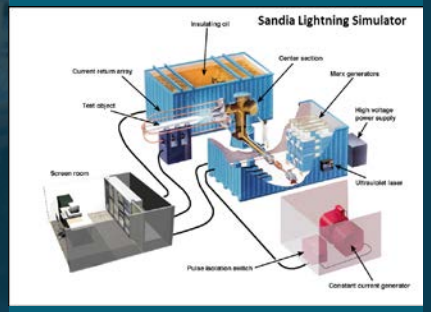
55-gallon-drum Lightning Integrity Laboratory Test



PRESENTED BY

Leonard Martinez Department 1353 Electrical Science & Experiments

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SAND2019-4050 PE

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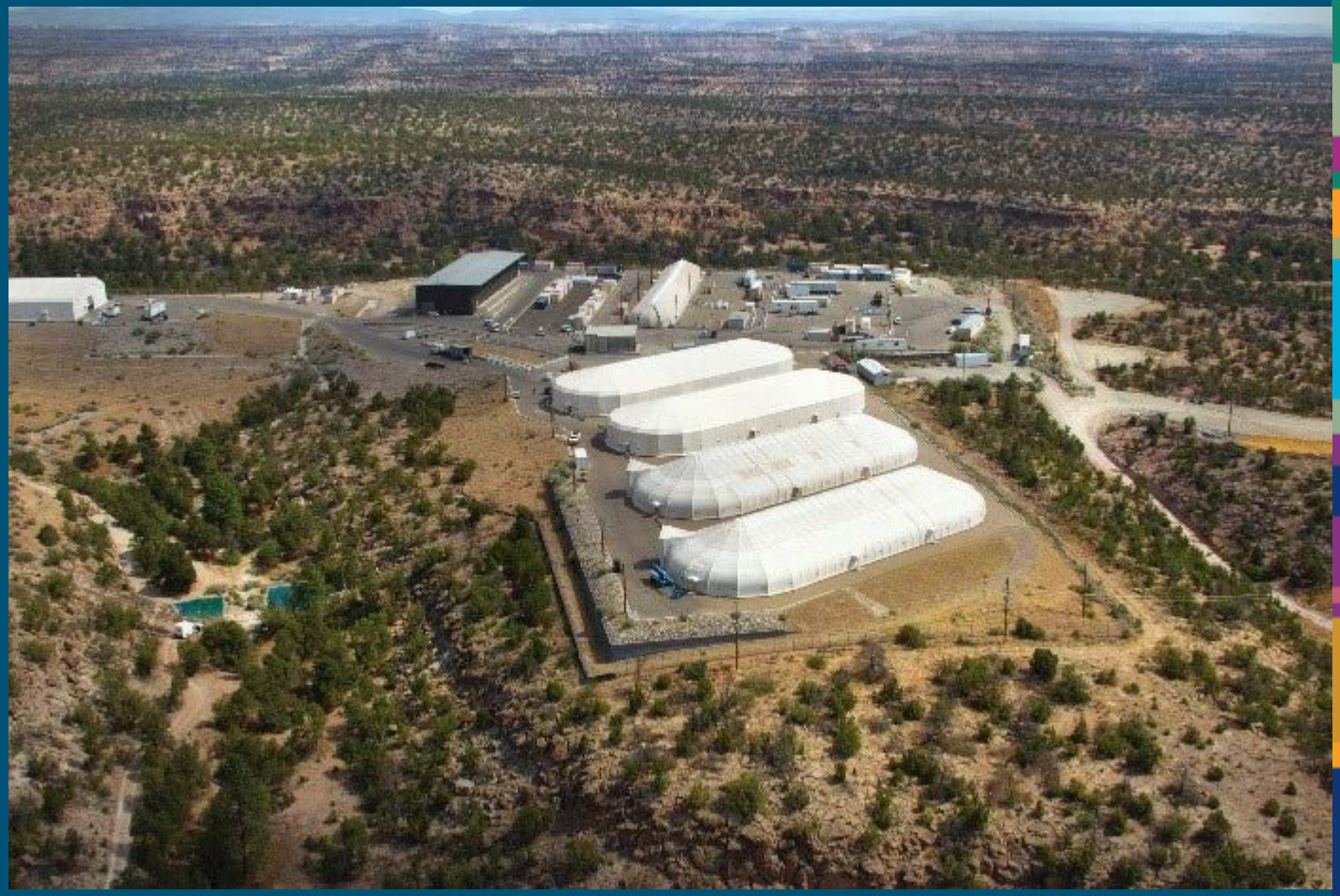
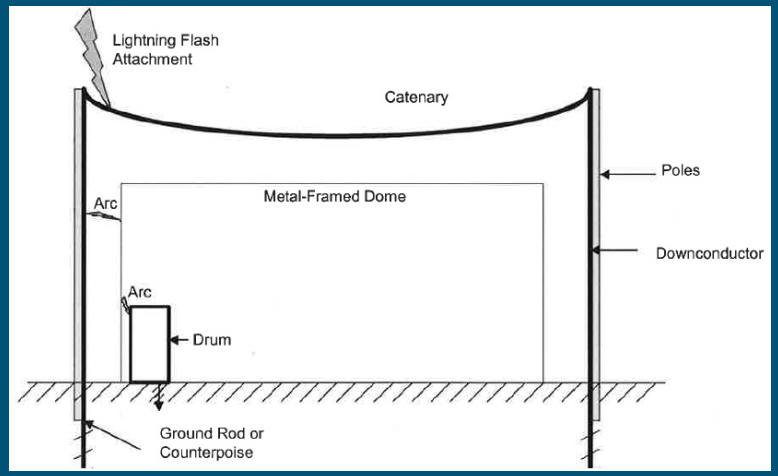
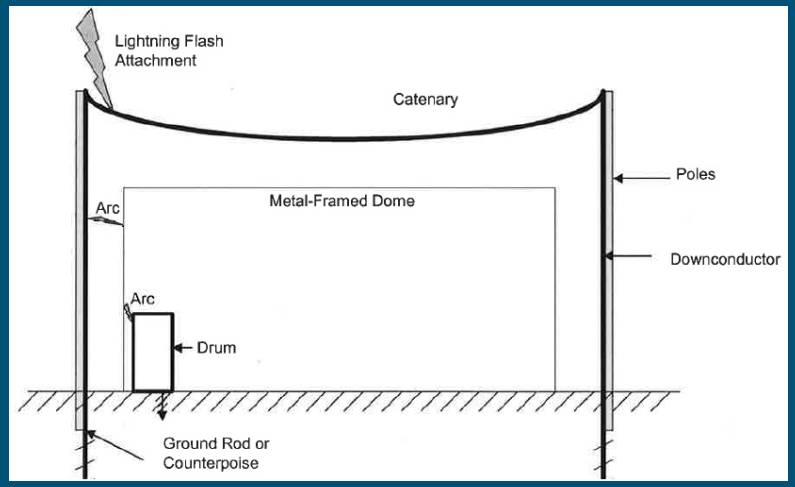



Lightning Flash
Attachment
Catenary
Poles
Metal-Framed Dome
Arc
Downconductor
Arc
Drum
Ground Rod or
Counterpoise

