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Protecting People and the Environment

Sandia National Laboratories

EPRI

DESIREE-FIRE

Direct Current Electrical Shorting In Response to Exposure-FIRE

2009 NEI Fire Protection Information Forum

Savannah, Georgia

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Office of Nuclear Regulatory Research

Fire Research Branch

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Project Overview

Gabe Taylor

Fire Protection Engineer

NRC/RES

Office of Nuclear Regulatory Research

Fire Research Branch

DESIREE-FIRE

- Experimental testing program to evaluate direct current (dc) circuit response to fire exposure.
- Cooperative research project with EPRI
- Sandia National Laboratories is conducting the testing

Need for Testing

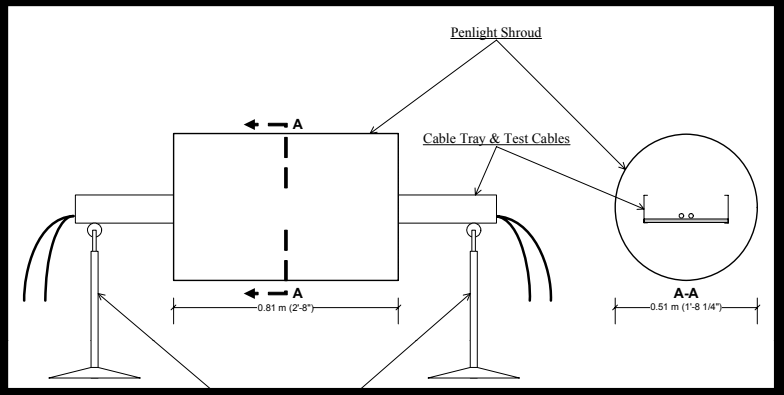
- Lack of data and uncertainties extrapolating alternating current (ac) results to dc circuits
- Numerous safety related systems commonly powered with dc
- Duke testing in 2006 indicated that dc circuits may react differently than ac circuits to fire-induced failures

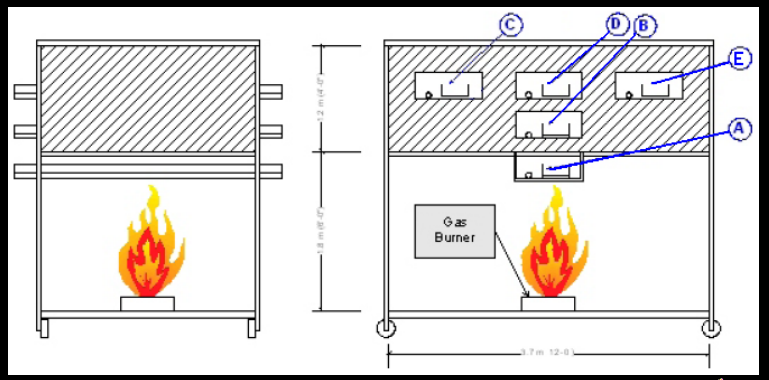
Public Comment / Peer Review

- Project plan developed in September 2008
- 30 day public comment period
- Extensive peer review comment period (2 months)
- Most of the review related to dc electrical circuit instrumentation and representation of actual NPP applications

