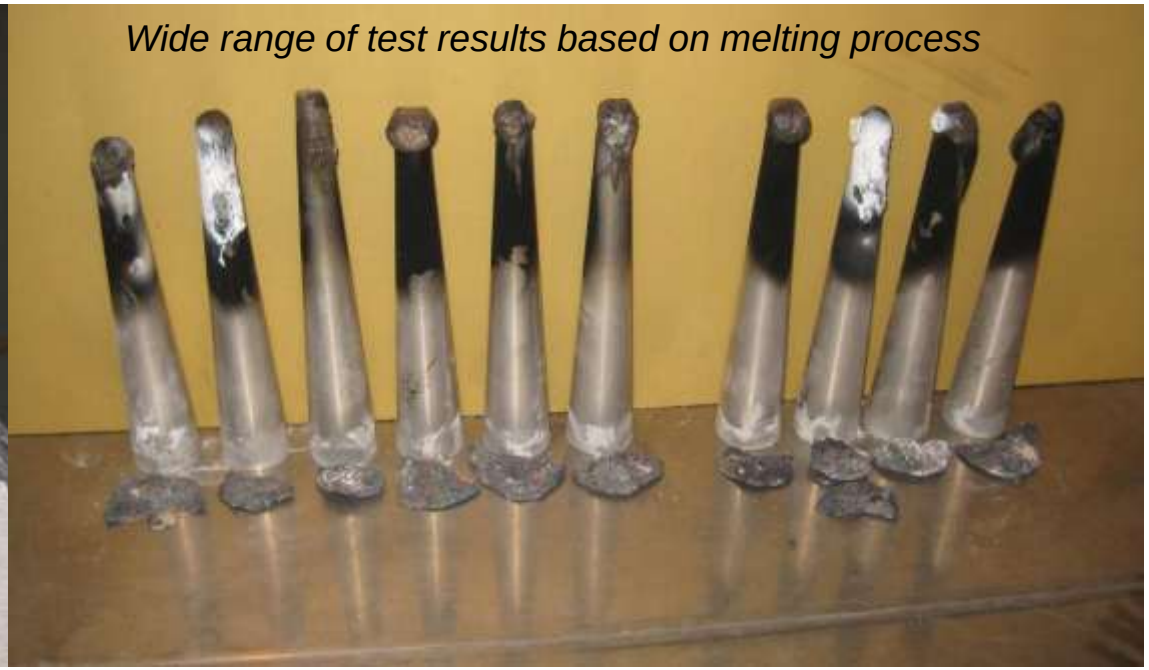
Repeatability

Molten section of cone falls down into pan, no ignition

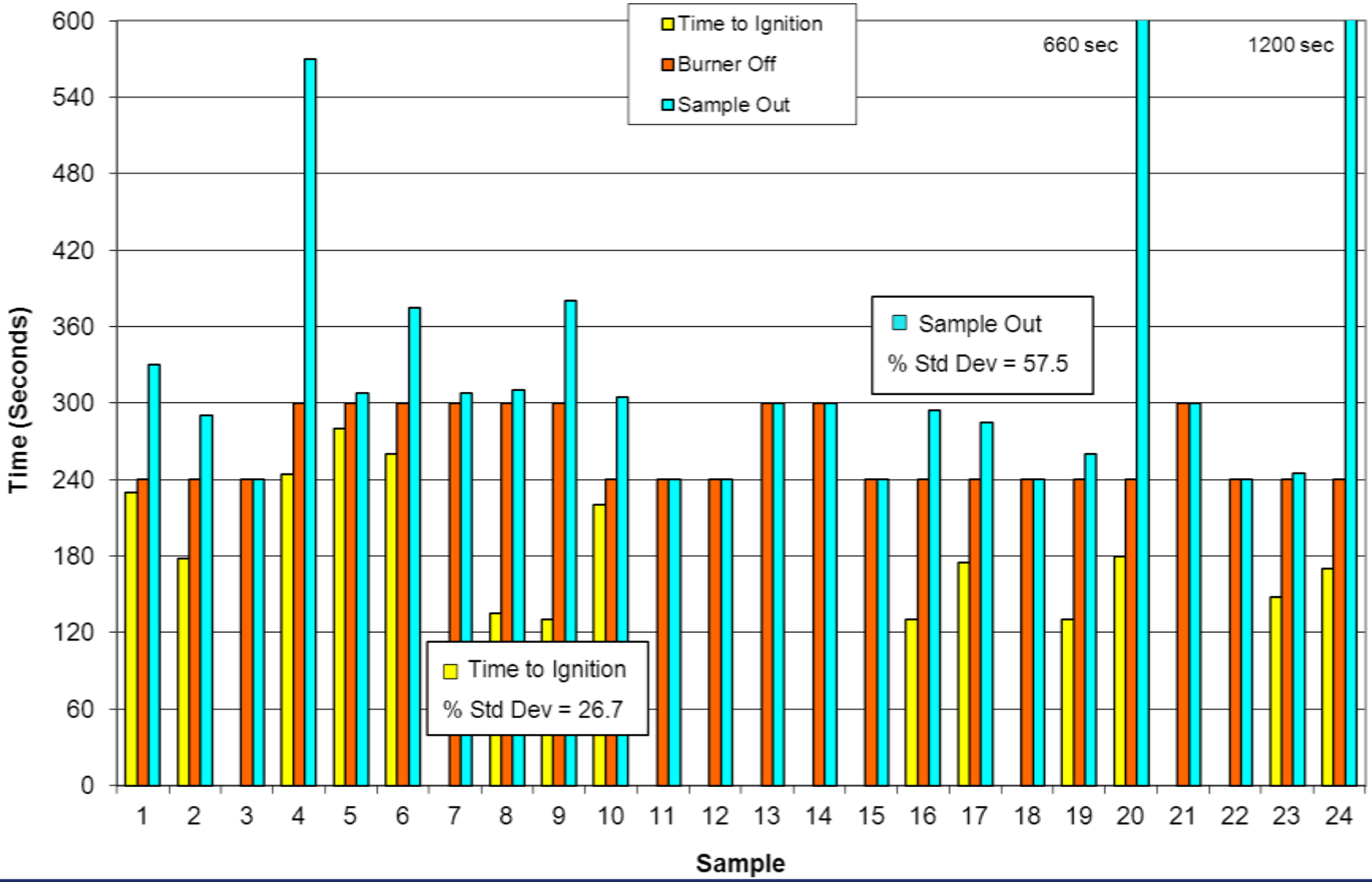
Molten alloy creates thin shape which is ignited; ignition stops after short period

Molten alloy creates shape that ignites; ignition of remaining cone occurs, resulting in extended ignition

Wide range of test results based on melting process



Vertically-Oriented Solid WE-43 Cone Test Results (2011)



