SMD Operations Procedures Manual

8.1.1.7 TEST OF SAFETY INTERLOCKS OF THE SHORT SAMPLE TEST FACILITY, TWIN 15 kA POWER SUPPLIES

Text Pages 1 through 10
Attachments 1, 2

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Revision No. 02 Approved:

Signature on File 8/25/2005
Division Head Date

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8.1.1.7 Test of Safety Interlocks of Short Sample Test Facility, Twin 15 kA Power Supplies

1.0 Purpose and Scope

1.1 The purpose of this Procedure is to provide step by step instruction in testing the Kirk Locks, electrical door interlocks, "crash" push buttons, DC overcurrent protection circuits, and warning lights associated with the twin 15kA power supplies.

2.0 Responsibilities

2.1 The Cognizant Engineer (CE) for the power supplies, or the Electrical Systems Section Head, shall:

2.1.1 Designate those persons authorized to perform the procedure.

2.1.2 Establish and maintain a list of authorized persons.

2.1.3 Appoint a Cognizant Technician for the Interlock Test database.

2.1.4 Review the completed "Interlock Test CheckList" (Attachment 1) and sign the "Interlock Test Approval Form" (Attachment 2).

2.2 The Cognizant Technician shall:

2.2.1 Initiate the procedure, when required.

2.2.2 Establish and maintain a paper database for the interlock test.

2.2.3 Arrange for the "Interlock Test Approval Form" to be posted at the appropriate locations.

2.3 Persons performing the procedure shall:

2.3.1 Complete the "Interlock Test Check List."

3.0 Prerequisites

3.1 Authorized Operator shall have the following qualifications and training:

3.1.1 Be instructed by the Cognizant Engineer for the power supplies;

3.1.2 Be trained as a "Authorized Employee", as defined by ESH Standard 1.5.1, "Lockout/Tagout Requirements".

3.1.3 Operator must be trained in NFPA 70E Personal Protective Equipment Requirements and Arc Flash Hazards.

3.1.4 Operator LOTO OJT Training on Power Supply System must be current.

3.1.5 Operator must follow SMD-OPM 8.1.1.44 Generic LOTO Procedure.

4.0 Precautions

4.1 The procedure requires that the Kirk Lock system be bypassed, or "defeated", during some tests. The Kirk Lock system shall be restored to full working order after the procedure is completed.

4.2 All doors that were unlocked for the purpose of testing the interlocks shall be locked when the procedure is completed.

5.0 Procedure

5.1 The procedure shall be performed half-yearly.

5.2 As each step is completed, check the appropriate boxes on the Interlock Test Check List (Attachment 1).

5.3 If a failure occurs, stop work, write "fail", and immediately notify the Cognizant Engineer.

5.4 Kirk Key Lock Mechanical System Test

OVERVIEW

Note: ***The safety Kirk lock system of the Short Sample Test Facility was designed to accommodate multitasking within the various stages of setup and testing of Superconducting magnet cable. Below is explanation of each integrated part.***

Within each test dewar their are three set of safety enclosures that protect the power leads used to energize superconducting test cable and a magnet coil. Each positive and negative power lead and magnet coil has an independent cover with the following designation. S4+, S4-, M4, S5+, S5-, M5, S6+, S6-, M6.

Each dewar test cage entry door has a Kirk lock installed on them designated as G4, G5, and G6. Dewar cage entry doors G4 and G5 have two doors that share the same Kirk key.

In the Short Sample control room there is three banks of four Kirk key locks. These are designated as the <u>Magnet Cover Safety Kirk key Interlock Logic Panel.</u> Next to that panel is four banks of five Kirk Key locks. This is called the <u>Power Supply Safety Kirk Key Interlock Logic Panel.</u>

On each power supply main disconnect switch is a Kirk Key lock labeled PS, PSS, PM and PSM. Kirk Keys PS and PM are the final results after all the correct Kirk Key logic has been satisfied in the Short Sample control room. Then each main power switch can be activated to each Short Sample power supply to conduct cable testing. The PSS and PSM Kirk keys are used to gain entry to the power supply doors for periodic maintenance. These Kirk keys in conjunction with the PS and PM Kirk key can gain entry to the Short Sample Link Box.