Testing Schedule

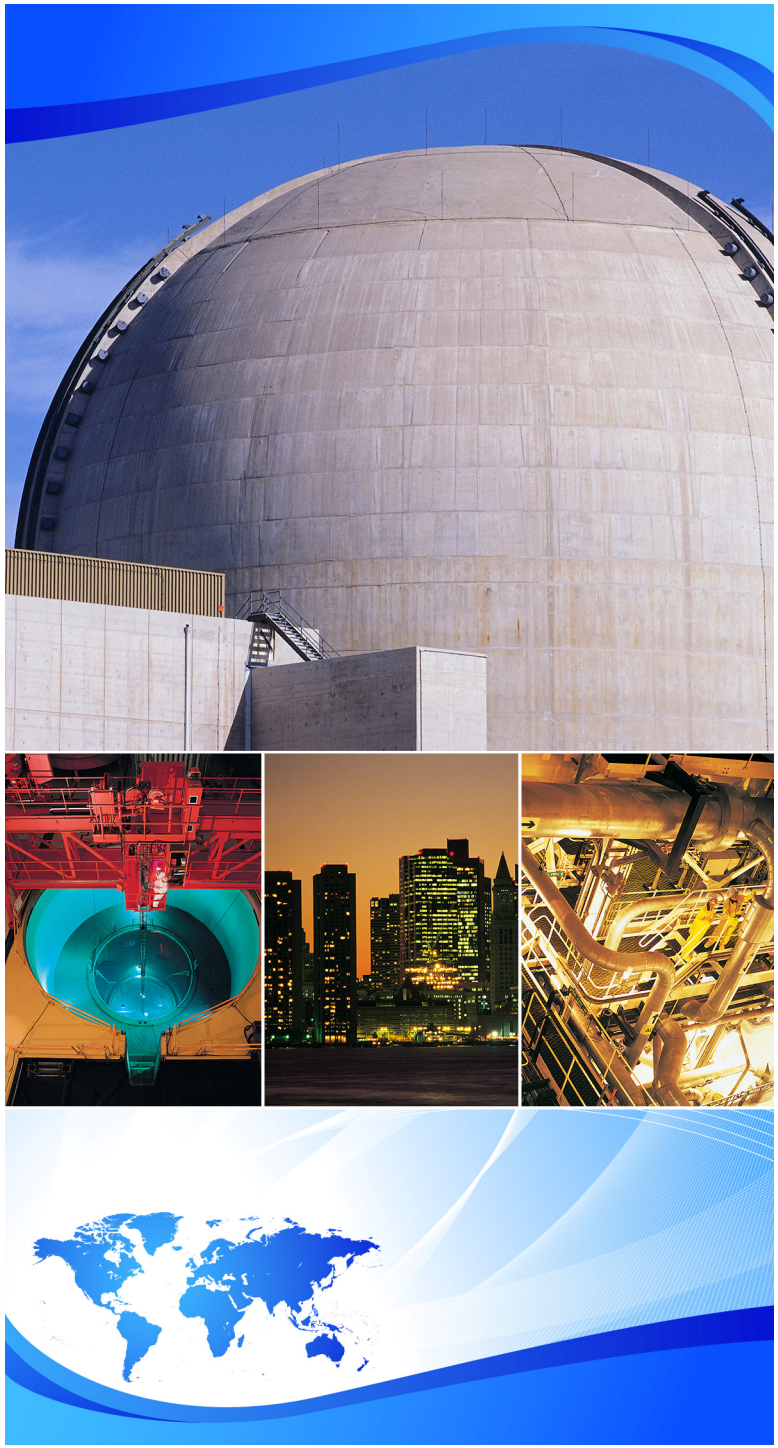
- Small-Scale
  - July to September 2009
- Intermediate-Scale
  - September to November 2009
- Draft Report
  - Early 2010





Benefits of working with EPRI

- 125Vdc Battery Bank from TSC
- Vintage (1970's) Kerite FR & HTK (FAQ 53)
- 200+ feet of armored cable
- 15kV circuit breaker
- Large coil (similar to PORV)
- 1" coil assembly (similar to head vent valve)



EPRI | ELECTRIC POWER RESEARCH INSTITUTE

DESIREE-FIRE Program

Approach & Key Objectives

2009 NEI Fire Protection Information Forum, Savannah, Georgia

September 20-24, 2009

Daniel Funk
Principal Engineer, Edan Engineering

Topics

Approach

- Peer review group & industry participation
- Test configuration
- Conduct of test & data collection