LANL


Lightning Flash
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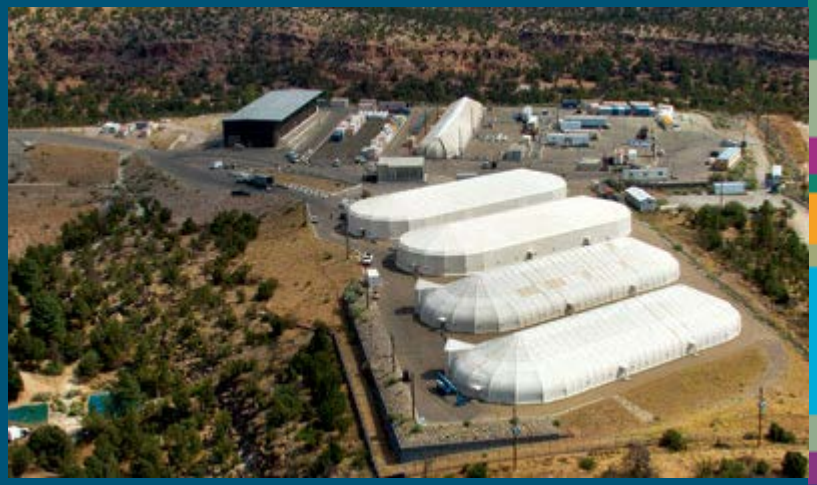
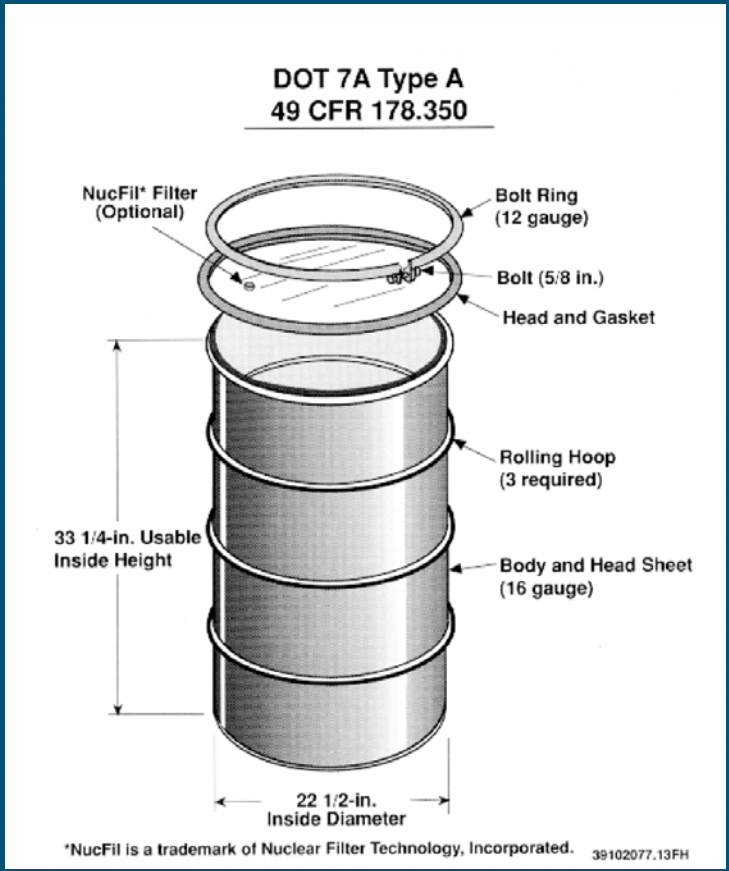
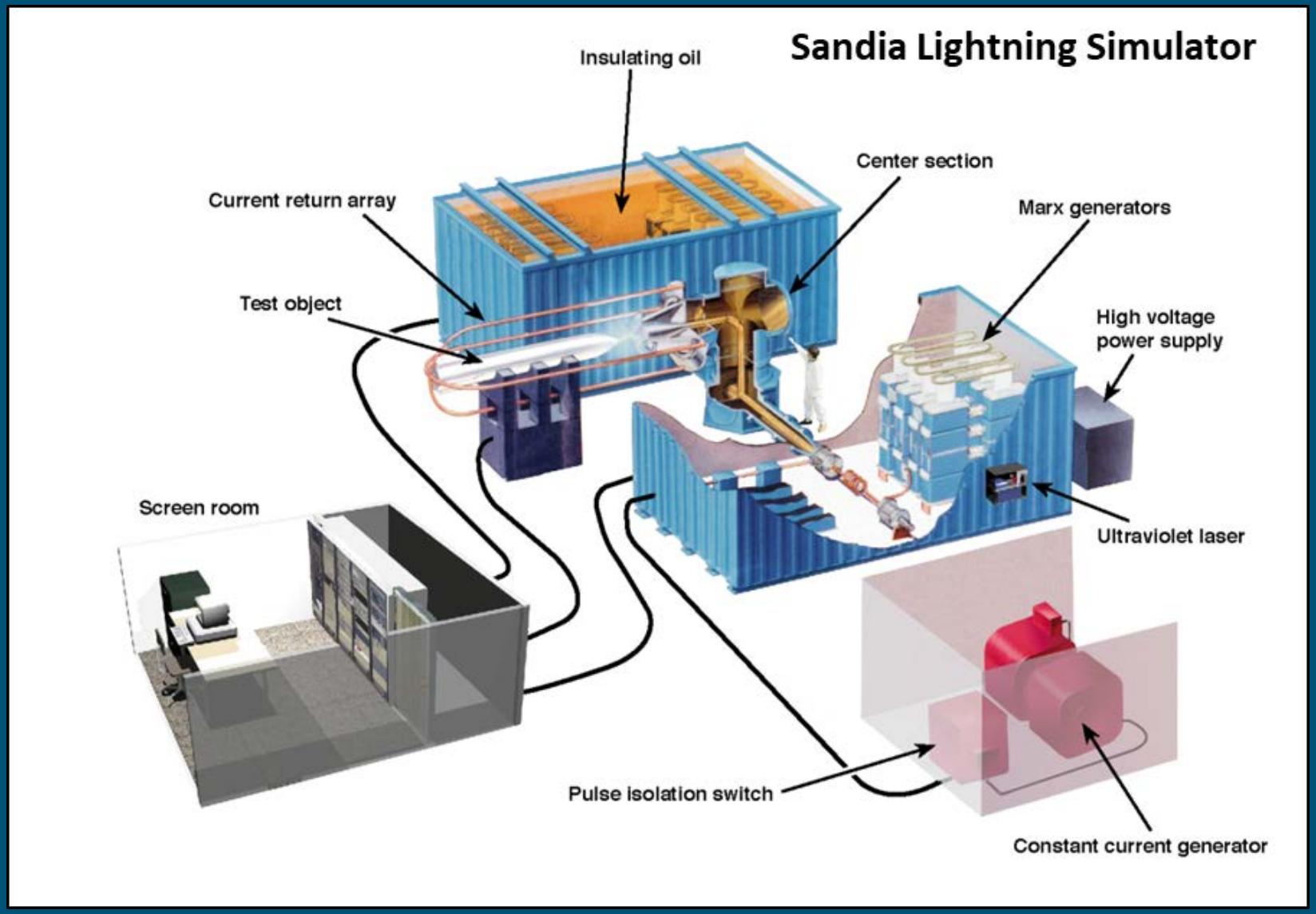
LANL

