

IEEE 592

Standard for Exposed Semiconductive Shields

IEEE Insulated Conductors Committee

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Subcommittee B, Cable Accessories

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**Georgia
Tech**



NEETRAC

National Electric Energy Testing, Research
and Applications Center



History of IEEE 592

- **First Edition, 1977**
IEEE Standard for Exposed Semiconductive Shields on Premolded High Voltage Cable Joints and Separable Insulated Connectors
 - N. Piccione, Chair; 10 Working Group Members
- **1st Revision, 1990**
IEEE Standard for Exposed Semiconductive Shields on High Voltage Cable Joints and Separable Insulated Connectors
 - G. P. Rampley, Chair; 16 Working Group Members
 - Dropped “Premolded”
- **2nd Revision, 2007**
IEEE Standard for Exposed Semiconducting Shields on High Voltage Cable Joints and Separable Connectors
 - Michael W. Malia, Chair; 16 Working Group Members
 - Dropped “Insulated” from Separable Connector



Purpose of Semiconductive Shield

- Protect the insulation
- Provide voltage stress relief
- Maintain the accessory surface at or near ground potential under normal operating conditions
- Initiate fault-current arcing if the accessory should fail

“This standard sets forth tests and requirements to demonstrate that the shield will perform these duties.”



What's Included?

- Maximum Shield Resistance
 - Assure that the accessory provides stress relief
 - Assure shield surface is maintained at or near ground potential
- Shield Fault Initiation Test
 - Assure initiation of fault current arcs to ground that will cause overcurrent protective devices to operate

Limitations:

- Full circuit voltage is applied during the test
- Doesn't attempt to simulate all service conditions nor field assembly



Performance Requirements

Shield Resistance

- Measured from cable entrance to furthest extremity
- ≤ 5000 ohms

Fault Current Initiation

- Capable of initiating two consecutive fault current arcs to ground
- 10kA, 10 cycles minimum
- Initiation within 3 seconds of voltage application

Number of Samples

- Minimum of 2 samples per test



Shield Resistance Test

- Use voltmeter-ammeter method, either ac or dc power supply allowed

Current Connections:

- Separable Connector—cable entrance to furthest shield extremity, circumferential connections
- Joint – cable entrance to physical center of the shield, circumferential connections
- Apply current of $1.0 \text{ mA} \pm 0.2 \text{ mA}$, measure voltage



Shield Resistance Test

- Measure shield resistance under two sets of conditions

Specimen Aging Condition

- Unaged specimen
- Specimen aged in air oven for 504 hours at 121 ± 5 °C

Specimen Temperature Condition

- Test specimen at 20 ± 5 °C
- Test specimen at 90 ± 5 °C



Fault Current Initiation Test

- Assemble per manufacturer's instructions
 - Exception: metallic cable shield extended over the accessory shield
- Fault rod of erosion resistant metal (copper tungsten) 3/8-inch diameter, threaded into accessory connector, flush with outer shield surface of accessory
- Mount accessories in typical field position
 - Elbow – vertical, rod close to shield extremity
 - Joint – horizontal, rod at center of connector

Fault Current Initiation Test

- Voltage source applied between specimen neutral ground and cable conductor
- Applied voltage

Separable Connector	Joint	Test
Voltage Rating Phase-to-Ground*	Voltage Rating Phase-to-Ground[^]	Applied Voltage Phase-to-Ground
(kV rms), Fig. 1	(kV rms), Fig. 2	(kV rms)
8.3	8.7	7.0
15.2	14.4	11.7
21.1	19.4	12.2