Objectives

- Characterize DC
- Clean up lingering issues

Peer Review Group & Industry Participation

Active group

Representatives from NRC, Sandia, EPRI, & Industry

NRC has been very receptive to industry input

Industry has come through…but we need more

- **KERITE CABLE**

Test Configuration

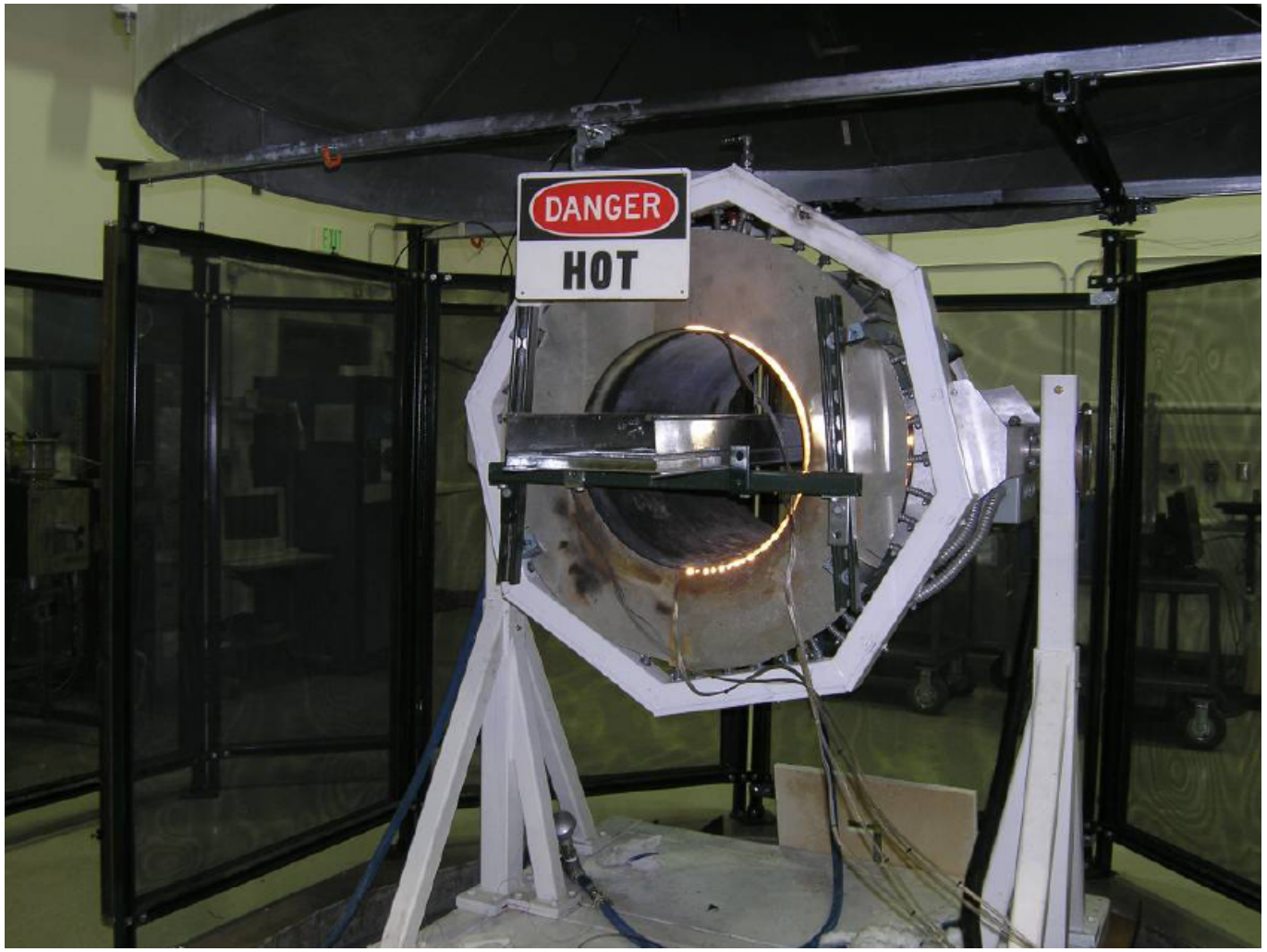
Realistic Setup

- Large station battery
- Realistic cable lengths and sizes
- Typical “DC rated” protective devices
- Representative sample of equipment