<u>SEQUENCE OF OPERATION OF THE KIRK KEY SAFETY INTERLOCK SYSTEM</u>

To perform a superconducting cable test, the Short Sample control room operator must insure that all safety covers on both test dewars that are <u>not</u> in use be secured and have Kirk key inserted in the proper designated Kirk locks (Magnet Cover Safety Kirk Key Interlock Logic Panel). Once this condition is satisfied, the Magnet Supply key (MS#) can be removed and inserted into the "Power Supply Safety Kirk Key Interlock Logic Panel" along with the gate key from the dewar facility be used for the cable test.

When all these conditions have been satisfied in the "Power Supply Safety Kirk Key Interlock Logic Panel," both the Power Supply Short Sample Key (PS#) and Power Supply Magnet (PM#) can be removed. These Kirk Keys can now be inserted into their respective Kirk locks to activate the main power supply to conduct superconducting cable testing.

NOTE: OPM 8.1.1.39, Test of Safety Interlocks for the Short Sample Test Facility, Magnet Power Supply should be done concurrently with this interlock test.

5.4.1 The Kirk Locks are tested as follows:

5.4.1.1 Unlock all dewar power and magnet leads safety covers (S+,S-,M) and verify that the Kirk Keys can not be removed.

5.4.1.2 Unlock dewar gates and verify that the Kirk key can not be removed.

5.4.1.3 In the "Magnet Cover Safety Kirk Key Interlock Logic Panel" in the Short Sample Control Room, verify that these (MS#) keys can not be removed from the locks without the logic condition be satisfied.

5.4.1.4 In the "Power Supply Safety Kirk Key Interlock Logic Panel" in the Short Sample Control Room, verify that these PS# and PM# keys can not be removed from the locks without the logic condition be satisfied.

5.4.1.5 Lock all dewar gates and remove Kirk lock keys G4, G5, and G6.

5.4.1.6 In the twin 15 kA Link Box, place the twin 15 kA supplies into a shorted condition.

5.4.1.7 Insert the dewar gate Kirk keys into the bypass Kirk Locks in the "Power Supply Safety Kirk Key Interlock Logic Panel." When this condition is satisfied, remove the PS and PM Kirk Keys.

5.4.1.8 Use the PS Kirk key to open the Main Lock at the Disconnect Switch and energize the Main Disconnect Switches.

5.4.1.9 Attempt to turn the key to remove it. Attempt to remove the key by re-closing the door. Verify that this cannot be done.

5.4.1.10 Attempt procedure 5.7.1.8 with the PSS Kirk Key.

5.4.1.11 De-energize the Main Disconnect Switches, re-close the door and remove the key.

5.4.1.12 Use the Kirk keys PS and PSS to open the doors of the Transformer Link Box and attempt to remove the key while the door is still open. Verify that this cannot be done. Re-close the door, remove the keys and verify that the door cannot be opened.

5.5 Door Interlocks

PS1 and PS2 of the Short Sample Power Supply System have electrical Door Interlocks on each of the four doors of the Main P.S. Enclosure and one on each Control Cabinet door. There is also one on the Short Sample Link Box.

In addition, there are captive Kirk key locks on the Short Sample Link Box, the Control Cabinet doors and one of the Main Enclosure doors at the 480Vac input which make it impossible to enter those doors with power ON without defeating the captive lock.

5.5.1 The electrical Door Interlocks on those doors with Kirk key locks can be checked as follows:

5.5.1.1 With input power OFF, defeat the captive key lock permitting access with power ON.

5.5.1.2 Leave the door open enough to activate the Interlock switch.

5.5.1.3 Energize the control circuits and RESET the faults.

5.5.1.4 Verify that there is a DOOR interlock fault.

5.5.1.5 De-energize the control circuits and lock the door.

5.5.1.6 Energize the control circuits and verify that a READY state can be obtained.

5.5.1.7 Repeat the process for each of the doors equipped with Kirk key locks.

5.5.2 The electrical Door Interlocks on doors without Kirk key locks can be checked as follows:

5.5.2.1 With input power OFF, unlock and open the door enough to activate the Interlock switch.

5.5.2.2 Energize the control circuits and RESET the faults.

5.5.2.3 Verify that there is a DOOR interlock fault.

5.5.2.4 Close and lock the door and verify that the fault indication remains until the fault is RESET and that the P.S. is then READY.