Various Sample Configurations Tested


Determine if ignition will continue horizontally

Thin Rectangular Box

Thinner Rectangular Box


Leg Plate “I” Web


“T” Web Machined from Leg Plate


“T” Web Machined from Leg Post


Inverted Cones of AZ-31, Suspended Vertically

Circular Tube WE-43, Mounted Vertically

Test 1

Circular Tube WE-43, Mounted Vertically

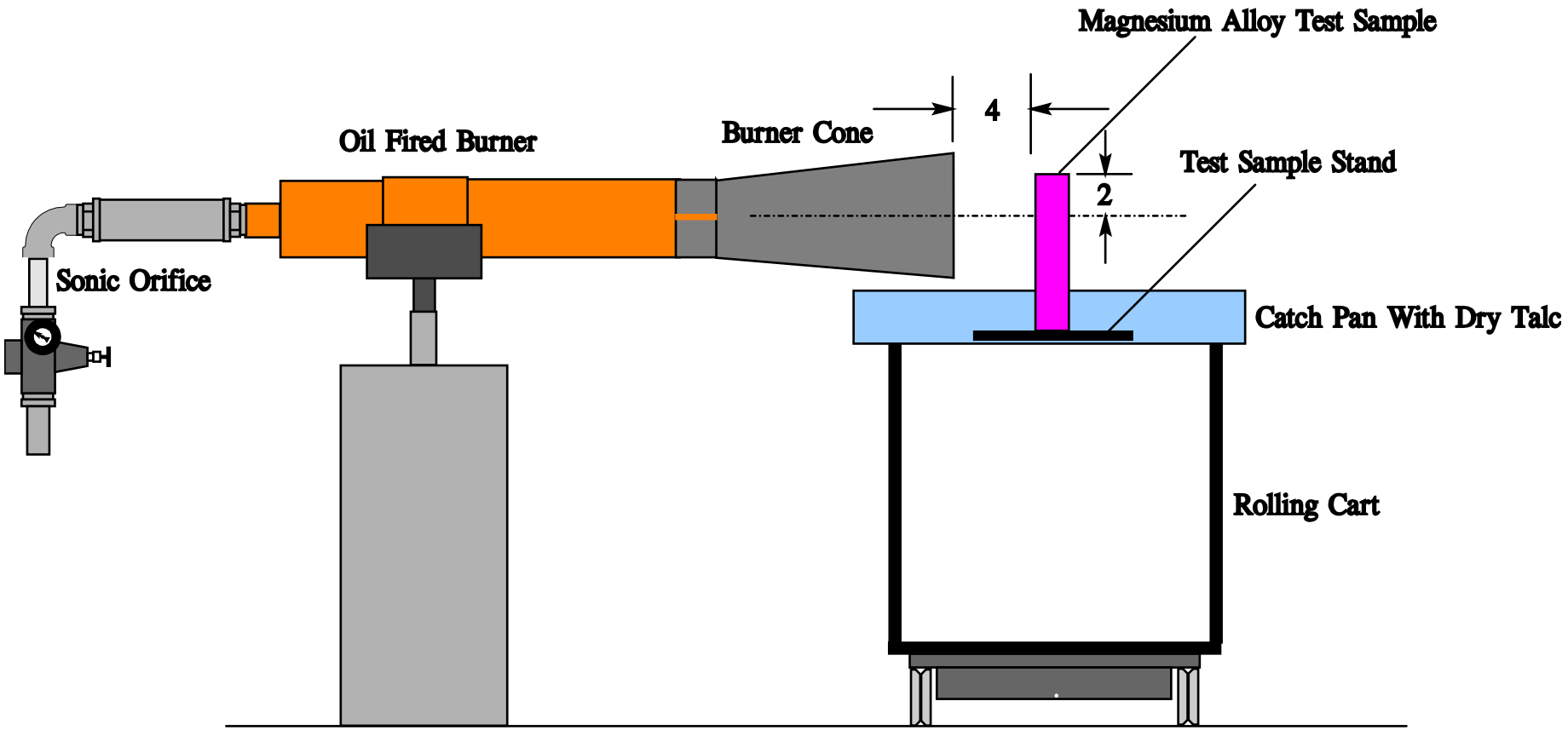
Test 1

Circular Tube WE-43, Mounted Vertically

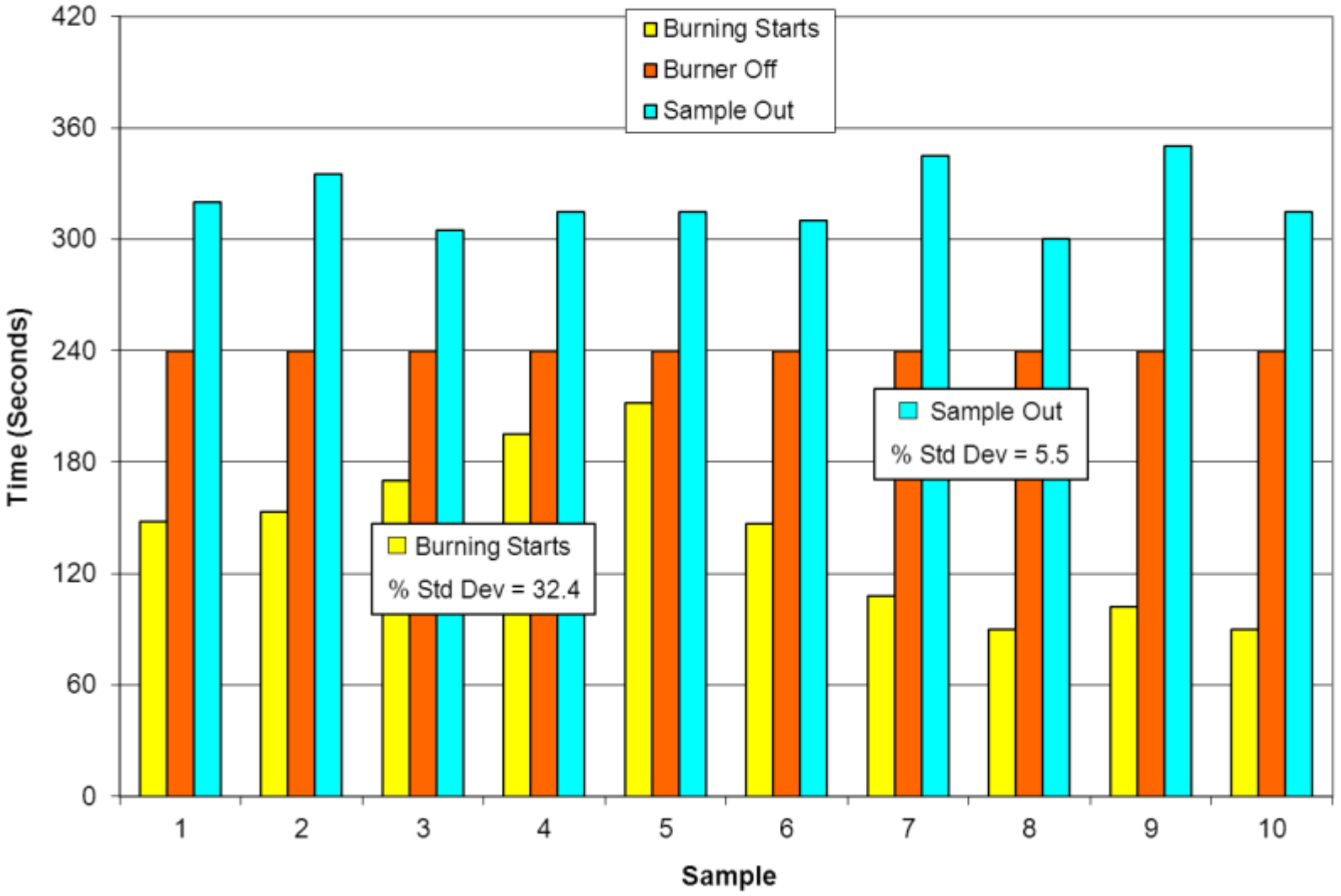
Circular Tube WE-43, Test Results

Very consistent results

(Gen III) Proposed Magnesium Alloy Flammability Test



Vertically-Oriented WE-43 Hollow Cylinder Test Results (Original Materials)



Summary of Results (Cones Vs. Cylinders)

Truncated cone sample suffered from repeatability issues:

- Time of ignition dependent on resulting molten shape
- Duration of burning following burner flame removal also dependent on resulting molten shape

Hollow cross-sections demonstrated better ignitability than solid cross-sections

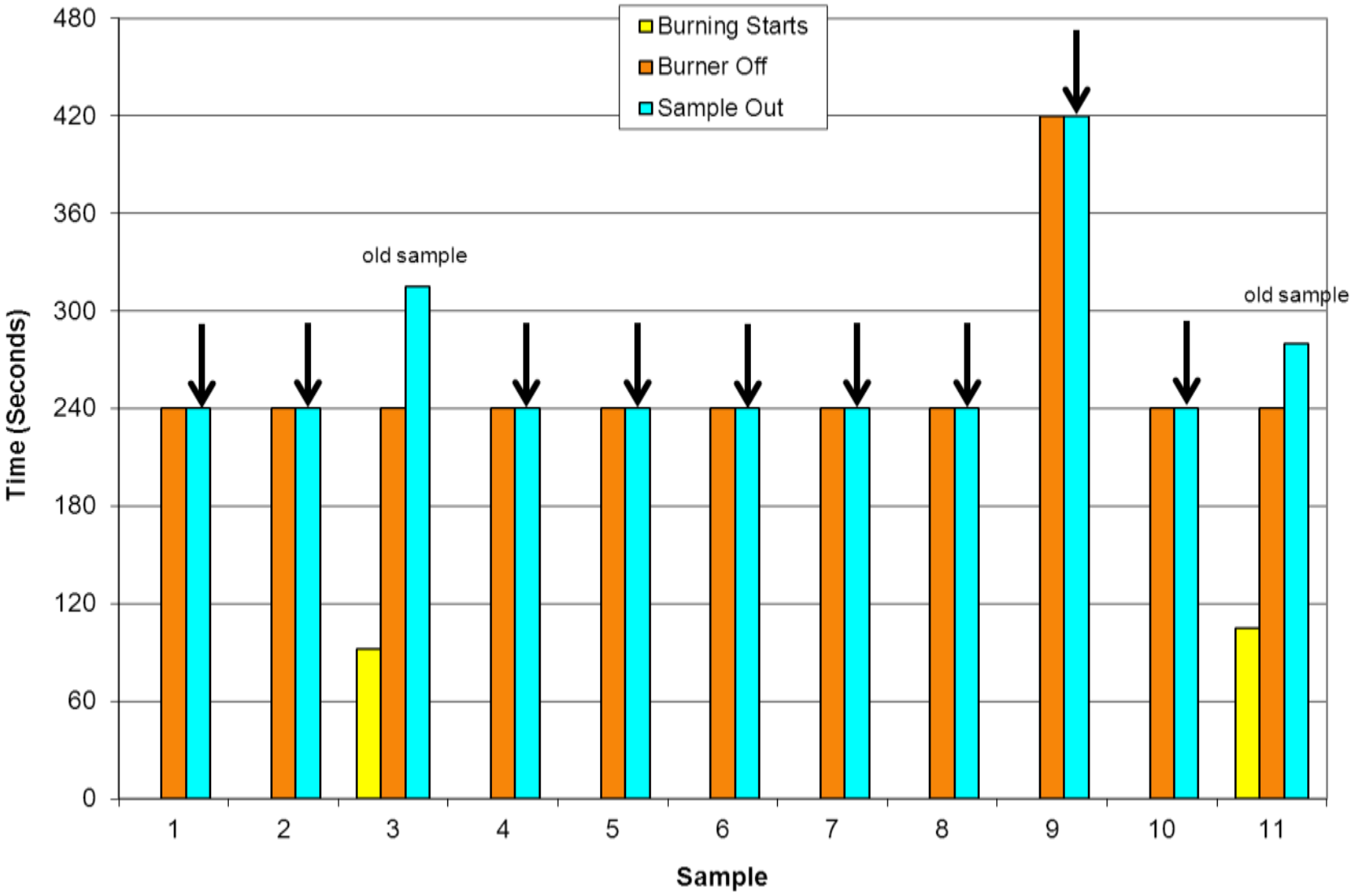
- Thinner wall has tendency to ignite simultaneous to melting
- Thick cross sections melt into complex shapes prior to ignition, reducing repeatability