Test Configuration

Test Configuration

Test Configuration



Test Configuration

Approach

Similar to CAROLFIRE

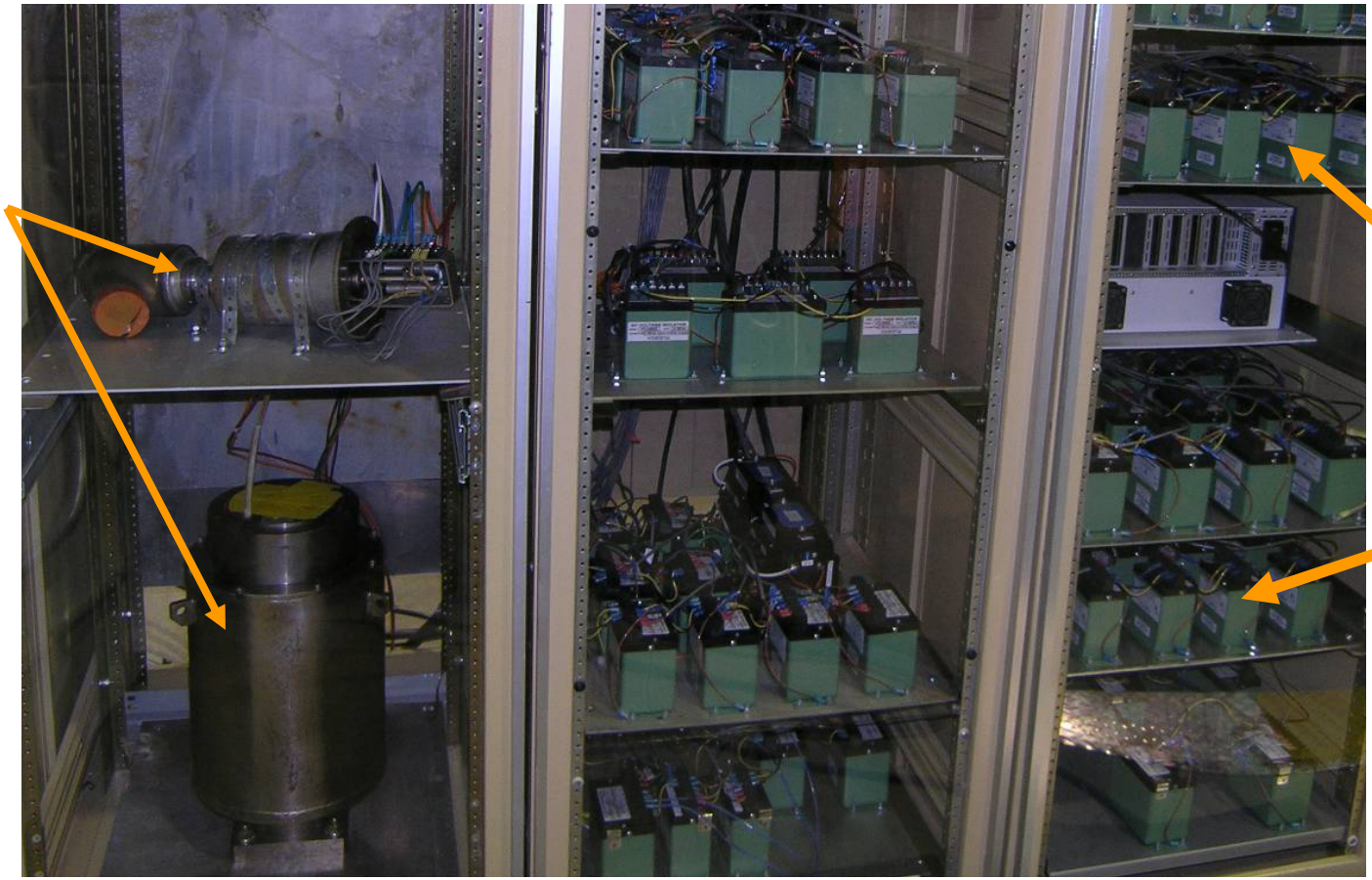
- Small-scale radiant exposure
- Intermediate-scale live fire tests

Numerous dc circuits evaluated

- DC motor starter (MOV)
- Small pilot DC SOV (ASCO red-hat)
- 15 kV circuit breaker (complete breaker assembly)
- 1” SOV
- Large coil (similar to PORV)
- Instrumentation loop