5.5.2.5 Repeat the process for each of the doors without Kirk key locks.

5.6 DC Overcurrent

5.6.1 Personal Protective Equipment must be worn as defined in NFPA 70E for verifying LOTO, 480V is a category 2 hazard. Only when LED Meter UT-100 and AC Panel Meters monitoring each AC Phase to ground are installed on the 480V Disconnect is the Hazard Category is reduced to (–1), operator can then follow PPE requirements for the lower classification. Reference Attachment 3 – Interpretation by the Laboratory Electrical Safety Committee – June 2005.

The DC Overcurrent of each P.S. is checked as follows:

5.6.1.1 Connect a shorting bar across the P.S. output.

5.6.1.2 Enter the control cabinet of the power supply and defeat the Kirk key lock.

NOTE: ***Measure the DC voltage first from TP6 and TP1 before any adjustment are made. Record these reading so that the overcurrent trip voltage can be set to its correct setting after overcurrent testing are completed.***

5.6.1.3 Energize the control circuits and reduce the DC Overcurrent trip voltage from TP6 and TP1 of the P.S. AUX CARD from its initial value to 1.0Vdc by adjusting R33 (see Drawing No. 33E-26.01-3).

5.6.1.4 Before turning on the DC, make sure the manual/DAC switch is set to manual mode and the current potentiometer is set to ZERO.

5.6.1.5 Increase the output current and monitor the DCCT output at DVM.

5.6.1.6 With TP1 and TP6 voltage set to 1 volt, the DC power supply should cause an Overcurrent at 1500 Amps.

5.6.1.6.1 Verify that DCCT voltage equals one half of set at trip for individual power supply.

5.6.1.7 Verify that the READY state can be obtained with a RESET.

5.6.1.8 Return the DC Overcurrent trip setting to its initial value.

5.6.1.9 Turn the DC ON and increase the output current while monitoring the Shunt Buffer voltage at TP6 and TP1. Increase the current to its maximum value (15kA, PS1; 15kA, PS2).

5.6.1.10 De-energize the power supply, restore the Kirk key lock on the control cabinet.

5.7 P.S. CRASH Push Buttons

5.7.1 The following test of the P.S. CRASH push buttons can be conducted only while the system is being operated remotely by the computer.

NOTE: ***While the system is being operated remotely and before any CRASH buttons tests are performed, the MANUAL/DAC switch and current potentiometer are in there proper positions.***

5.7.1.1 Energize PS1 and PS2, clear faults with a RESET and go to the DC ON state for both Supplies. Increase the output current to 100A.

5.7.1.2 Depress the CRASH push button at the SAMPLE PS Interface Panel and verify that both power supplies go to a Fault state and that PS1 CRASH and PS2 CRASH are indicated on the monitor.

5.7.1.3 Repeat steps 5.6.1.1 and 5.6.1.2 above for the CRASH push buttons on the MAGNET PS Interface Panel, the two CRASH push buttons in the P. S. room, O22A, and the CRASH push button in the Cryogenic Controls area.

5.8 <u>"PS ON" Light Box Test</u>

5.8.1 The "PS ON" Light Box on the Short Sample Link Box is tested as follows:

5.8.1.1 Energize the Short Sample Power Supply (PS1), bringing it to a READY state by means of the Computer controls. Verify that the "PS ON" light is still OFF.

5.8.1.2 Put PS1 in the ON state at minimum current. Verify that the "PS ON" light is ON.

5.8.1.3 De-energize PS1 and verify that the "PS ON" light goes out.

5.8.1.4 Repeat steps 5.8.1.1 through 5.8.1.3 for PS2, the Magnet Power Supply.

5.9 Complete, date, and sign the Interlock Test Check List.

5.10 The CE/ESSH shall review the Check List and sign an "Interlock Test Approval" form (Attachment 2), which shall be posted on the Short Sample Power Supplies, the Short Sample Link Box, and in the Short Sample Control Room.

5.11 The Cognizant Technician shall maintain a file containing:
A. One copy of the Check List;
B. One copy of the Approval Form.