Hollow cylinder test sample demonstrates good repeatability

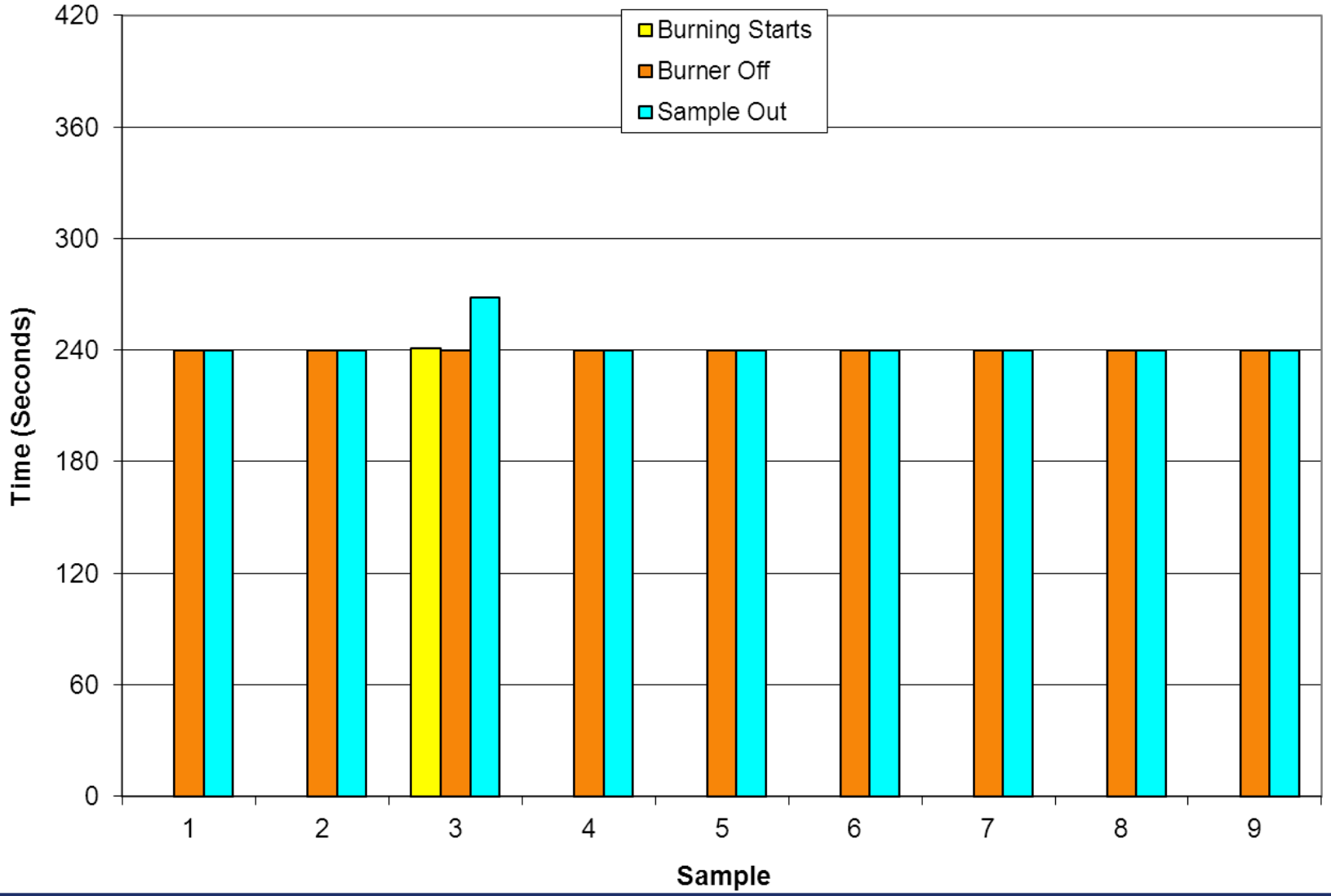
- Time of ignition and duration of after flame very consistent
- Resulting molten shape also very repeatable, demonstrating test robustness

…continue with cylinder testing

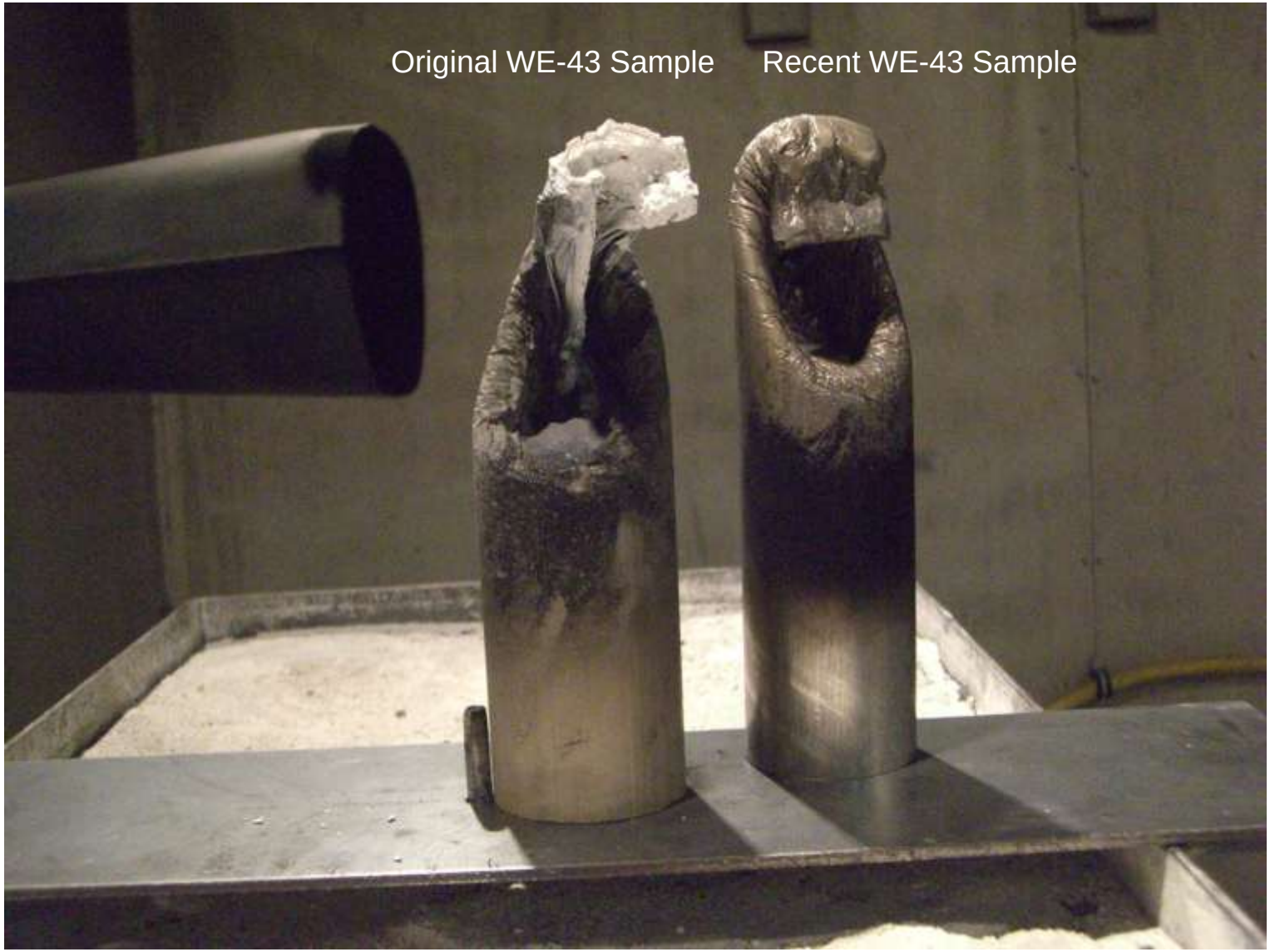
Vertical WE-43 Hollow Cylinder 1.75-Inch O.D. (New Samples 12/2011)



Vertical WE-43 Hollow Cylinder 1.25-Inch O.D. (New Samples 12/2011)



“Same” Material but Different Result



???

