

| | | |
|---|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 1 of 15 |

CONTENTS:

- 1.0 PURPOSE
- 2.0 APPLICABILITY
- 3.0 RESPONSIBILITIES
- 4.0 DEFINITIONS
- 5.0 REFERENCES
- 6.0 GENERAL REQUIREMENTS
- 7.0 SAFE OPERATING AND MAINTENANCE PROCEDURES
- 8.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)
- 9.0 OTHER PROTECTIVE EQUIPMENT
- 10.0 TRAINING AND CERTIFICATION

SUPPLEMENT 2.721-1, STANDARD ARC FLASH AND SHOCK HAZARD WARNING SIGN

SUPPLEMENT 2.721-2, TASKS REQUIRING SPECIFIC ARC FLASH PPE & INSULATED TOOLS

SUPPLEMENT 2.721-3, ARC FLASH FLAME RESISTANT CLOTHING (FRC) SPECIFICATIONS

1.0 PURPOSE

This General Instruction (GI) provides minimum safe work requirements for protection of personnel against electrical arc flash hazards in the workplace in accordance with NFPA 70E, *Standard for Electrical Safety in the Workplace*.

2.0 APPLICABILITY

All Saudi Aramco departments shall apply this instruction to construction, commissioning, start-up, operation, maintenance, and demolition activities at electrical installations whenever there is the possibility that an electrical arc flash may occur, such as during electrical isolation, operating breakers, switches or starters, racking breakers in/out, testing electrical circuits, applying safety grounds, etc. Detailed design specifications for new electrical equipment and design of retrofits for existing electrical equipment are beyond the scope of this GI. This GI covers Saudi Aramco and contractor personnel working within Saudi Aramco (SA) facilities and project sites, as well as contractor camps and temporary facilities covered under a Saudi Aramco Land Use Permit (LUP).

3.0 RESPONSIBILITIES

Department managers, division heads, and unit heads are responsible for ensuring compliance with this GI. Contractors and workers shall comply with the safe work methods and use of protective equipment in this GI.

| | | |
|---|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 2 of 15 |

4.0 DEFINITIONS

Arc Flash – A rapid release of electrical energy due to an arcing fault between electrical phases, neutral or ground, resulting in a plasma arc through the adjacent surrounding air. An arc flash is sometimes inappropriately called a “flashover.”

Arc Flash Hazard – A dangerous condition associated with the release of energy caused by an electric arc. See Supplement 2.721-2 for examples of tasks that could pose an arc flash hazard.

Arc Flash Hazard Analysis – A study investigating a worker’s potential exposure to arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash protection boundary, and the appropriate levels of personal protective equipment (PPE).

Arc Flash Suit – A complete flame resistant clothing and equipment system that covers the entire body. This includes pants/bib, jacket, and beekeeper-type head protection hood fitted with a face shield.

Arc Rating – The value attributed to a material that describes its performance during exposure to an electrical arc discharge. The arc rating is expressed in calories per centimeter squared (cal/cm^2) and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (should a material system exhibit a breakopen response below the ATPV value).

Arc Thermal Performance Value (ATPV) – The incident energy on a fabric or material that results in a fifty percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second-degree skin burn injury. The ATPV is determined as per ASTM F1959.

Balaclava (Sock Hood) – An arc-rated, flame resistant (FR) hood that protects the neck and head except for the facial area of the eyes and nose.

Boundary, Arc Flash Protection – When an arc flash hazard exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur. The arc flash protection boundary is the distance at which the incident energy equals $1.2 \text{ calories per centimeter squared } (\text{cal}/\text{cm}^2)$.

Boundary, Limited Approach – An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

Boundary, Prohibited Approach – An approach limit at a distance from an exposed energized electrical conductor or circuit part within which work is considered the same as making contact with the electrical conductor or circuit part.

Boundary, Restricted Approach – An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased risk of shock, due to electrical arc over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit part.

| | | |
|---|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 3 of 15 |

Electrical Equipment – A general term, including switchgear, transformers, control gear (motor control centers [MCCs]), machinery, and the like used as a part of, or in connection with, an electrical installation.

Electrical Safety – The recognition of hazards associated with the use of electrical energy and the precautions to be taken so that hazards do not cause injury or death.

Energized – Electrically connected to, or is, a source of voltage.

Exposed (as applied to energized electrical conductors or circuit parts) – Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Flame-Resistant (FR), Flame Resistant Clothing (FRC) – Materials or clothing with the inherent characteristic that combustion is prevented, terminated, or inhibited following the application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source.

Hazard/Risk Category (HRC) – The minimum acceptable arc rating, as designated by NFPA 70E, for a given flame resistant (FR) fabric or other personal protective equipment (PPE). For simplicity, the Hazard/Risk Category is often referred to as merely the “Category” (e.g., Category 2). The minimum arc ratings for HRC 1 (Category 1) through HRC 4 (Category 4) are as follows:

- HRC 1 (Category 1): minimum arc rating of 4 calories per centimeter squared (cal/cm²)
- HRC 2 (Category 2): minimum arc rating of 8 calories per centimeter squared (cal/cm²)
- HRC 3 (Category 3): minimum arc rating of 25 calories per centimeter squared (cal/cm²)
- HRC 4 (Category 4): minimum arc rating of 40 calories per centimeter squared (cal/cm²).