LANL




DOT 7A Type A
49 CFR 178.350
NucFil* Filter (Optional)
Bolt Ring (12 gauge)
Bolt (5/8 in.)
Head and Gasket
Rolling Hoop (3 required)
33 1/4-in. Usable Inside Height
Body and Head Sheet (16 gauge)
22 1/2-in. Inside Diameter
*NucFil is a trademark of Nuclear Filter Technology, Incorporated.
39102077.13FH

Sandia Lightning Simulator

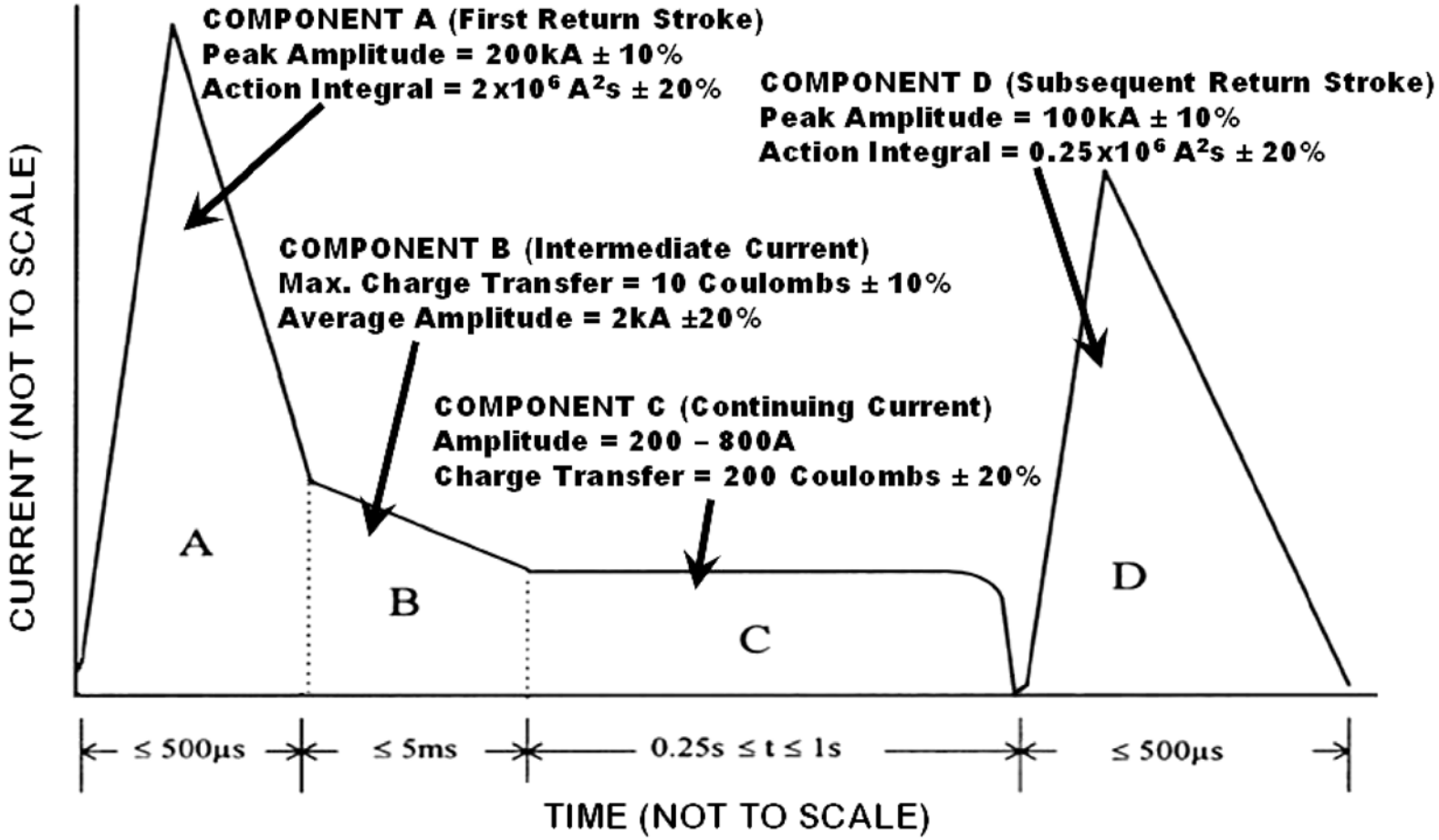


Continuing Current Source

Controller

Continuing Current Source

MIL-STD-464C



Electrical Current Waveforms

Coupon Tests with Continuing Current

Aluminum
- 16 Gauge

Steel (bare)
- 16 Gauge, 12 Gauge, 10 Gauge, 7 Gauge
  - Drum lid 16 Gauge
  - Bolt Ring 12 Gauge