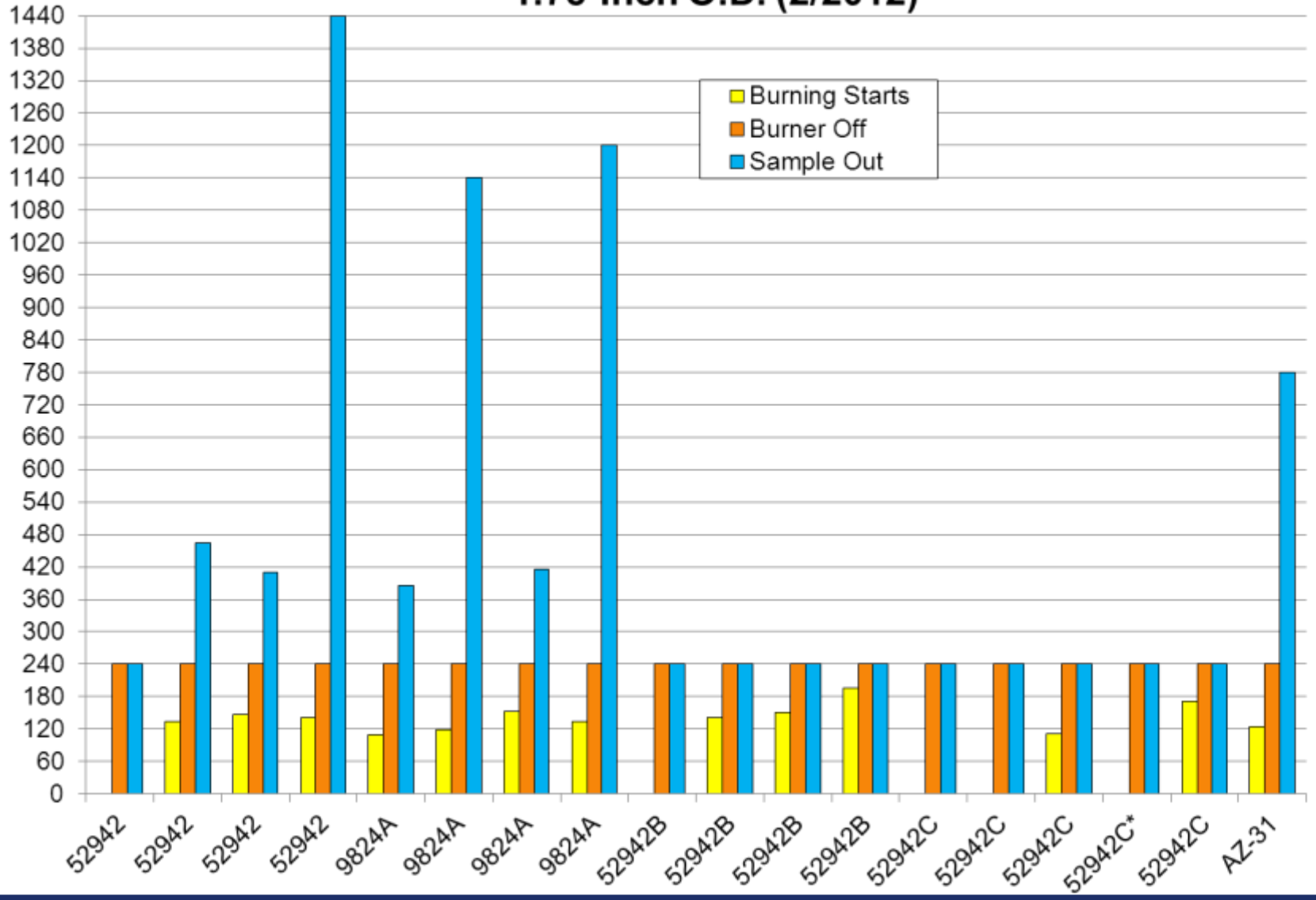
Determine fix for “non-burning” WE-43 samples

Original and recent WE-43 samples sent to Magnesium Elektron for analysis

Analysis revealed no chemical differences, possible structural differences?

Possible to replicate original samples for testing purposes?

"Can-We-Get-It-To-Burn-Again" Cylinder Samples
1.75-Inch O.D. (2/2012)



Which Configuration?

Rectangular Bars (horizontal)

Hollow Cylinders (vertical)

Solid Cones (vertical)

Recent Testing on Various Alloys

Hollow Cylinders (vertical): 59 Tests

WE-43: (15)
EL-21: (18)
ZE-41: (18)
AZ-80: (3)
AZ-31: (1)
EXP: (4)

1 cylinder configuration tested

VS.

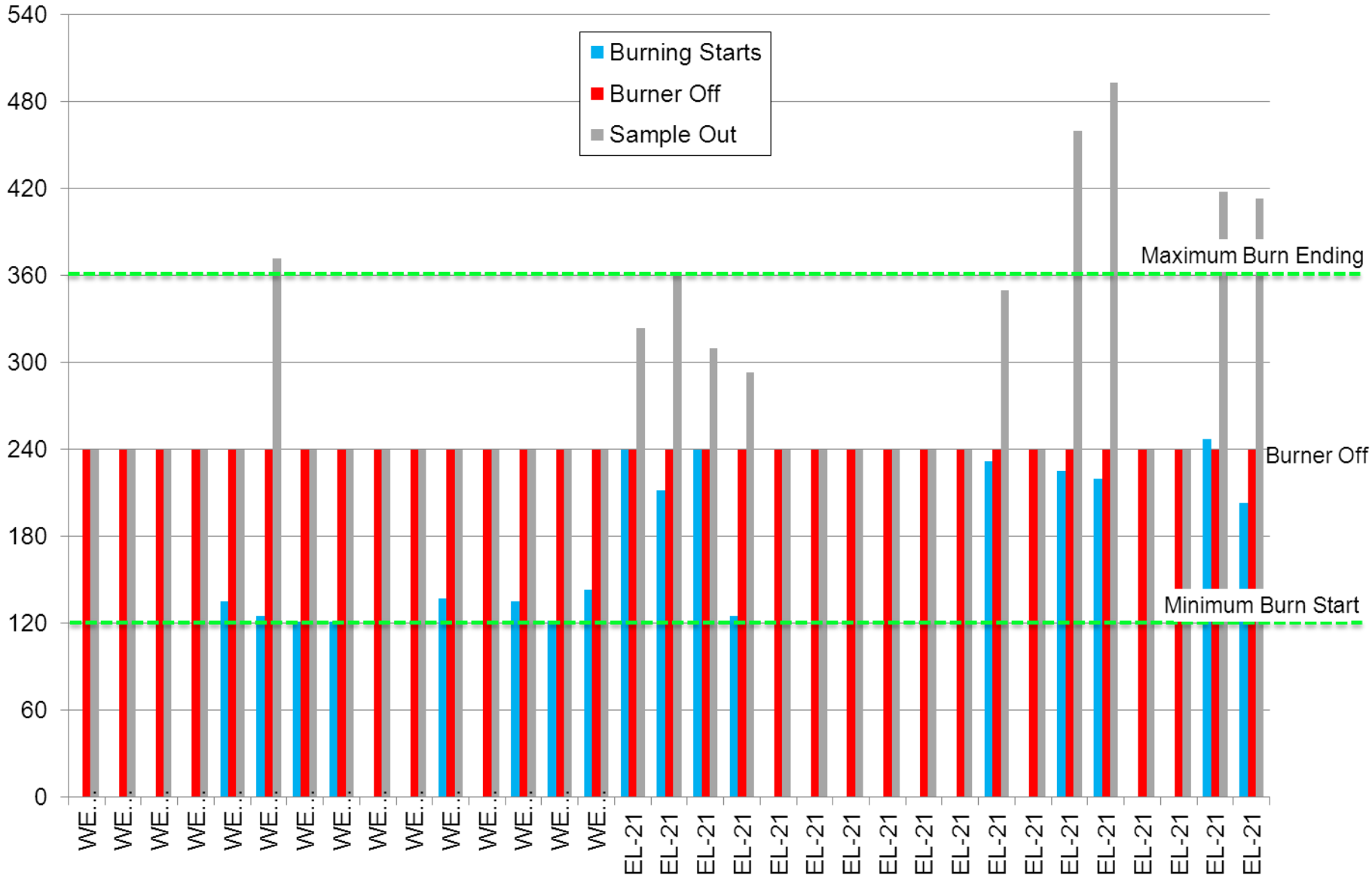
Rectangular Bars (horizontal): 137 Tests