* For separable connector voltage ratings, see IEEE 386

[^] For joint voltage ratings, see IEEE 404

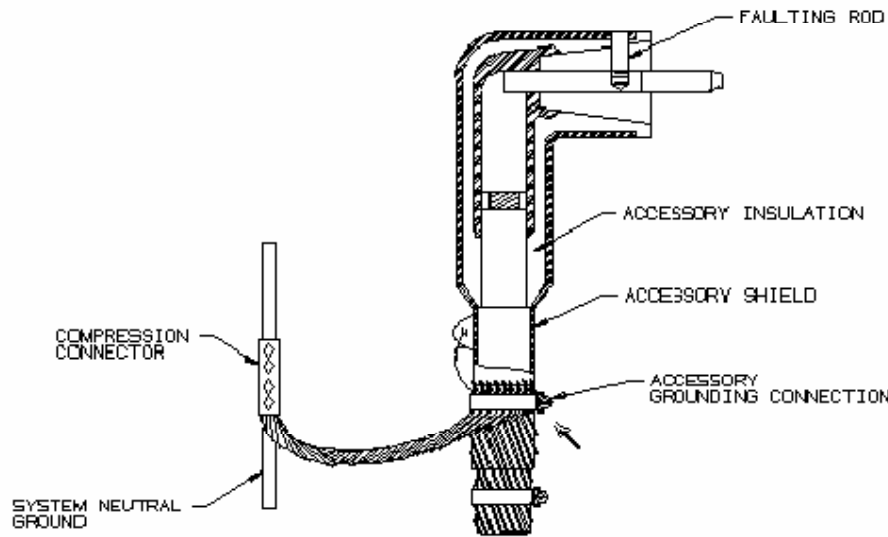
Lower test voltage may be used provided fault is initiated and sustained for minimum required cycles.



Fault Current Initiation Test

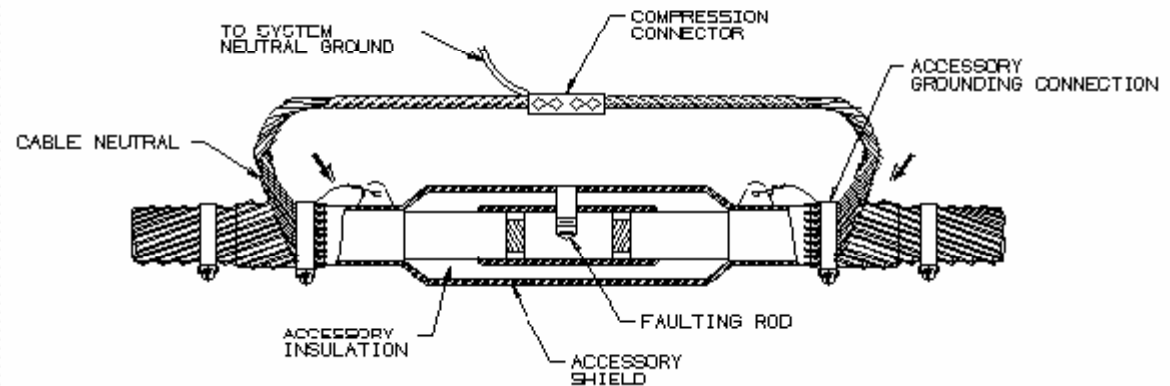
- Available short circuit current of 10kA
(Note: No specification on tolerance, IEEE 4 assumed)
- Two applications of fault current
- Minimum current flow duration of 10 cycles
- Fault initiation must occur within 3 seconds
- Initiate second fault current application in the “shortest practical time”
- Do not disturb samples between fault applications