Simulated lightning currents
- 300A, 400A, 500A

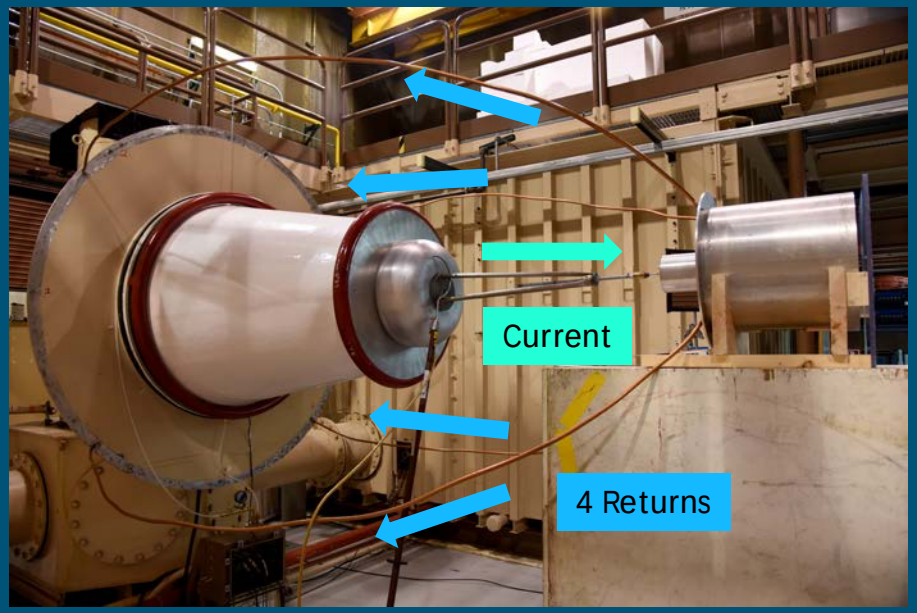
Continuing current durations

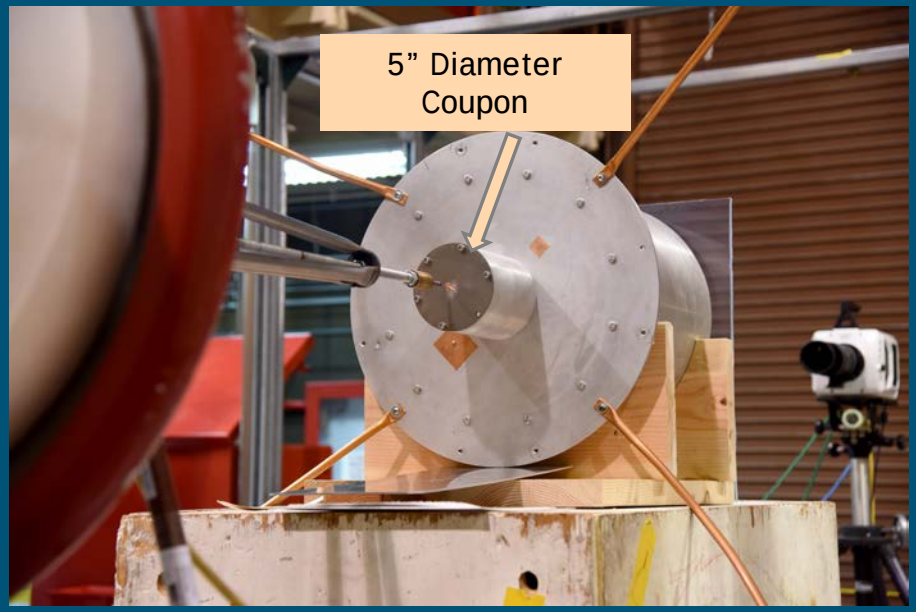
700ms, 880ms, 1.17s, up to 2.6s

Vertical Coupons
- Tested with non-diverter tip
- Starter wire (Starter Wire 0.010" Copper)

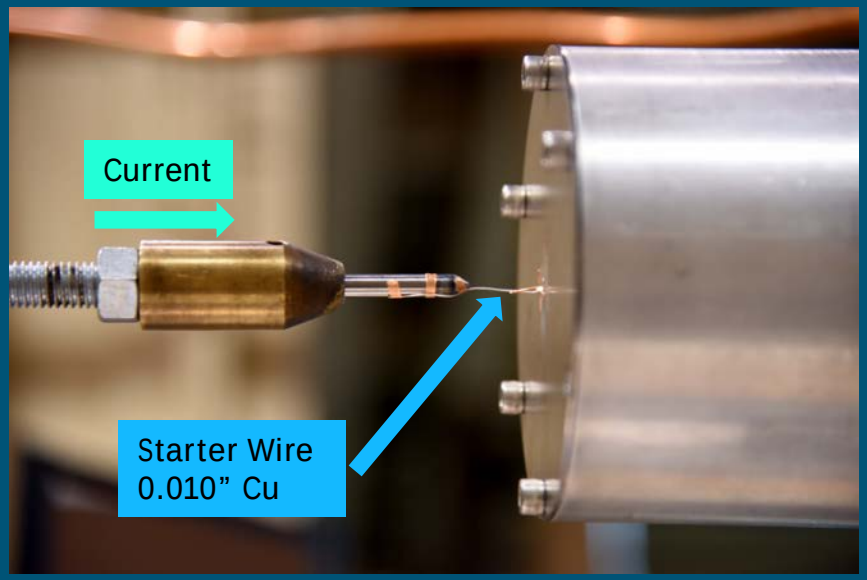
Horizontal Coupons
- Tested with non-diverter tip
- Tested with diverter tip
- Starter wire (Starter Wire 0.010" Copper)