WE-43: (18)
E-43: (25)
EL-21: (34)
EXP-2: (2)
ZE-41: (24)
AZ-80: (27)
AZ-31: (7)

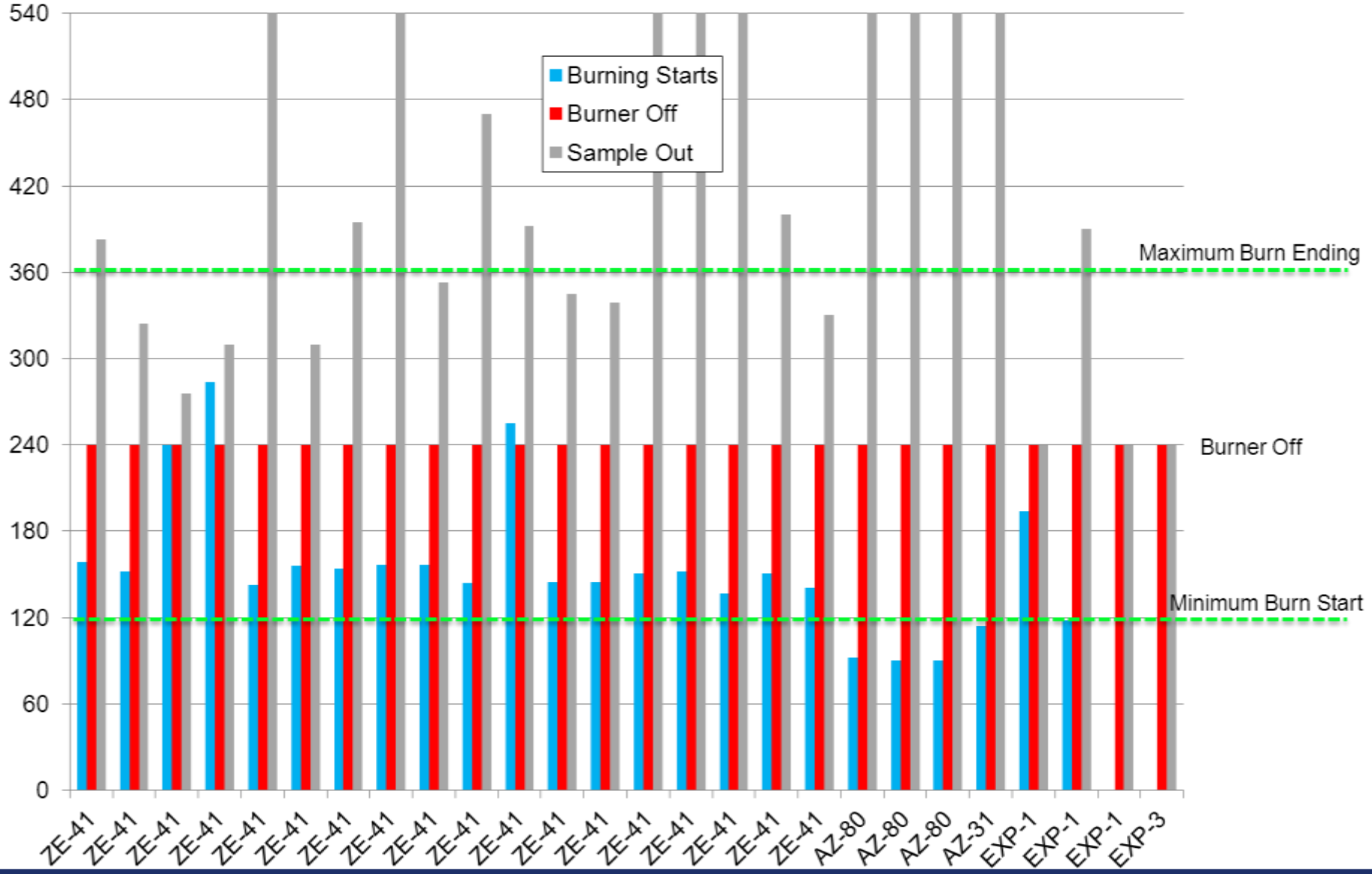
4 different bar thicknesses tested

Cylinder Test Results

WE-43 and EL-21 Cylinder Test Results 1.625-Inch O.D. (4/2012)



ZE-41 and AZ Cylinder Test Results 1.625-Inch O.D. (4/2012)