Fault Current Initiation Test



- Separable Connector

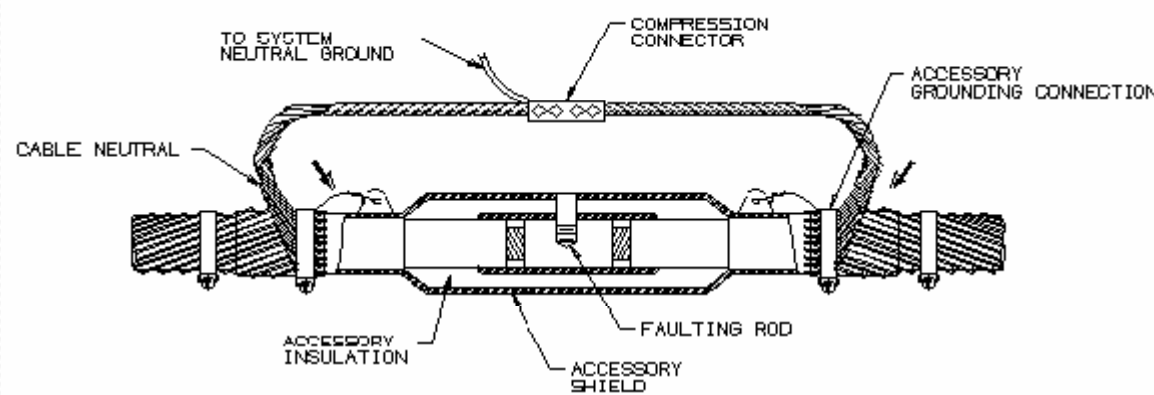
- Joint



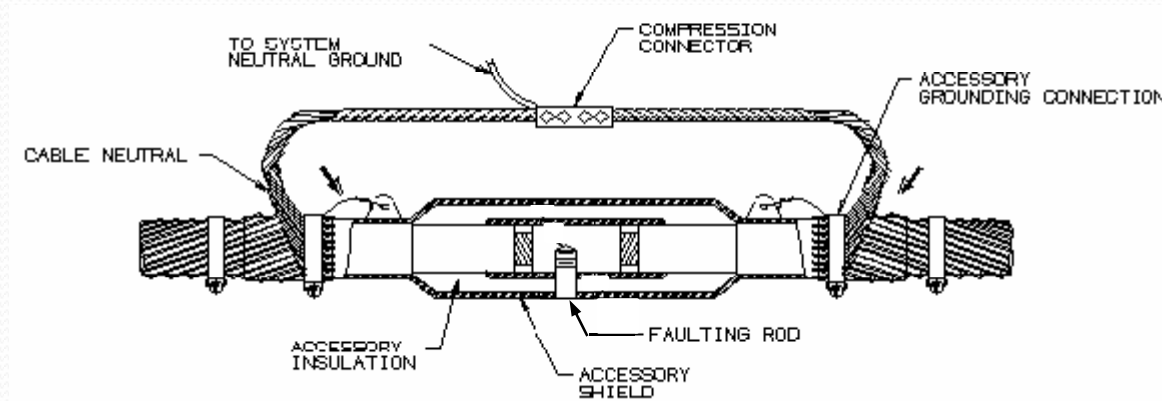
Error in Drawing

Fault Rod is in wrong position!

Place Rod at GREATEST Distance from NEAREST Ground



1990 and 2007 Versions



Original 1977 Version



Why the current interest?

- Field installation practices have changed
- The IEEE 592 standard was written many years ago when semiconductive shields were exposed and not covered
- Most cables are now jacketed, which means that jackets are now applied over joints and portions of terminations
- The effect of a jacket on the performance of semiconductive shielding systems has never been evaluated, although most installations now use jacketed constructions