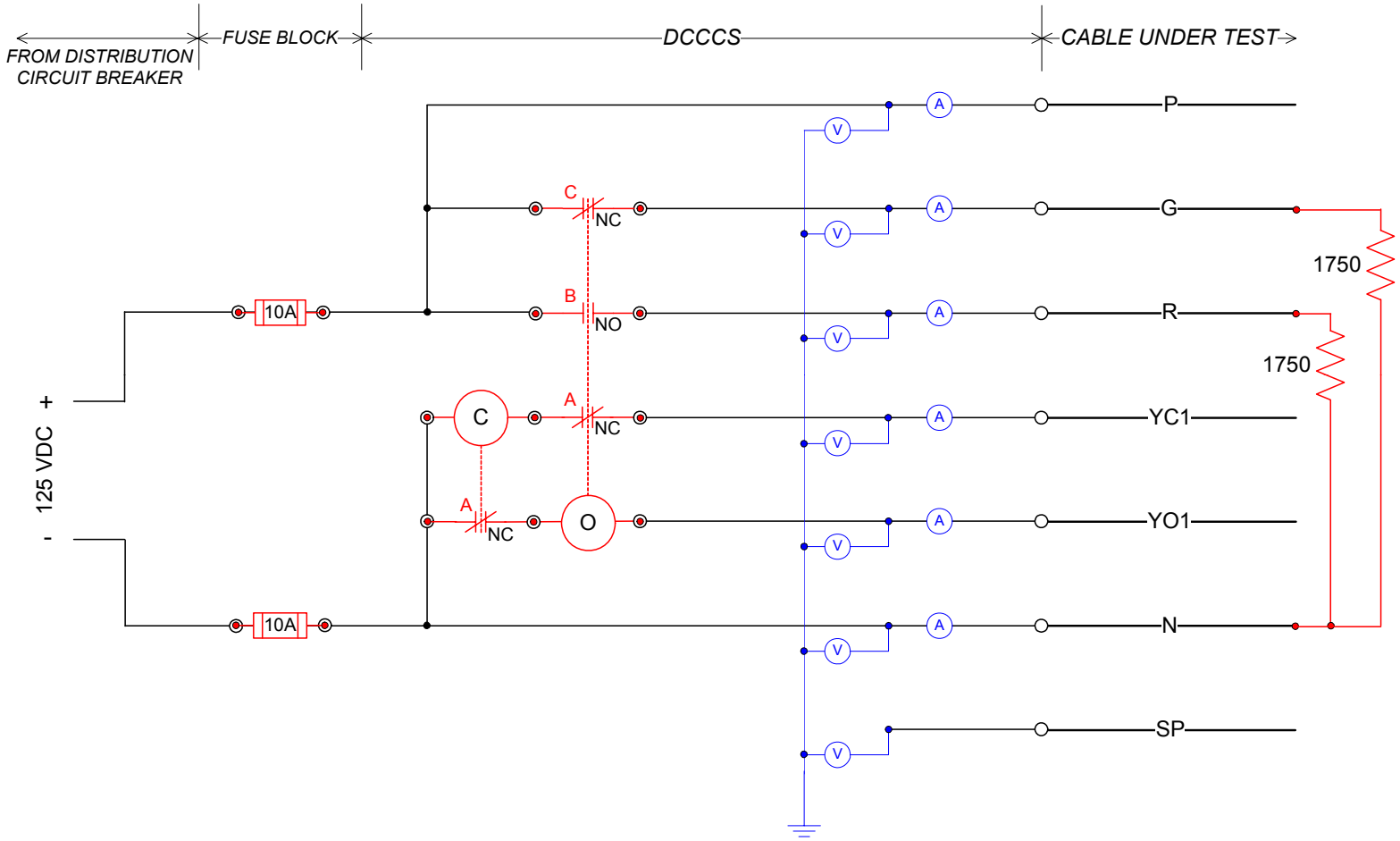
Approach & Scope

1” & Large Coil



Voltage & Current Transducers

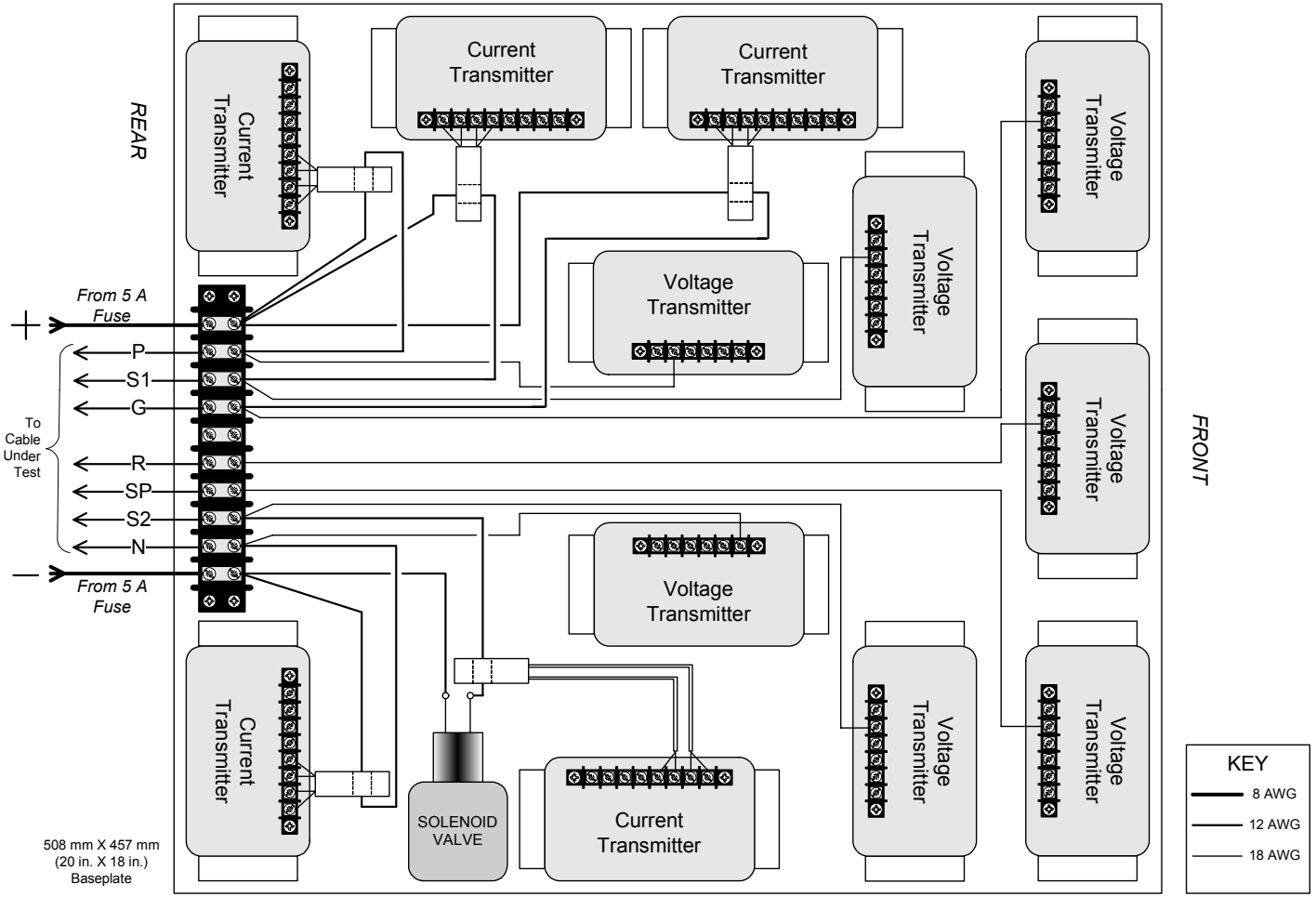
Test Circuit and Data Collection



DCCCS Layout for DC MOV Control Circuit

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Test Circuit and Data Collection



DCCCS COMPONENT LAYOUT FOR SMALL DC SOV CIRCUIT

Key Test Objectives

Characterize DC

- Realistic circuits and configuration
- Inter-cable shorting
- Interactions with ground plane
- Multiple proper-polarity, coincident hot shorting
- Ground detection circuit

Follow up testing

- Role of CPTs
- Kerite cable characteristics
- Instrument circuits

Objectives – Analysis of Data

What is Success?

- Adequate DC data and quality to support analysis
- Resolve CPR issue
- Resolve Kerite cable issue
- Better answer for inter-cable hot shorts of thermoset cable
- Definitive position/likelihood for multiple, proper-polarity

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Preliminary Results

Harry Barrett

Senior Fire Protection Engineer

NRC/NRR

Office of Nuclear Regulatory Research

Fire Research Branch

Preliminary Results

- Open Circuits

Preliminary Results (2)

- Arcing & Cable Ignition
  - Electrical failure appears to be more energetic than in AC testing
  - In most cases arcing appears to act as the pilot for cable ignition
  - Electrical arcing also appears to cause adjacent cables to ignite in some tests

Preliminary Results (3)