Tests Run on 5/9 – 5/10/2012

Close-up of sample bottom post-test

Bar Test Results

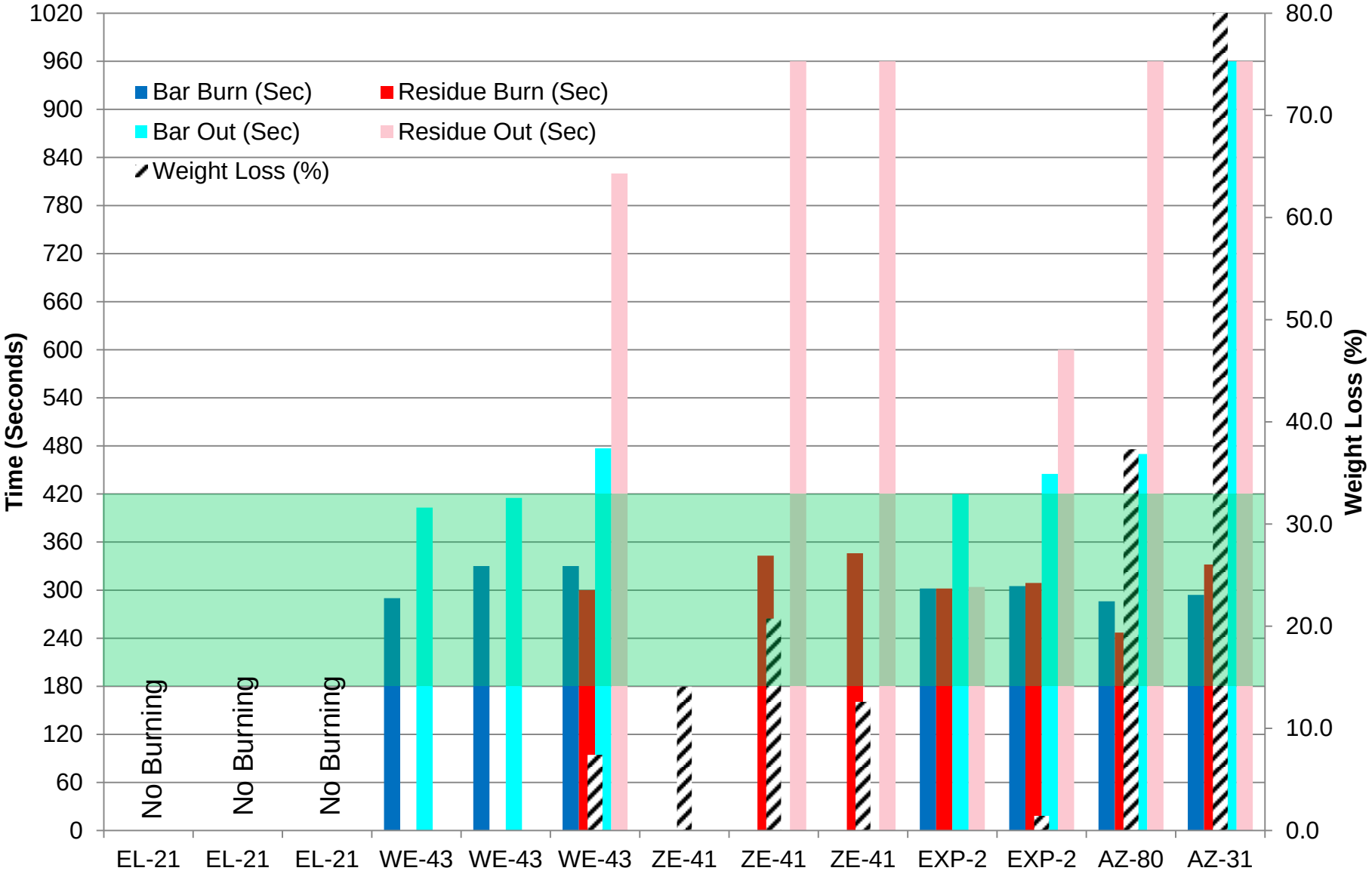
New Horizontal Bar Testing Rig 2012

New Horizontal Bar Testing Rig 2012

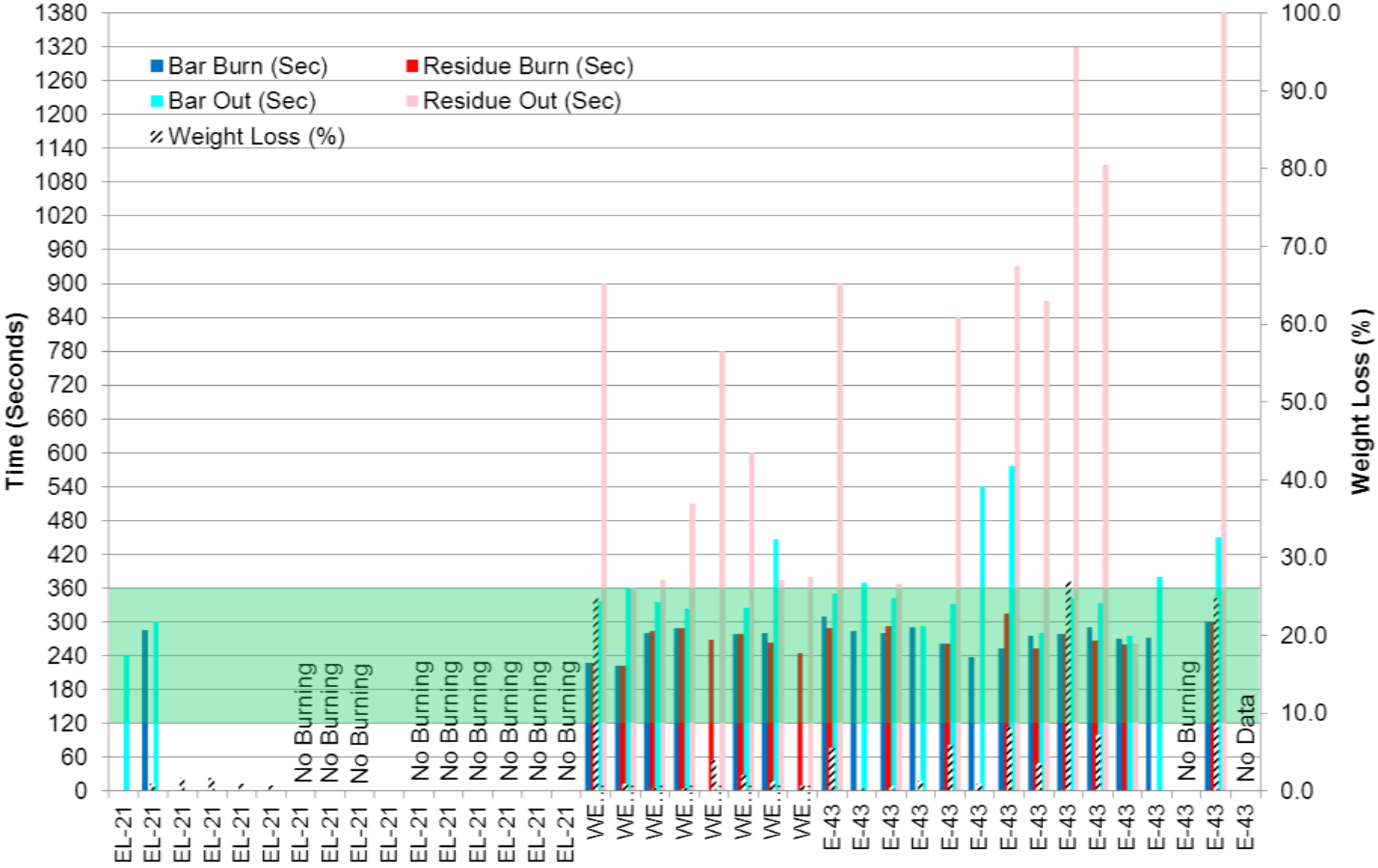
Parameters Measured During Bar Tests

Test No.	Date	Alloy	Thick-ness (inches)	Height (inches)	Length (inches)	Melt (Sec)	Ignition (Sec)	Bar Burn (Sec)	Bar Out (Sec)	Residue Burn (Sec)	Residue Out (Sec)	Burner Off (Sec)	Initial Weight (lbs)	Final Weight Bar (lbs)	Final Weight Residue (lbs)	Weight Loss (%)	Total Bar Burn Duration	Total Residue Burn Duration	Sample Total Burn Duration
2	4/23/2012	WE-43	0.669	1.57	19.69	290	290	290	403	0	0	360	1.350	0.980	0.370	0.0	113.0	0.0	113
3	4/23/2012	WE-43	0.669	1.57	19.69	298	298	330	415	0	0	360	1.350	1.000	0.350	0.0	85.0	0.0	85
12	4/24/2012	WE-43	0.669	1.57	19.69	300	300	330	477	300	820	360	1.350	0.960	0.290	7.4	147.0	520.0	667
5	4/24/2012	EL-21	0.669	1.57	19.69	339	N/A	0	0	0	0	360	1.320	1.050	0.270	0.0	0.0	0.0	0
6	4/24/2012	EL-21	0.669	1.57	19.69	308	N/A	0	0	0	0	360	1.320	1.030	0.290	0.0	0.0	0.0	0
11	4/24/2012	EL-21	0.669	1.57	19.69	324	N/A	0	0	0	0	360	1.320	1.030	0.290	0.0	0.0	0.0	0
1	4/23/2012	ZE-41	0.669	1.57	19.69	344	N/A	0	0	0	0	360	1.350	1.160	0.000	14.1	0.0	0.0	0
10	4/24/2012	ZE-41	0.669	1.57	19.69	343	350	0	0	343	960	360	1.350	1.070	0.000	20.7	0.0	617.0	617
13	4/25/2012	ZE-41	0.669	1.57	19.69	346	420	0	0	346	960	360	1.350	1.180	0.000	12.6	0.0	614.0	614
16	4/25/2012	EXP-2	0.669	1.57	19.69	304	302	302	420	302	304	360	1.410	1.010	0.400	0.0	118.0	2.0	120
17	4/25/2012	EXP-2	0.669	1.57	19.69	309	305	305	445	309	600	360	1.400	0.990	0.390	1.4	140.0	291.0	431
9	4/24/2012	AZ-80	0.669	1.57	19.69	247	286	286	470	247	960	360	1.340	0.840	0.000	37.3	184.0	713.0	897
4	4/23/2012	AZ-31	0.669	1.57	19.69	332	294	294	960	332	960	360	1.310	0.250	0.000	80.9	666.0	628.0	1294
61	5/22/2012	WE-43	0.575	1.57	19.69	N/A	N/A	0	0	0	0	300	1.200	1.194	0.000	0.5	0.0	0.0	0

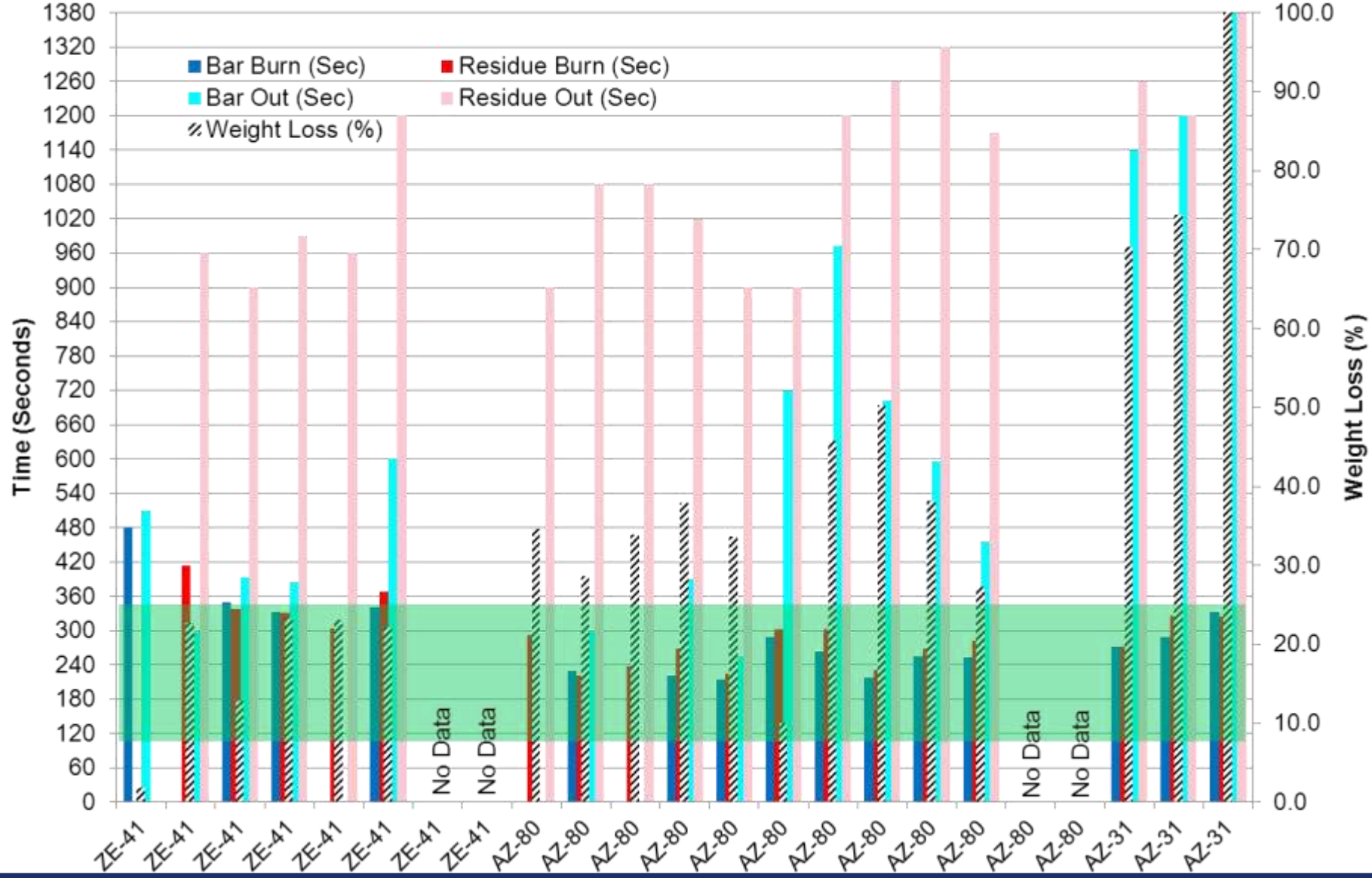
.669-Inch Thickness Bar Results (6-Minute Test)