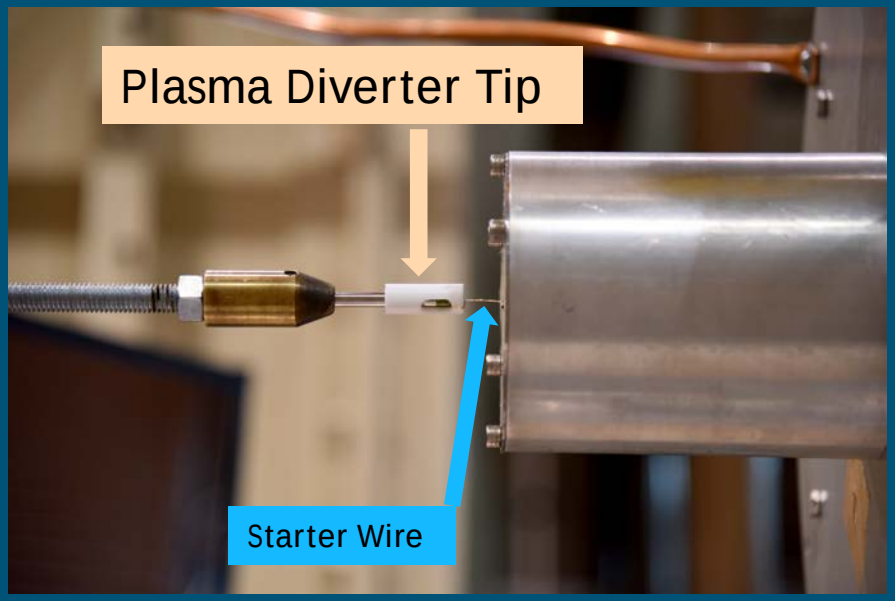
Vertical Coupon Test Setup





Vertical Coupon Test Setup

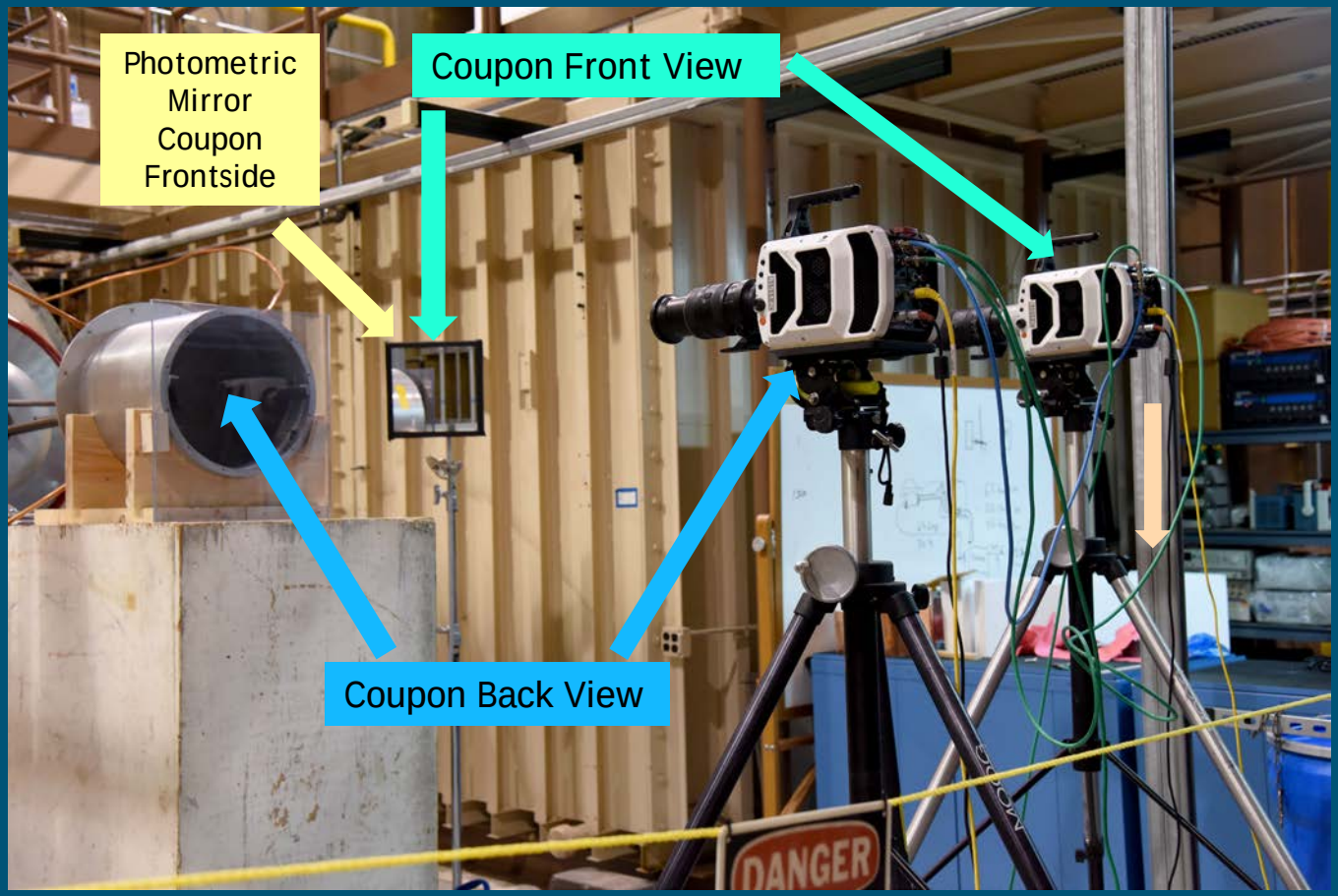




Photometric Test Setup

High Speed Cameras

- Phantom Model 1610
- 7000 Frames Per Second



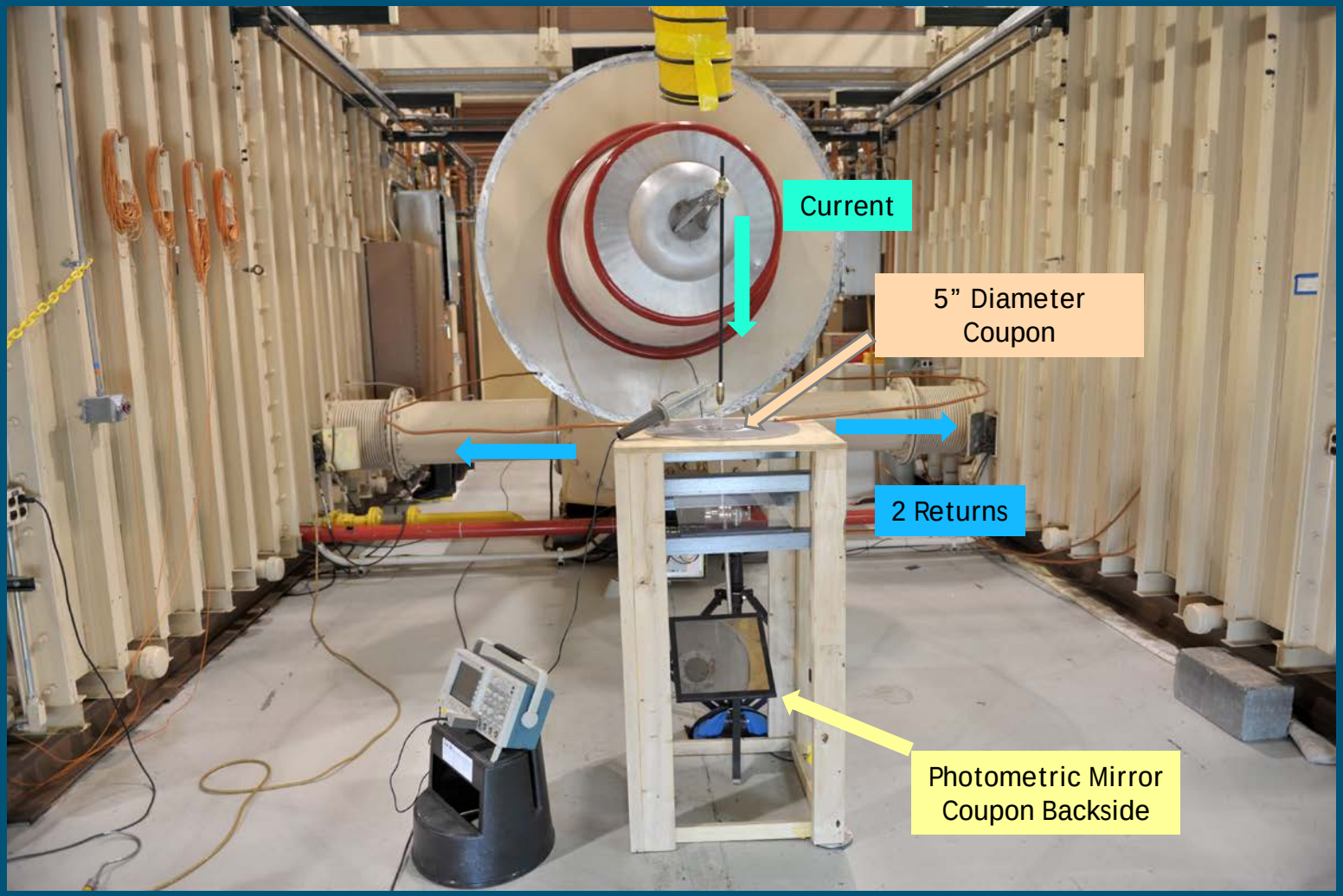
Vertical Coupon Burnthrough Video

Steel

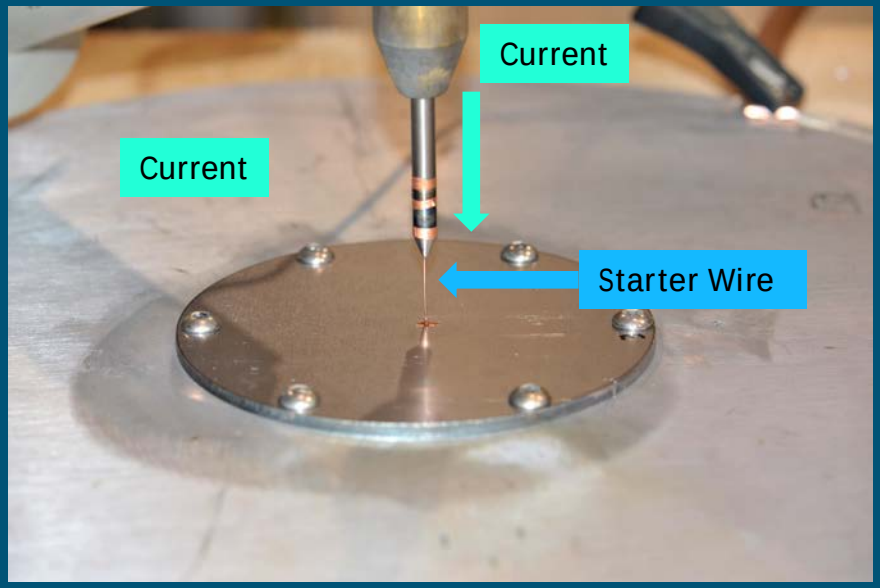
- 16 Gauge 200ms to Burnthrough
- 400A for 906ms (362 Coulombs)
- Hole size = 0.571”