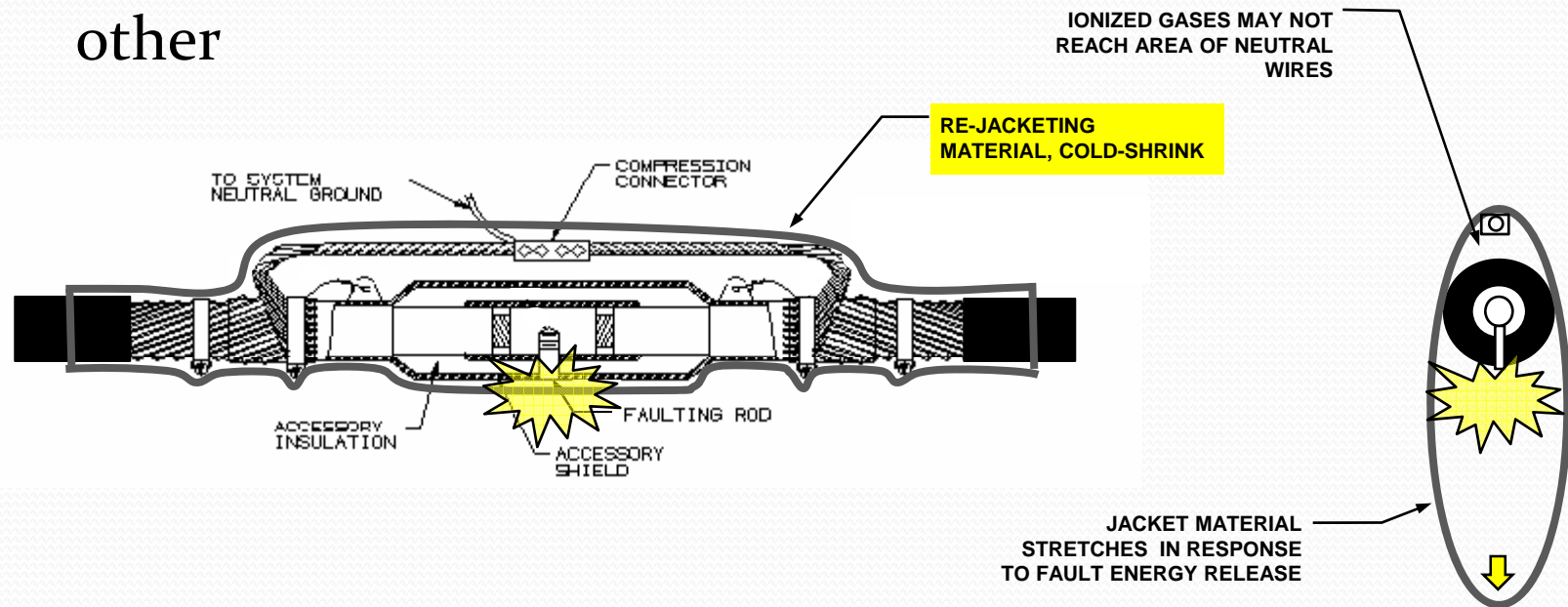


Why the current interest?

- Coverings may affect the distribution of the ionized plasma generated during a fault
- This could impact the ability of the shielding system to conduct and maintain the fault for sufficient time to clear
- Different types of coverings may give different response

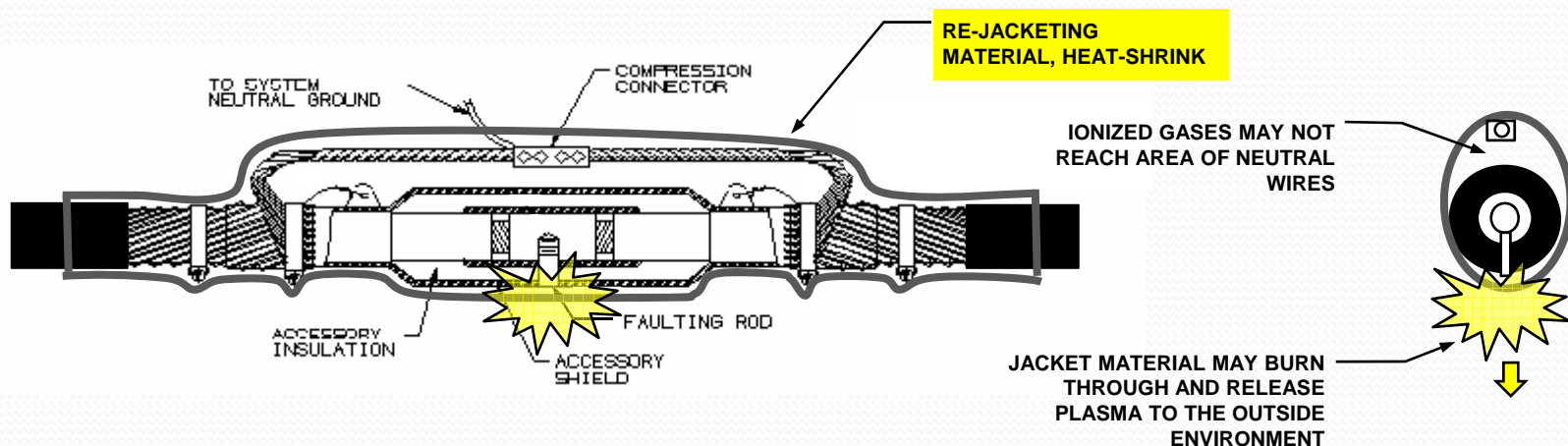
How might a jacketed joint respond differently during a fault?

- Cold shrink coverings
 - Flexible - expands on one side, pulled in and seals on the other