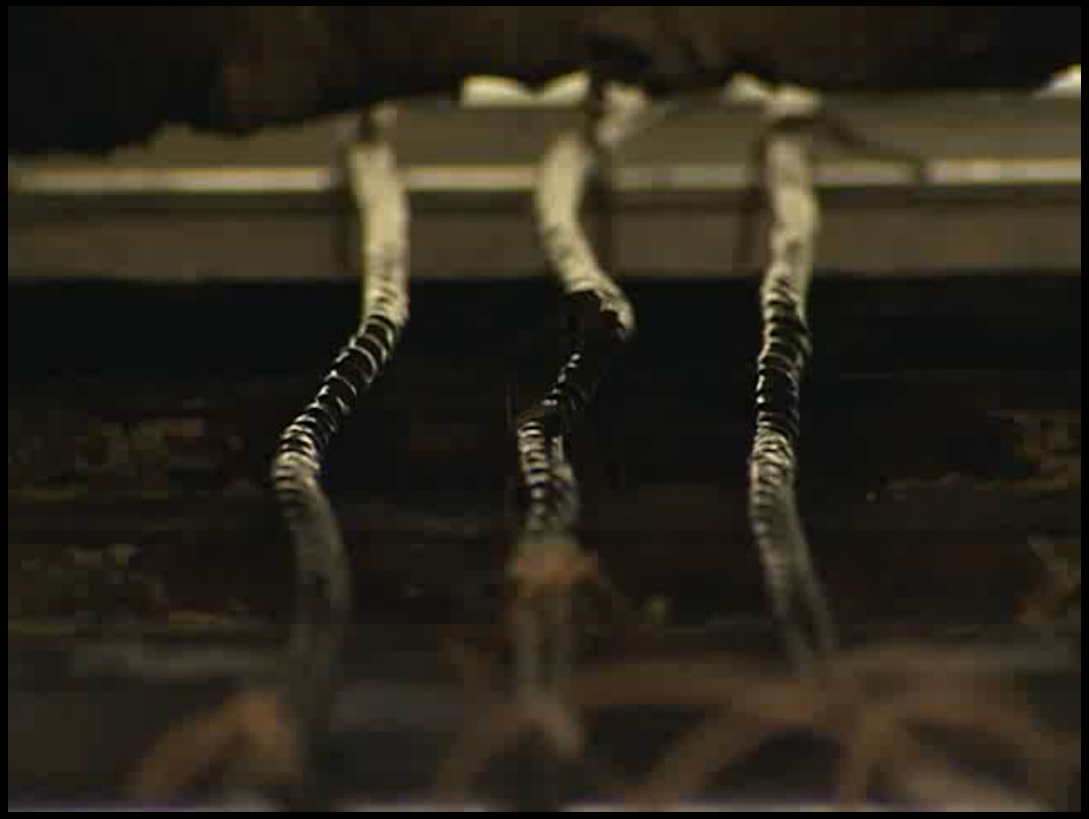
- Fuse sizing
  - Initial observations indicate that larger fuses (15-35A) take longer to clear then small 5-10A fuses
  - In some tests the 35A fuses did not clear, instead electrical arching caused an open circuit in cable conductors

15kV Circuit Breaker Test #29

Tefzel 7/c

12AWG

Breaker Actuation



Preliminary Results (4)

- Grounding
  - DC battery bank is ungrounded
  - In at least one test, a fuse cleared on one test circuit with a subsequent spurious actuation
    - This could be possible by having the cable tray act as a conduction path between the energized and de-energized cables.
    - Analysis will be required to determine the root cause of this particular spurious actuation

Test Report

- NUREG/CR similar to CAROLFIRE report will contain test results, including all data files
- Report will not provide failure probabilities, but will proved summary tables

Follow-on Work

- Expert Elicitation and Phenomena Identification and Ranking Table (PIRT)
- PIRT will rank the importance of various aspects related to fire-induced cable damage

Objectives – Analysis of Data

- Expert Elicitation will re-evaluate original spurious op probabilities (EPRI Report 1006961)
- Incorporate DC results
  - Spend time to Re-evaluate DC motor starter (MOV)
  - Small pilot DC SOV (ASCO red-hat)
  - 15 kV circuit breaker (complete breaker assembly)
  - 1” SOV
  - Large coil (similar to PORV)
  - Instrumentation loop

Questions