6.0 Documentation

6.1 Interlock Test Check List.

6.2 Interlock Test Approval Form

7.0 References

7.1 ESH Standard 1.5.1, "Lockout/Tagout Requirements".

7.2 ESH Standard 1.5.0, “Electrical Safety”.

7.3 Drawing No. 33E-26.01-3

7.4 OPM 8.1.1.44, Generic LOTO Procedure Incorporating UPA-100 Led Meter and AC Panel Meters.

7.5 NFPA 70E.

7.6 System Specific SMD LOTO OJT Training.

8.0 Attachments

1. Interlock Test Check List, "TEST OF SAFETY INTERLOCKS"

2. Interlock Test Approval Form

3. Interpretation by the Laboratory Electrical Safety Committee (LESC).

Attachment 1

TEST OF SAFETY INTERLOCKS
TWIN 15 kA POWER SUPPLIES

ID#	DISCRIPTION	LOCATION	CHK
KL-1	Dewar Short Sample Power lead covers interlock (S+,S-)	DEWAR 4	
KL-2	Dewar Short Sample Power lead covers interlock (S+,S-)	DEWAR 5	
KL-3	Dewar Short Sample Power lead covers interlock (S+,S-)	DEWAR 6	
KL-4	Kirk lock in SSCR interlock cover master key (M4)	SSCR	
KL-5	Kirk lock in SSCR interlock cover master key (M5)	SSCR	
KL-6	Kirk lock in SSCR interlock cover master key (M6)	SSCR	
KL-7	Kirk lock gate key (G4)	DEWAR 4	
KL-8	Kirk lock gate key (G5)	DEWAR 5	
KL-9	Kirk lock gate key (G6)	DEWAR 6	
KL-10	Kirk lock in SSCR interlock power supply master key (PS)	SSCR	
KL-11	Kirk lock in SSCR interlock power supply master key (PS)	SSCR	
KL-12	Kirk lock in SSCR interlock power supply master key (PS)	SSCR	
KL-13	Kirk lock on main disconnect switch (PS Key)	P.S. Room	
KL-14	Kirk lock on main disconnect switch (PSS Key)	P.S. Room	
KL-15	Kirk lock on PS1 XFMR1 link box	P.S. Room	
KL-16	Kirk lock on PS1 control cabinet door	P.S. Room	
KL-17	Kirk lock on PS2 XFMR2 link box	P.S. Room	
KL-18	Kirk lock on PS2 control cabinet door	P.S. Room	
KL-19	Kirk lock on PS2 door	P.S. Room	
KL-20	Kirk lock on Short Sample P.S. link box	DEWAR AREA	
UT-100	Verify LED Meter UT-100 goes to zero		
DIL-1	Interlock on PS1 control cabinet door	P.S. Room	
DIL-2	Interlock on PS1 door	P.S. Room	
DIL-3	Interlock on PS1 door	P.S. Room	
DIL-4	Interlock on PS1 door	P.S. Room	
DIL-5	Interlock on PS1 door	P.S. Room	
DIL-6	Interlock on PS2 control cabinet door	P.S. Room	
DIL-7	Interlock on PS2 door	P.S. Room	
DIL-8	Interlock on PS2 door	P.S. Room	
DIL-9	Interlock on PS2 door	P.S. Room	
DIL-10	Interlock on PS2 door	P.S. Room	
DIL-11	Interlock on Short Sample P.S. link box	DEWAR AREA	
DCO-1	DC overcurrent interlock – PS1 Initial ___________	P.S. Room	
DCO-2	DC overcurrent interlock – PS2 Initial ___________	P.S. Room	
CB-1	Crash button	P.S. Room	
CB-2	Crash button	P.S. Room	
CB-3	Crash button	SSCR	
CB-4	Crash button	SSCR	
CB-5	Crash button	CRYO AREA	
WL-1	Flashing warning light	DEWAR AREA	

Date of Test__________________ Tested by ____________________ Life #_________

____________________ Life #_________

Cognizant Engineer ____________________ Life # _________

Attachment 2

Safety Interlock Test Approval

The safety interlocks of the Short Sample Power Supply System have been tested and approved

Approval Date_____________

The approval is valid until the expiration date shown. DO NOT OPERATE THE SHORT SAMPLE POWER SUPPLIES AFTER THE EXPIRATION DATE.

Expiration Date____________

Approval Signature (CE or ESSH) ____

Post on PS1 Control Cabinet

Safety Interlock Test Approval

The safety interlocks of the Short Sample Power Supply System have been tested and approved

Approval Date_____________

The approval is valid until the expiration date shown. DO NOT OPERATE THE SHORT SAMPLE POWER SUPPLIES AFTER THE EXPIRATION DATE.