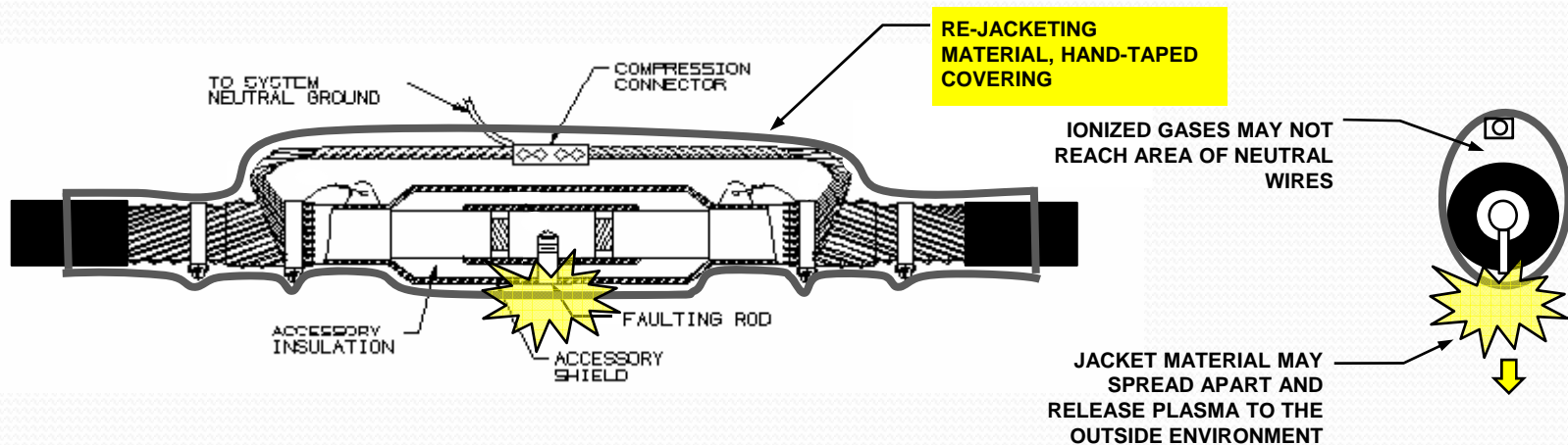
How might a jacketed joint respond differently during a fault?

- Heat shrink coverings
 - Less flexible, more rigid, allows plasma to encompass component or may burn through at the failure site

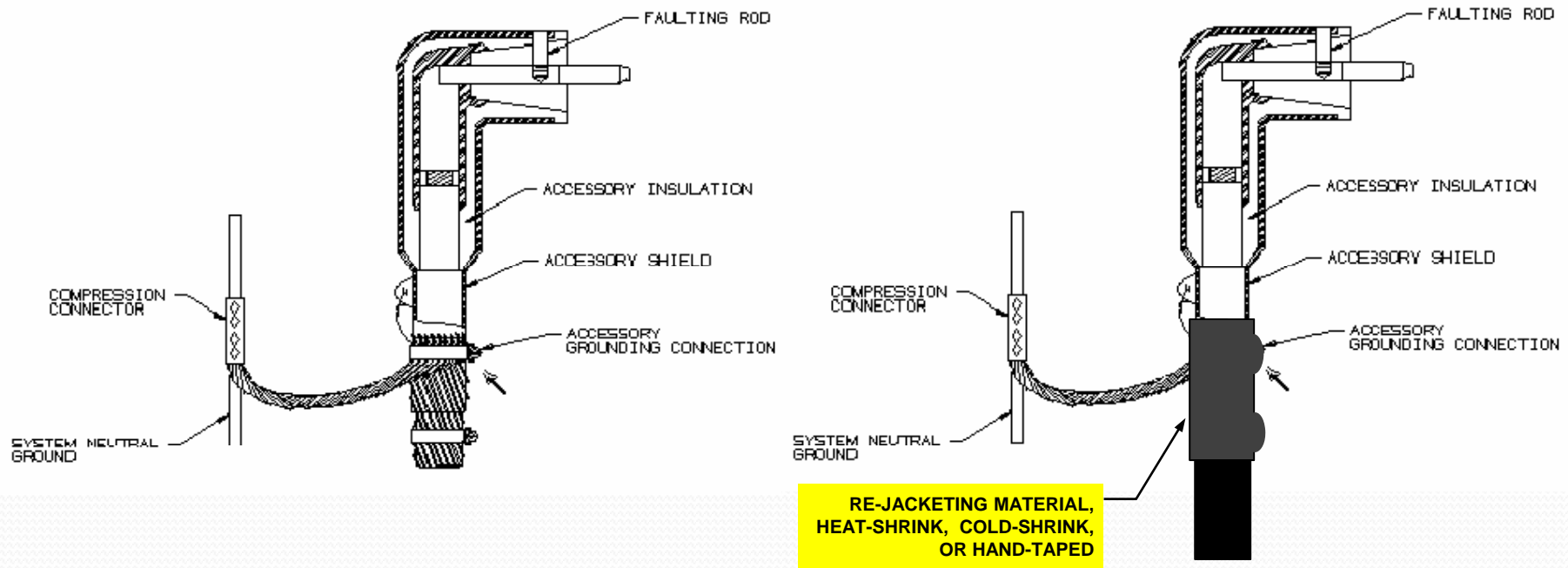


How might a jacketed joint respond differently during a fault?