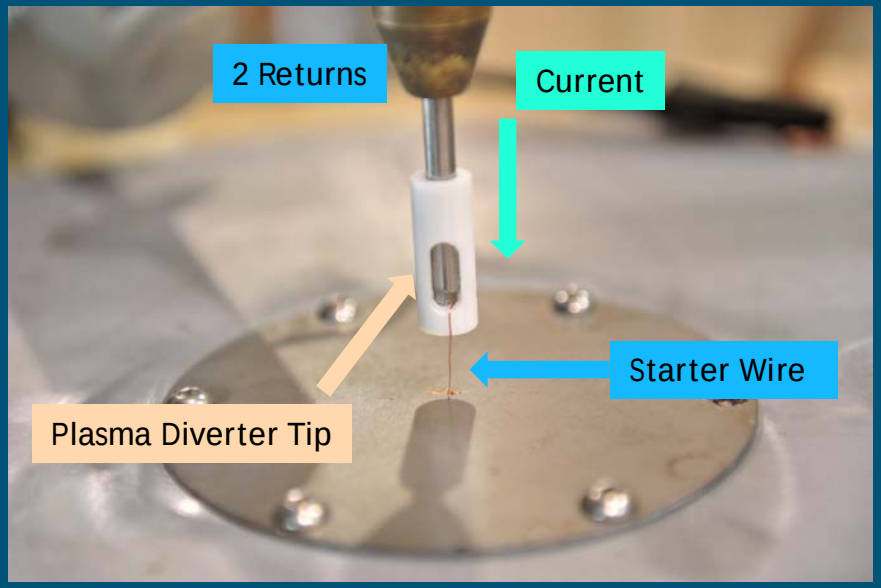
Vertical Coupon Post Test

Horizontal Coupon Test Setup



Horizontal Coupon Test Setup



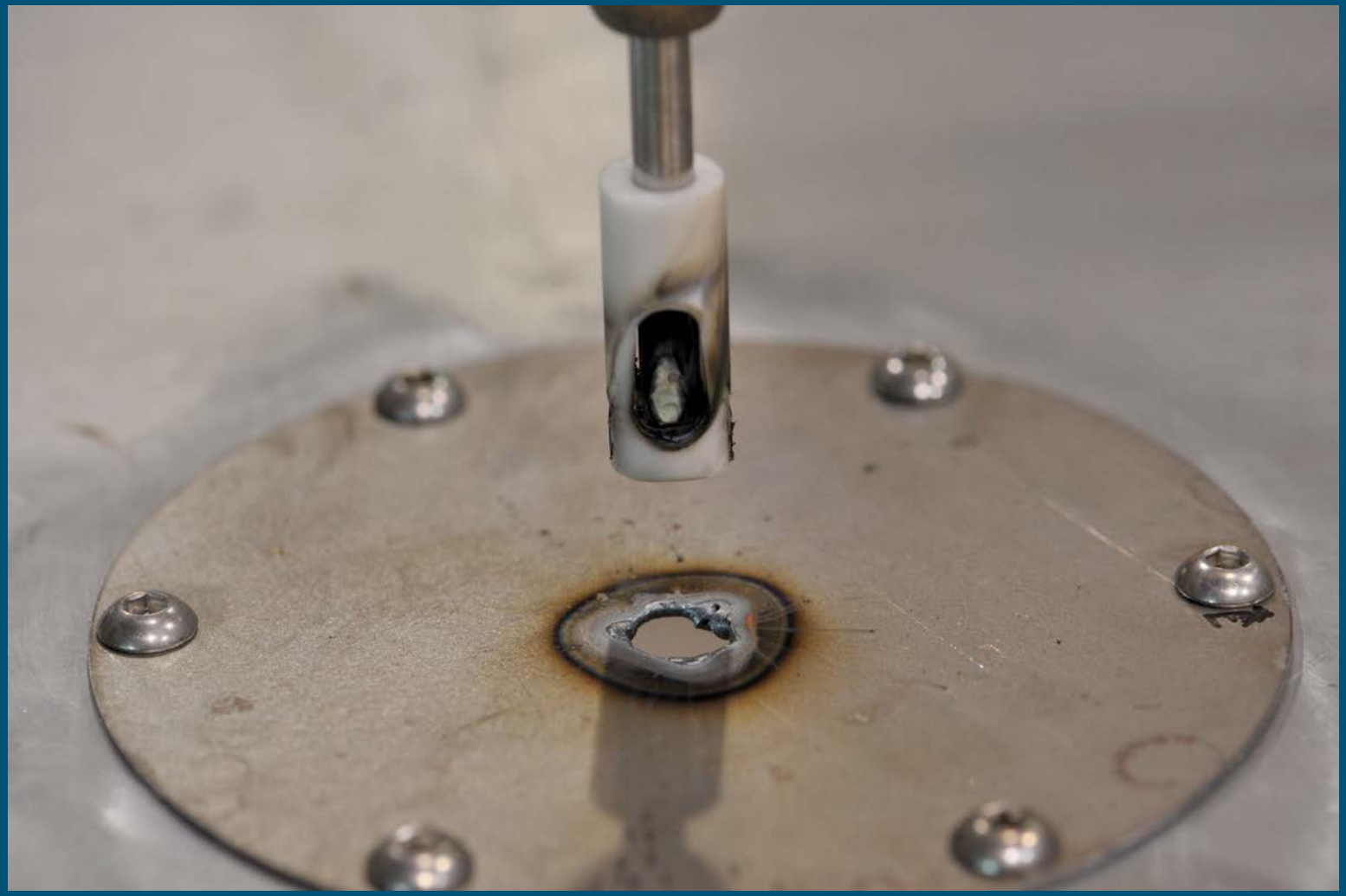


Horizontal Coupon Burnthrough Video

Steel

- 16 Gauge 178ms to Burnthrough
- 520A for 718ms (374 Coulombs)
- Hole size = 0.348”