Expiration Date____________

Approval Signature (CE or ESSH) ____

Post on PS2 Control Cabinet

Safety Interlock Test Approval

The safety interlocks of the Short Sample Power Supply System have been tested and approved

Approval Date_____________

The approval is valid until the expiration date shown. DO NOT OPERATE THE SHORT SAMPLE POWER SUPPLIES AFTER THE EXPIRATION DATE.

Expiration Date____________

Approval Signature (CE or ESSH) ____

Post on Short Sample Link Box

Safety Interlock Test Approval

The safety interlocks of the Short Sample Power Supply System have been tested and approved

Approval Date_____________

The approval is valid until the expiration date shown. DO NOT OPERATE THE SHORT SAMPLE POWER SUPPLIES AFTER THE EXPIRATION DATE.

Expiration Date____________

Approval Signature (CE or ESSH) ____

Post on SSCR Control Panel

Safety Interlock Test Approval

The safety interlocks of the Short Sample Power Supply System have been tested and approved

Approval Date_____________

The approval is valid until the expiration date shown. DO NOT OPERATE THE SHORT SAMPLE POWER SUPPLIES AFTER THE EXPIRATION DATE.

Expiration Date____________

Approval Signature (CE or ESSH) ____

File Copy

Attachment 3

Interpretation by the Laboratory Electrical Safety Committee – June 2005

Engineered Voltage Monitoring Solutions for Lockout/Tagout

Properly engineered and installed voltage monitoring can simplify operations by providing a method of implementing lockout/tagout without requiring the use of personal protective equipment.

When used according to approved procedures, the systems described in this document can establish that system voltage has been reduced to levels where subsequent zero-voltage tests may be made using a hand-held meter and wearing safety glasses, and without additional personal protective equipment. In some engineered configurations, the installed devices will serve to indicate zero voltage without the need for further tests.

The Importance of Procedure and Timeliness

Zero-voltage verification during electrical lockout/tagout follows an A-B-A sequence. A hand held meter is tested on a known voltage source, the equipment voltage is measured to confirm a zero-voltage state, and the meter is tested once again on a known voltage source.

Timely performance of this sequence is required, with the A-B-A steps performed within minutes of one another. It is not sufficient to believe that the meter worked in the past, to measure the equipment, and to start work on the equipment intending to verify meter operation at a later time. The principle of timeliness is vital in considering alternative methods of assuring a zero-voltage state.

If a technician arrived at equipment with front panel voltage-indicating devices and observed the devices indicating zero voltage, it would not be clear if power were truly removed or if the measuring devices were simply defective. On the other hand, if the devices indicated the equipment was being powered, and when power was removed the devices responded in a timely manner to indicate zero voltage, then the device indication can be trusted to show the true condition of the equipment. In an operational situation, if a technician called to fix a piece of equipment arrived to find panel-mounted devices indicating voltage, and the equipment was then turned off and the devices indicated zero voltage, the technician could complete lockout/tagout while using safety glasses and without additional personal protective equipment and work could begin. If the technician arrived to find the devices already indicating zero voltage, the technician would have no way of knowing if the equipment were powered down or if the voltage-indicating devices were defective. In the latter case, direct contact measurement would have to be made to execute lockout/tagout, while wearing full appropriate PPE in accordance with the NFPA 70E tables appearing in the SBMS Personal Protective Equipment Manual.

Interpretation by the Laboratory Electrical Safety Committee – June 2005

Engineered Voltage-Monitoring Systems

1. Front Panel Meters

Front panel meters, commonly used on equipment handling large amounts of power, can be used to confirm a zero-voltage state. Meters used for this purpose should be wired so they directly monitor the source of power. Meter switches, if used, should be industrial-grade devices intended for this service, such as GE type SB switches.

2. Voltage Indicators

A UPA-100 "Universal Power Alert," a UL listed voltage indicator, is available from STC (Automatic Timing and Controls, Lancaster, PA). The voltage indicator can be used in the same way as front panel meters, to assist in confirming a zero-voltage state. The indicators may be wired to monitor ac or dc power, and LED lamps are lighted whenever the device senses voltage more than 40 volts. The single design operates to 600 volts and has four leads, one for each phase and one for connection to ground. This arrangement allows the device to be used on single phase and three phase circuits, and even on direct current circuits. A data sheet on the UPA-100 is attached to this document.