- Hand-taped coverings
 - Tapes spread apart, channeling plasma away from shield



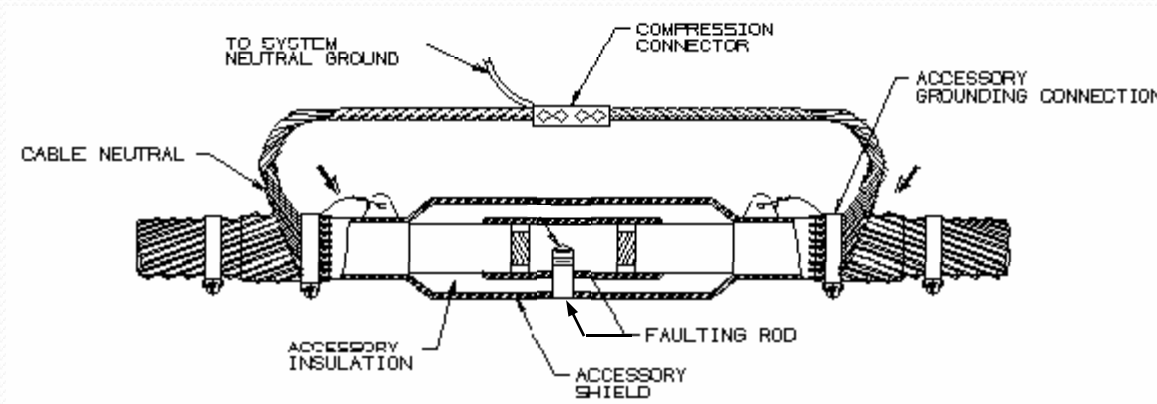
Test Configuration for Separable Connectors