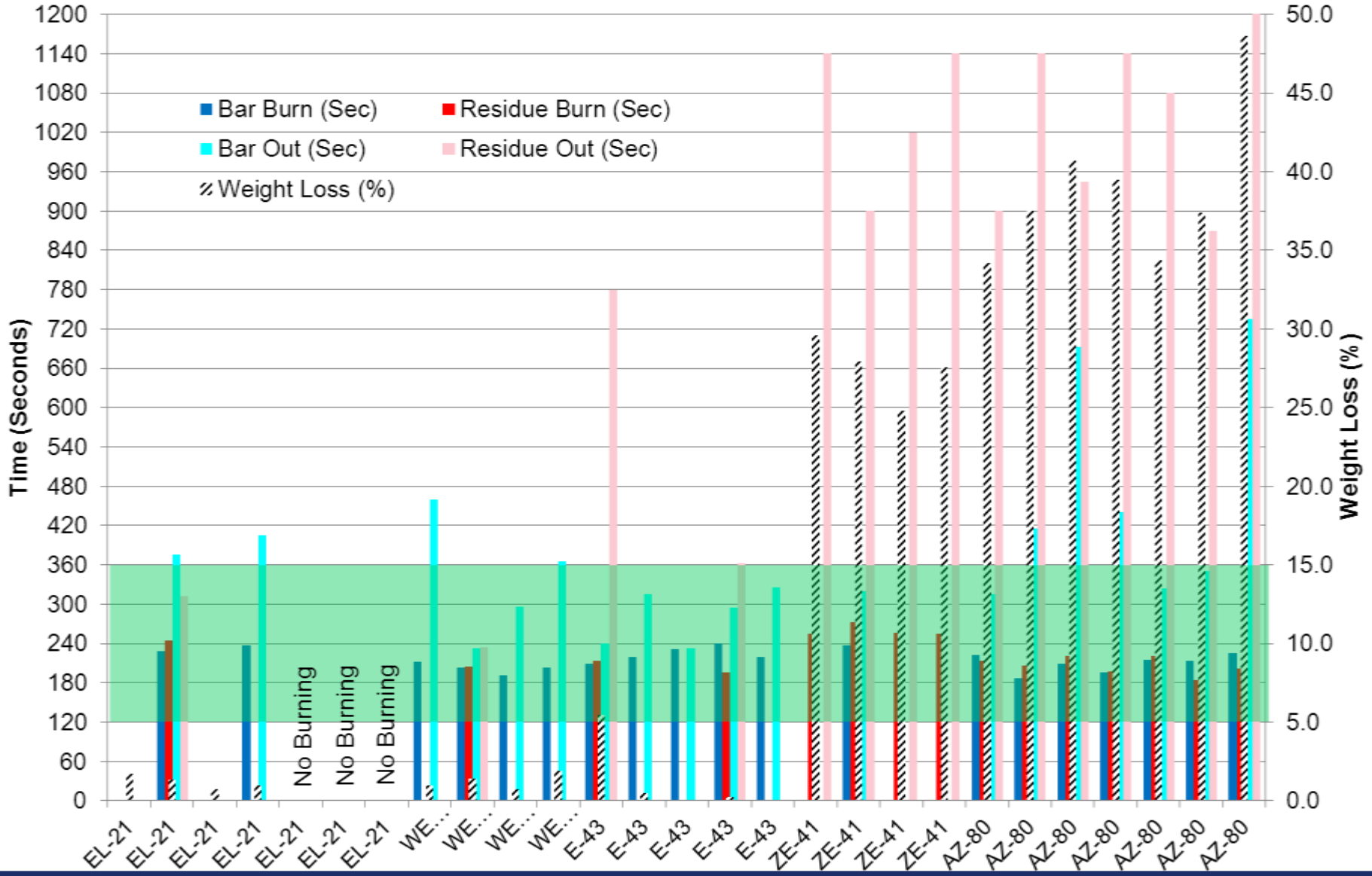
.5-Inch Thickness Bar Results (5-Minute Test)



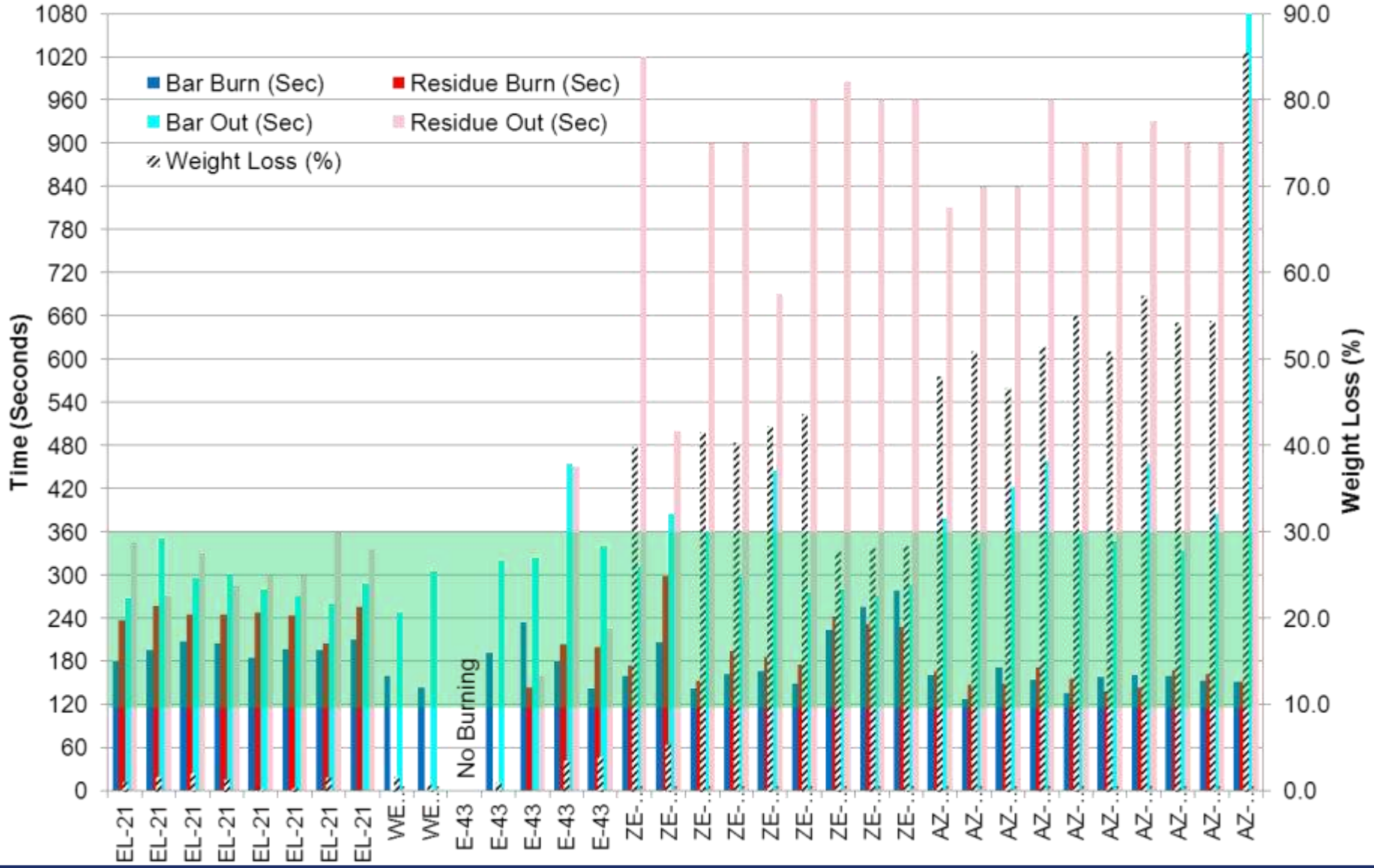
.5-Inch Thickness Bar Results (5-Minute Test)