Incident Energy – The amount of energy impressed on a surface, at certain distance from the source, generated during an electrical arc flash event. One of the units used to measure incident energy is calories per centimeter squared (cal/cm²).

Power Distribution Instruction (PDI) – Procedure developed by Power Distribution Department (PDD) that covers a specific topic related to safe electrical work.

Proponent – Organization responsible for the management of a facility.

Proponent’s Electrical Support Organization – a department that operates and/or maintains electrical equipment for a proponent (e.g., Power Distribution Department, Utilities Department).

Qualified Person – One who has the skills, knowledge, and certification related to the installation, operation, and maintenance of electrical equipment and has received safety training to recognize and avoid the hazards involved.

Switching – The operation of switches, circuit breakers, fuses, or any other method of making or breaking a circuit. Switching includes racking-in/racking-out circuit breakers and opening/closing grounding devices.

| | | |
|---|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 4 of 15 |

Voltage Testing – Test conducted to determine if voltage is present or not in a conductor or item of electrical equipment. Also called potential testing.

Working On/Work On – The possibility of coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing. There are two categories of “working on”: *Diagnostic (testing)* is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; *repair* is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.).

5.0 REFERENCES

- ASTM F 1959 Standard Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing
- ASTM F 2178 Standard Test Method for Determining the Arc Rating and Standard Specification for Face Protective Products
- GI 2.100 Work Permit System
- GI 6.001 Notification Requirements for Incidents (Including Fires)
- GI 6.003 Incident Investigation
- GI 6.004 Near Miss Reporting Process
- GI 6.005 Reporting, Investigation and Recording of Injuries/Occupational Illnesses
- GI 6.007 Reporting of Contractor On-Job Injuries/Occupational Illnesses
- GI 6.012 Isolation, Lockout and Use of Hold Tags
- GI 1809.001 Job Certification
- IEC 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements
- IEEE 1584 Guide for Performing Arc-Flash Hazard Calculations
- NFPA 70E Standard for Electrical Safety in the Workplace
- SAES-B-019 Portable, Mobile and Special Fixed Firefighting Equipment
- Saudi Aramco Safety Management System (SMS) Manual
- Saudi Aramco Safety Management Guide 05-001-2006, Management of Change (MOC)
- Saudi Aramco Safety Management Guide 06-001-2008, Flame Resistant Clothing (FRC)
- Saudi Aramco Safety Management Guide 08-001-2008, Emergency Preparedness
- Saudi Aramco Loss Prevention Department’s Emergency Management Guide

| | | |
|---|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 5 of 15 |

6.0 GENERAL REQUIREMENTS

- 6.1 In accordance with the Saudi Aramco Safety Management System (SMS) manual, exposures to arc flash hazards shall be mitigated or controlled using one or more of the following:
1. Engineering controls – Risks are avoided, eliminated, or minimized through good engineering design, such as remote switching and racking. Saudi Aramco Engineering Standards (SAESs) establish minimum standards for controlling hazards through engineering design.
 2. Administrative controls – These controls include operating and maintenance (O&M) procedures, location and proximity, training, certification, work assignments, etc.
 3. Personal protective equipment (PPE) controls – PPE controls are necessary to help prevent injury from arc flash for personnel working on or near energized electrical equipment, especially where other controls have not yet been implemented or have been implemented and found to be inadequate to completely control the risk.
- 6.2 During the design of new electrical equipment or modification of existing electrical equipment, feasible design options (including remote switching and racking) shall be chosen to eliminate or reduce arc flash hazards, enhance the effectiveness of safety-related work practices, and minimize fault current magnitude and duration.
- 6.3 For projects initiated after the issue date of this GI, the design of all new or modified electrical equipment to be operated at higher than 240 volts shall include an arc flash hazard analysis, in accordance with IEEE 1584, to determine the Arc Flash Protection Boundary, the incident energy a worker may be subject to, the Hazard/Risk Category, and the PPE to be worn.
- 6.4 Proponents and their electrical support organizations shall identify any existing 600 Volt Class electrical equipment inside substations that has a short circuit available current and/or fault clearing time greater than the maximum used as the basis for Table 2.1 of Supplement 2.721-2. These maximum short circuit available currents and fault clearing times are noted in NFPA 70E-2009, Table 130.7(C)(9). An arc flash hazard analysis is required when these values are exceeded. For such equipment, proponents are responsible for having an arc flash hazard analysis conducted in accordance with IEEE 1584. The proponent's electrical support organization and Consulting Services Department's Electrical Systems Division shall be contacted for assistance on conducting an arc flash hazard analysis, which may need to be performed by a consulting engineering firm, and any necessary equipment design/operating modifications.
- 6.5 Proponents and their electrical support organizations shall install Arc Flash and Shock Hazard Warning Signs (based on the standard layout in Supplement 2.721-1) on electrical equipment operated at higher than 240 volts. The arc flash protection portion of this sign shall be completed if arc flash analysis results are available (e.g., as per sections 6.3 and 6.4 above). The shock protection portion of this sign shall be completed for all installations.
- 6.6 Proponents and their electrical support organizations shall install Task Warning Signs, in a highly visible location, at all new and at all existing installations with electrical equipment operated at higher than 240 volts (e.g., substations and electrical rooms). These Task Warning Signs shall

| | | | |
|--|--|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL | | G.I. NUMBER Approved 2.721 | |
| | | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | | APPROVAL AFW | PAGE NUMBER 6 of 15 |

show the tasks from Table 2.1 of Supplement 2.721-2, along with the arc flash Hazard/Risk Category personal protective equipment (PPE) and insulated tools required for each task.