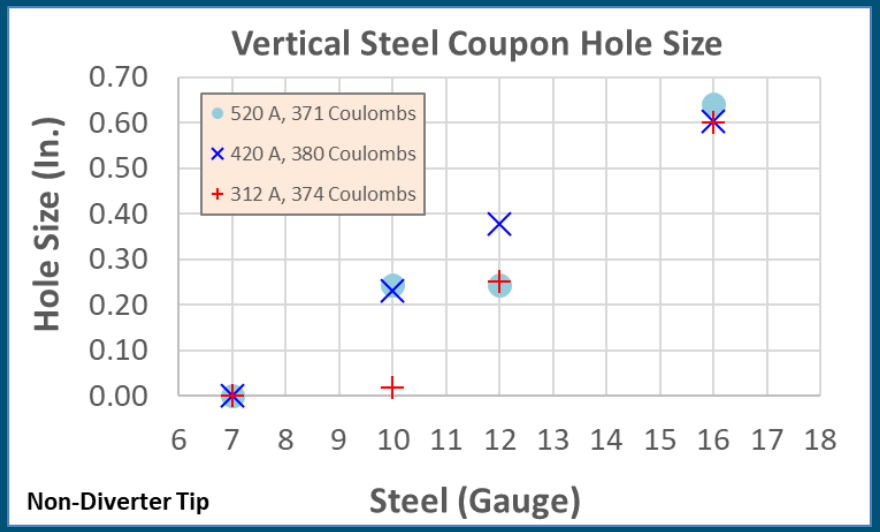
Horizontal Coupon Post Test

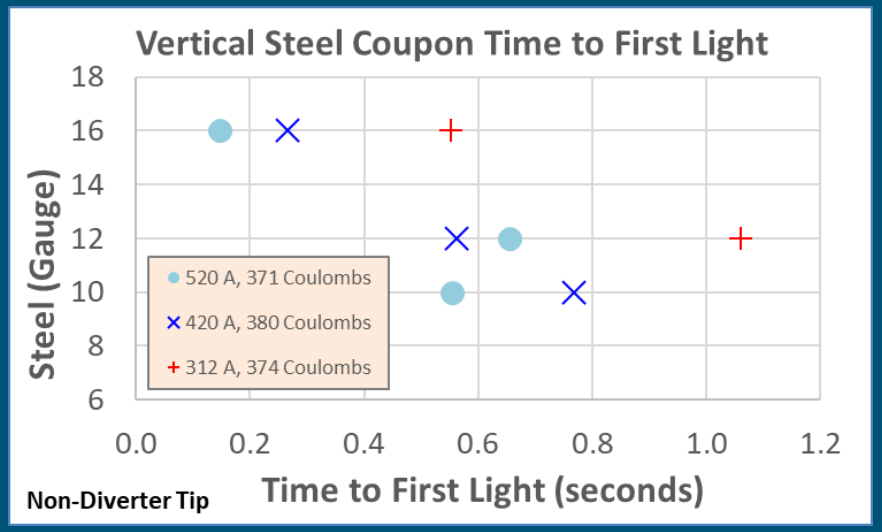


Coupon Data Set (Non-Diverter Electrode)

Coupon Orientation	Coupon Material	Material Gauge	CCG Measured Time (s)	CCG Measured Current (A)	Charge Transfer(C)	Hole Size (Inches)	Time to First Light (s)
Vertical	Steel	16	1.200	312	374.4	0.601	0.5520
Vertical	Steel	12	1.191	312	371.6	0.251	1.0597
Vertical	Steel	10	1.200	312	374.4	0.018	-
Vertical	Steel	7	1.200	312	374.4	0.000	NO HOLE
Vertical	Steel	16	0.907	420	380.9	0.603	0.2659
Vertical	Steel	12	0.914	420	383.9	0.377	0.5617
Vertical	Steel	10	0.910	418	380.4	0.230	0.7674
Vertical	Steel	7	0.900	420	378.0	0.000	NO HOLE
Vertical	Steel	16	0.710	520	369.2	0.640	0.1477
Vertical	Steel	12	0.714	520	371.3	0.243	0.6554
Vertical	Steel	10	0.714	520	371.3	0.243	0.5533
Vertical	Steel	7	0.714	520	371.3	0.000	NO HOLE

Plots of Hole Size and Time to First Light





7 Gauge Steel

- No Burnthrough Expected with < 400 C

12 Gauge Steel

- Anomaly at 520 A
- Poor Arc Attachment (Slow to Connect)

7 Gauge Steel

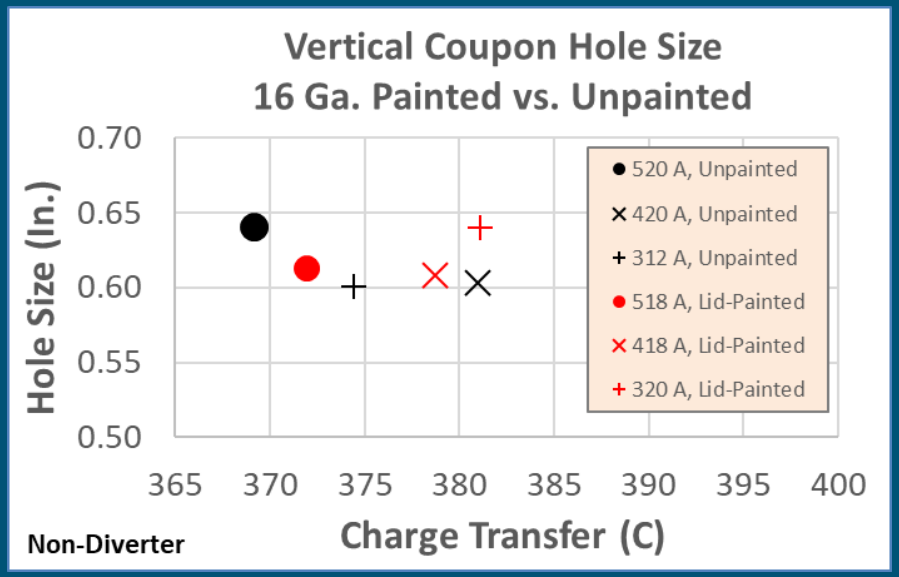
- No Burnthrough Expected with < 400 C

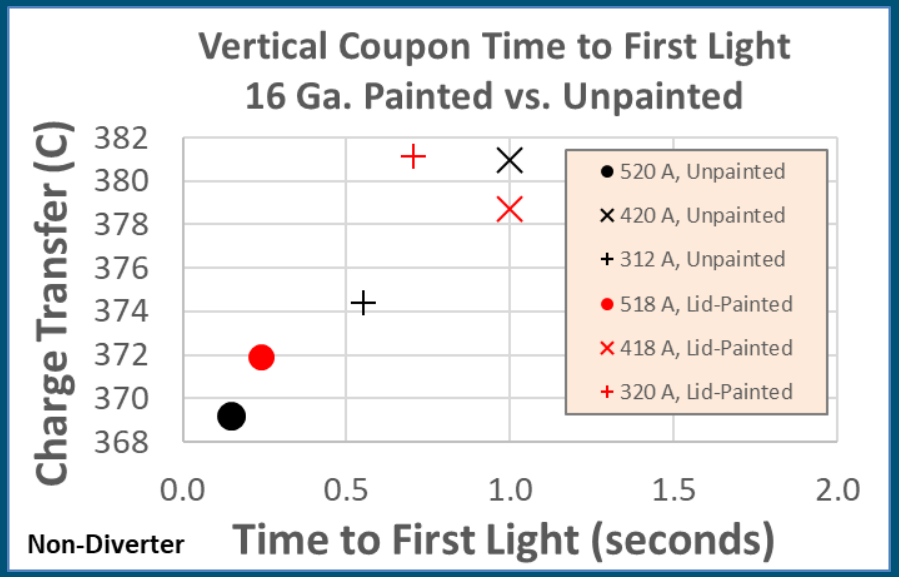
12 Gauge Steel

- Anomaly at 520 A
- Poor Arc Attachment (Slow to Connect)
- Long time to Burnthrough (0.655 s)
- Burnthrough was expected at 0.35-0.40 s