.375-Inch Thickness Bar Results (4-Minute Test)



.250-Inch Thickness Bar Results (4-Minute Test)



Cylinder and Horizontal Bar Results

AZ-80 and AZ-31 consistently fail during both cylinder and bar tests

ZE-41 consistently fails cylinder and bar tests due to excessive burning after burner removal

WE-43 consistently passes cylinder tests, but often fails bar tests in certain configurations (.5 inch)

EL-21 consistently passes bar tests, but often fails during cylinder tests (5 of 18 failed)

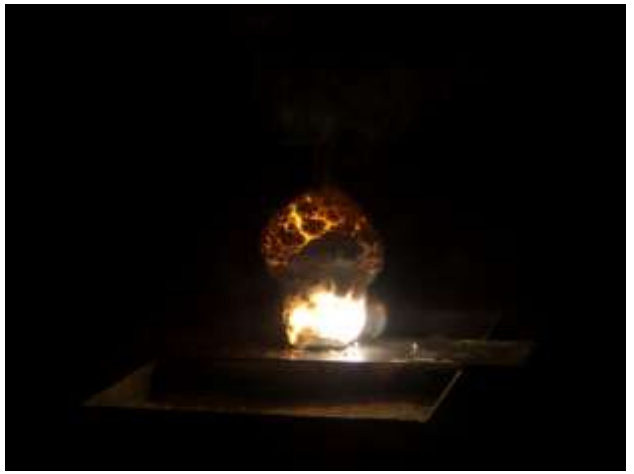
Bar test results seem to be more configuration dependent than cylinder

Weight loss criteria provides increased accuracy

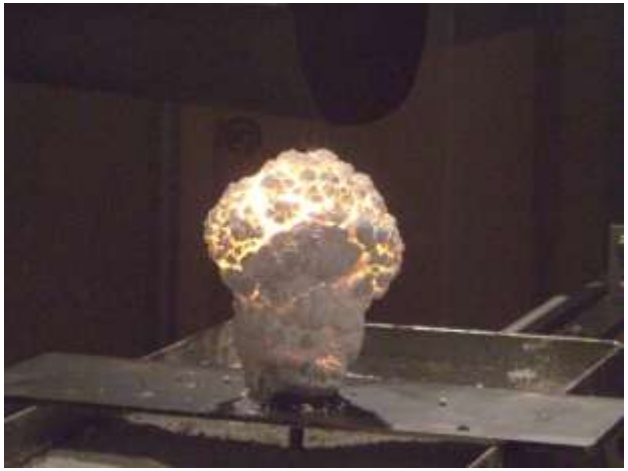
Bar samples easier/less expensive to produce

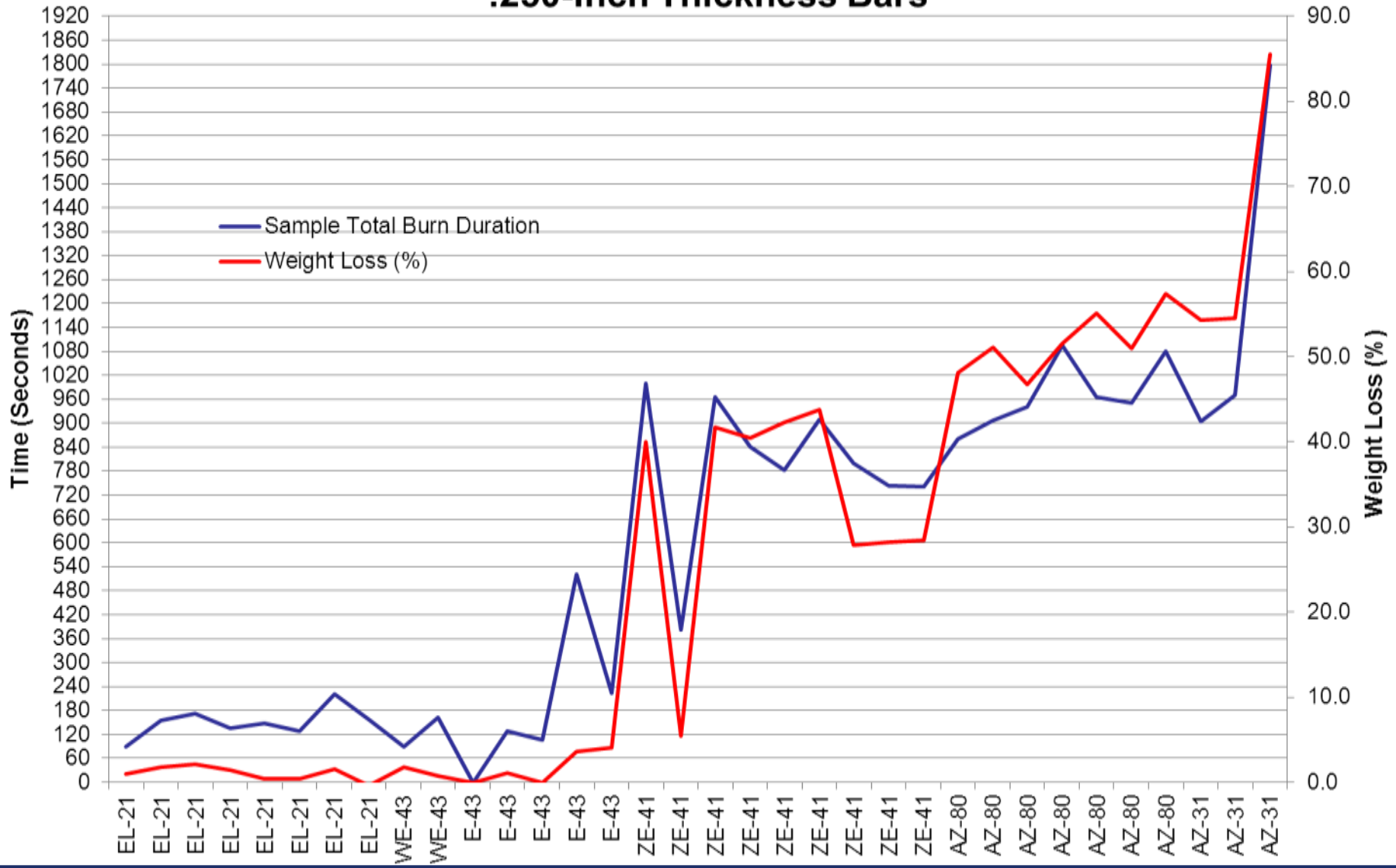
Visual vs. Weight Loss Example





When is it “Out”?




Burn Duration vs. Weight Loss
.250-Inch Thickness Bars
Time (Seconds)
Weight Loss (%)
Sample Total Burn Duration
Weight Loss (%)
1920
1860
1800
1740
1680
1620
1560
1500
1440
1380
1320
1260
1200
1140
1080
1020
960
900
840
780
720
660
600
540
480
420
360
300
240
180
120
60
0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
EL-21
EL-21
EL-21
EL-21
EL-21
EL-21
EL-21
EL-21
WE-43
WE-43
E-43
E-43
E-43
E-43
E-43
ZE-41
ZE-41
ZE-41
ZE-41
ZE-41
ZE-41
ZE-41
ZE-41
AZ-80
AZ-80
AZ-80
AZ-80
AZ-80
AZ-80
AZ-80
AZ-31
AZ-31
AZ-31

Influence of Talc in Pan vs. No Talc

Planned Activities

What is the impact of the catch pan on the residue burning?

- Current test configuration uses talc in catch pan, which acts as insulator
- Limited testing has shown that removal of talc increases cooling of sample in catch pan
- Determine appropriate configuration, proper height of talc, type?

Conduct additional tests on most appropriate thickness of bars

- Experiment with different heights? Lengths?

Finalize test parameters (i.e., time to ignition, exposure time, weight-loss)

- Should the recording of the time the sample is “out” be eliminated?