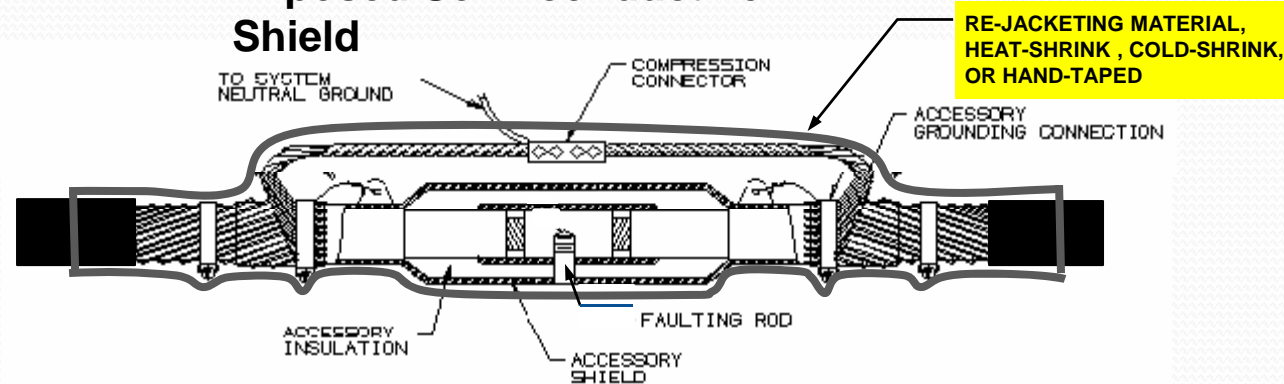
Exposed Semi-conductive Shield

Jacket Material Installed Over Semi-conductive Shield

Test Configuration for Joints



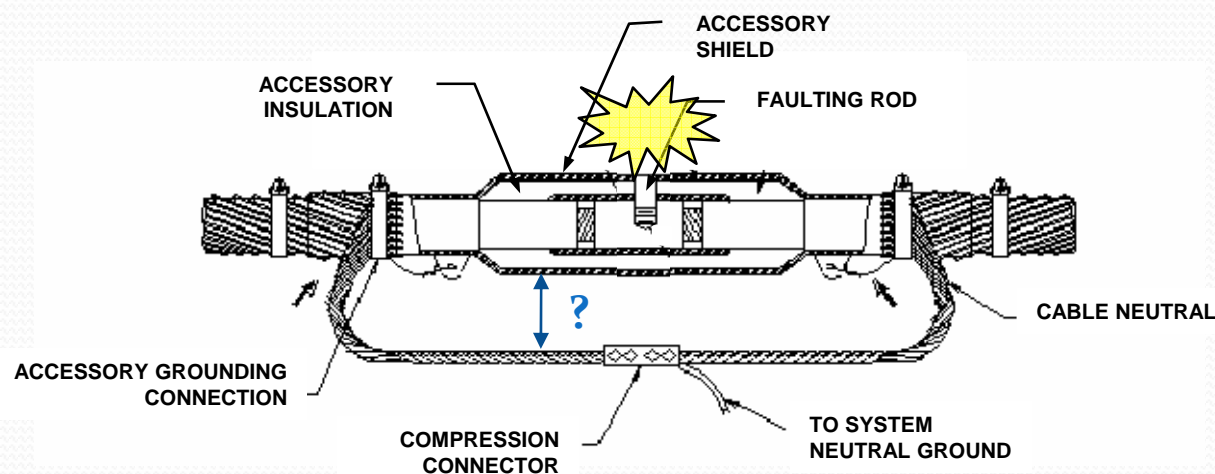
Exposed Semi-conductive Shield



Jacket Material Installed Over Semi-conductive Shield

Test Configuration for Joints

- Two possible issues with joint testing configuration
 - How far above (or below) the joint body should the neutral wires be placed? Should other configurations be considered, such as spreading wires around the joint?
 - Is the orientation top to bottom optimal? Should the fault rod be on the top side and the neutrals on the bottom? (Hot gases wouldn't rise up into the neutral)





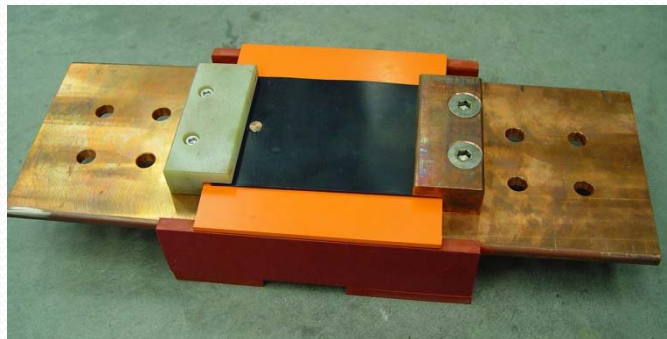
What's Needed or Missing?

No mention of what should go in the test report

- Time between fault applications is “shortest practical time.” Why not record this time in the test report?
- Resistance values are recorded when samples are within a given temperature range. Why not report the actual temperature at the time of test?
- Minimum current flow duration of 10 cycles during fault-current test. Record the actual number of cycles.

What's Needed or Missing?

- Developmental Tests for use in developing new materials?
- Why wait to test on full scale products?
- Why not test on sample sheets of material?
 - Platens
 - How could this test be performed?
 - Do the test values scale?





Where Do We Go From Here?

- IEEE 592-201?
IEEE Standard for ~~Exposed~~ Semiconductive Shields on High-Voltage Cable Joints and Separable Insulated Connectors
- IEEE 592-201?
IEEE Standard Fault Duty Requirements for Semiconductive Shielding of High-Voltage Electrical Components

Does this Apply to Other Electrical Equipment?



Polymer Insulated Vacuum Recloser

- Painted semiconductive shield over vacuum bottle casting
- Shield fails to carry sufficient fault current
- Circuit protective devices did not operate
- Multiple failures

An Example—Vacuum Recloser



- Dielectric puncture occurring at embedded metallic screen
- Current transfers to painted shield
- Shield impedance limits fault current
- Polymer insulation chars along path to nearest metallic ground

Consequences of Failure to Clear Fault



- Severe electrical noise
- Flicker
- Molten and flaming components dropping to ground
- Pole fire
- Ground fire
- Damage to equipment beyond initial failure
- Service interruption

Consequences of Failure to Clear Fault



- Safety hazard to personnel
- Damage may not be externally visible
- Voltage present within a normally grounded area



Problems and Solutions

Problem

- Change in scope would broaden coverage of standard to areas outside the jurisdiction of ICC

Solution

- Joint Working Group with T&D



Are There Other Examples?

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Other Problems and Solutions?

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