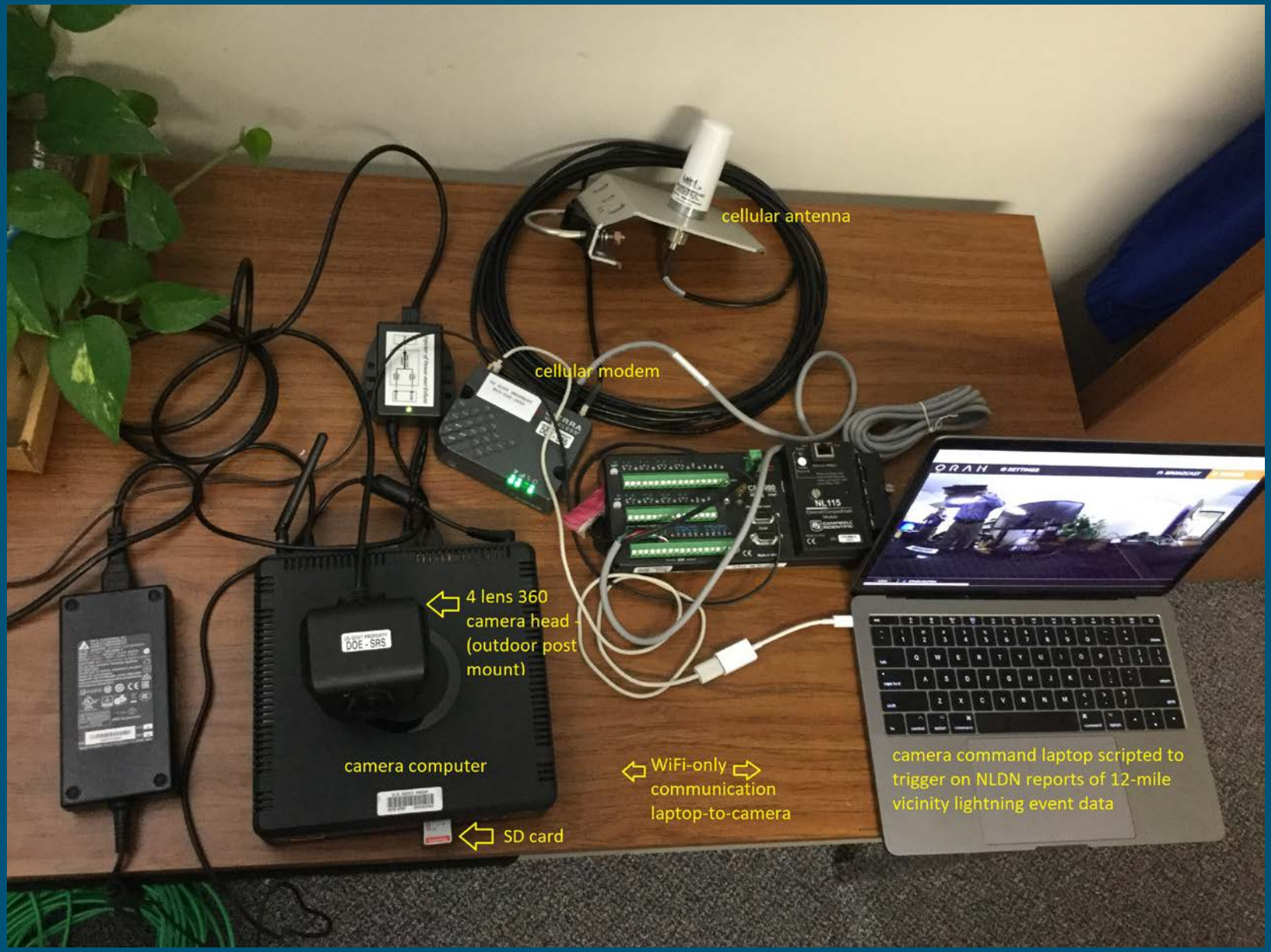
Plots of Hole Size and Time to First Light

Coupon Orientation	Coupon Material	Material Gauge	CCG Measured Time (s)	CCG Measured Current (A)	Charge Transfer(C)	Hole Size (inches)	Time to First Light (s)
Vertical	Steel	16	1.200	312	374.4	0.601	0.5520
Vertical	Steel	16	0.907	420	380.9	0.603	0.2659
Vertical	Steel	16	0.710	520	369.2	0.640	0.1477
Vertical	Barrel Lid	16	1.191	320	381.1	0.640	0.7030
Vertical	Barrel Lid	16	0.906	418	378.7	0.608	0.2414
Vertical	Barrel Lid	16	0.718	518	371.9	0.613	0.2367





LANL Lightning Ground Truth project



LANL Lightning Ground Truth project

LANL Lightning Ground Truth project

LANL Lightning Ground Truth project

Flash							
1							
2							
3							
4							
5							
6							
7							
8							
9							

Table 2: Thumbnail frame-by-frame stills of CG flashes captured Aug 9 -11 on or near LANL.

Path Forward

Lightning Tests on 55 Gallon TRU Waste Drums

- Lightning Return Stroke [30kA-200kA with 500 A continuing current (750ms)]

Drum Test Areas

- Lid
- Bolt Ring (Attached to drum)
- Structural Rib

Tests planned for June 2019

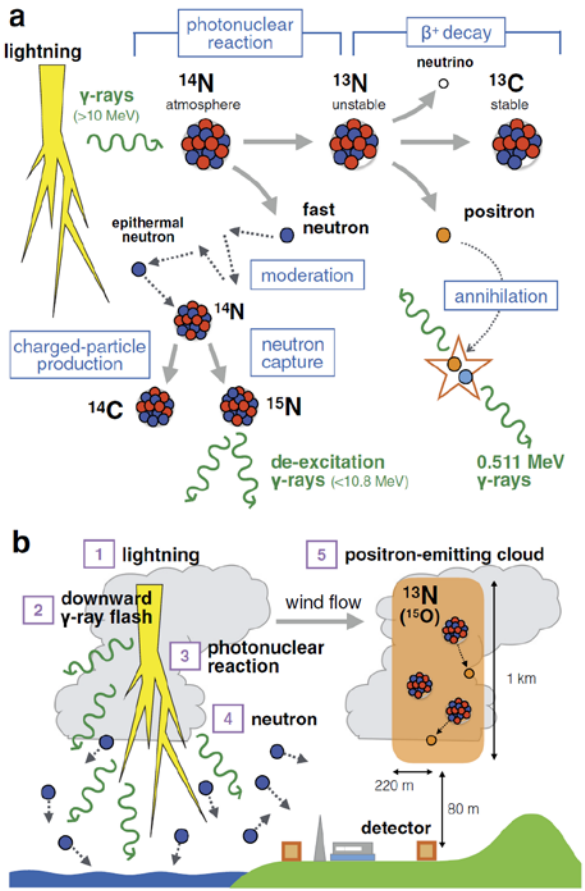
Acknowledgements

Sandia National Laboratories

- John Pilkey, Electrical Surety Analysis
- Leonard Martinez, Electrical Science and Experiments
- Shannon Feathers, Electrical Science and Experiments
- John Brown, Electrical Science and Experiments
- Mark Olona, Graphics, Video, Photo Services
- Jason Everett, Graphics, Video, Photo Services

Questions

Teruaki Enoto



Extended Data Figure 3 | Illustration of lightning-triggered physical processes. a, Physical processes during a chain of radiation events induced by the photonuclear reactions. b, Diffusion of neutrons produced in lightning and drift of the positron-emitting cloud.

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