The device works reliably with grounded systems. Some facilities on a site have ungrounded power distribution systems designed to enhance operational reliability. These systems actually have high-resistance grounding due to the equipment continually monitoring for ground faults on any phase. The UPA-100 has a 470-k ohm resistor in each leg, and will operate properly on less than a tenth of a milliampere. Since the voltage indicator requires minimal current for proper operation, the high-resistance grounding is adequate for proper operation of the indicator.

As noted, the LED lamps are lighted whenever the device senses voltage more than 40 volts. While deployment of the UPA-100 does not permit voltage verification to zero volts, use of this device allows access to the equipment for further testing using a hand-held meter with no requirement for personal protective equipment since the voltage has been established through use of the device as below 50 volts.

3. Voltage Test Points

Personnel protective equipment (PPE.), including voltage-rated gloves and leather glove protectors, must be used when measurements are made on circuits normally energized at voltages greater than 50 volts. Aside from safety glasses, no additional PPE. is required for measurements on power-limited voltage sources less than 50 volts. If voltage step-down devices are designed into equipment normally operating more than 50 volts, and with the reduced voltages available at test points, then the zero-voltage lockout/tagout confirmation measurements can be made at the test points while using safety glasses and without using additional PPE. Preferably, the test points would be available at the equipment front panel.

A voltage step-down can be achieved using transformers. Three transformers would be required for three-phase power supply circuits.

A voltage step-down can also be achieved using resistive voltage dividers. The disadvantage of this approach is that heat would be continually released into the enclosure. Resistors chosen for this application should be wire-wound or equivalent in reliability (not metal film). They should have identical power ratings, selected as at least three times the anticipated continuous power dissipation as if the test point were connected to a solid ground. A 10:1 divider is suggested for this application, so that a 120-volt source would present 12 volts to a test point.

Level of Safety

Commercially off-the-shelf (COTS) components are used to assemble electrical equipment. These COTS components have all been examined by a Nationally-Recognized Testing Laboratory (NRTL) and are labeled or listed. Finally, when the COTS components are assembled into their final configuration, all systems must be reviewed and accepted by a representative of the Authority Having Jurisdiction (AHJ). It is by use of labeled or listed components such as switches, fuses, circuit breakers, and similar devices that safety of the electrical installation is assured.

Use of engineered voltage monitoring solutions for lockout/tagout follows the same safety pathway. ATC's UPA-100 "Universal Power Alert" is a commercial off-the-shelf device listed by UL, an NRTL. When installed under engineering control, and with the installation (and associated procedures) reviewed and accepted by a representative of the Authority Having Jurisdiction, the device is equal to switches and circuit breakers and conduits in affording personnel protection.

Installation of other means of engineered voltage monitoring solutions for lockout/tagout, including installed metering and voltage test points, follows a similar pathway. The major issue with these alternate devices is that they are not labeled or listed like the UPA-100 and therefore more engineering controls and AHJ reviews are required.

The initial topic in this document discussed *The Importance of Procedure and Timeliness*. Using procedures discussed under the second topic, *Engineered Voltage-Monitoring Systems*, the techniques discussed in this document are classified as Hazard Severity Category IV. This category is shown in the table below, which has entries typical of many versions of the same material available in the military and civilian sectors. Aside from the engineered aspects of each installation and the fact that the UPA-100 is UL listed if this is the chosen device, the basic reason lies in procedures. Since verification of voltage must occur first, followed by removal of power and timely verification that voltage has been removed, the devices are, in effect, being tested each and every time they are used. Further, no periodic testing is required since they are repeatedly tested at each use. No other component of an electrical system is periodically tested, except for items like insulation tests for transformers and large motors.

Hazard Severity		
Category	Descriptive Word	Potential Consequences
I	Catastrophic	May cause death or system loss
II	Critical	May cause severe injury, severe occupational illness, or major system damage
III	Marginal	May cause minor injury, minor occupational illness, or minor system damage
IV	Negligible	Will not result in injury, occupational illness, or system damage

Routine Voltage Testing on De-Energized Equipment

It should be noted that careful technicians routinely apply meter leads to test for voltage on parts they know to be de-energized, such as equipment which has been unplugged or locked and tagged. While safety glasses are required for this and all electrical work, the technicians do not need additional PPE for this operation.