- 6.7 Only qualified persons shall work on electrical equipment operated at higher than 240 volts. They shall wear the proper PPE in accordance with section 8.0, be trained and certified in accordance with section 10.0, and be familiar with the specific work procedures and/or tests required. Unqualified persons shall not be permitted to enter spaces that are only allowed to be accessible to qualified persons (e.g., unqualified persons shall not be within the limited approach boundary).
- 6.8 All arc flash incidents shall be reported as per GI 6.001, GI 6.004, GI 6.005 and/or GI 6.007. Incident investigations, when required, shall be conducted in accordance with GI 6.003.
- 6.9 Proponents and their electrical support organizations shall identify credible scenarios of arc flash incidents and incorporate the corresponding prevention and mitigation measures into their emergency response plan (ERP). Refer to the Saudi Aramco Safety Management Guide 08-001-2008 and the Emergency Management Guide for guidance.

7.0 SAFE OPERATING AND MAINTENANCE PROCEDURES

- 7.1 Proponents and their electrical support organizations shall implement uniform electrical system operation procedures (including switching/isolation and clearance/outage request procedures) that are aligned with the company's uniform electrical system operation procedures.
- 7.2 Proponents and their electrical support organizations shall implement uniform preventive maintenance (PM) procedures for similar electrical equipment operated at higher than 240 volts that are aligned with the company's uniform PM procedures.
- 7.3 Proponents, electrical support organizations, contractors, and relevant third parties shall develop and implement written, clear, and consistent delineation of operation and maintenance interfacing and responsibilities.
- 7.4 In accordance with Element 6, "Safe Operations," of the Saudi Aramco Safety Management System (SMS) manual, proponents, electrical support organizations, and contractors shall perform a Job Safety Analysis (JSA) for critical tasks with an exposure to arc flash hazards.
- 7.5 It is the policy of Saudi Aramco that energized electrical equipment shall be properly de-energized, voltage tested, grounded, locked-out and tagged in accordance with GI 6.012 and local operating instructions prior to being worked on, whenever possible. [Note: the tasks listed in Table 2.1 are necessarily performed while the equipment is or could be energized.] Multi-lock-out clips shall be used when isolating electrical equipment.
- 7.6 Unless fully covered by a properly rated arc flash suit or arc rated face shield, personnel shall not wear meltable (plastic) or conductive (metal) glasses, jewelry, rings, watches, belt buckles, etc., within the limited approach boundary of energized electrical equipment.

| | | | |
|--|--|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL | | G.I. NUMBER Approved 2.721 | |
| | | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | | APPROVAL AFW | PAGE NUMBER 7 of 15 |

- 7.7 Electrical conductors shall be considered energized until proven otherwise (e.g., by voltage testing).
- 7.8 Work Permits shall be properly issued in accordance with GI 2.100. For work in substations, the work permit issuer shall verify that the fire detection/alarm system is operational and ensure that a Carbon Dioxide (CO₂), Type BC, fire extinguisher(s) is available, as per SAES-B-019.
- 7.9 Whenever feasible, remote racking and remote switching devices shall be installed and used. When racking and switching is not being performed remotely, proper personal protective equipment (PPE) as per section 8.0 shall be worn and bodily exposure to potential arc flash minimized (e.g., by standing as far away from the equipment as possible).
- 7.10 Personnel shall not work alone on electrical equipment, except when performing remote switching outside of the Arc Flash Protection Boundary. To prevent personnel from working alone when performing local switching, a fire watch with appropriate fire extinguishers (see above) shall be continuously present outside the arc flash protection boundary shown on the arc flash hazard warning sign, at least 3 meters (10 feet).
- 7.11 Proponents and electrical support organizations shall implement proper Management of Change (MOC) procedures in accordance with the Saudi Aramco Safety Management Guide 05-001-2006. No modification, renovation, or change in relay protection settings shall take place unless MOC procedures, which include review and update of the arc flash hazard analysis, are completed.
- 7.12 Proponents and electrical support organizations, in coordination with the area Loss Prevention division as needed, shall perform periodic site inspections and auditing to ensure personnel working on electrical equipment operated at higher than 240 volts are properly certified, properly following procedures, using the required personal protective equipment (PPE), etc. If safe work procedures are not being followed, appropriate corrective actions shall be immediately taken.

8.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

- 8.1 The everyday work clothing for Saudi Aramco and contractor electrical workers who work on electrical equipment operated at higher than 240 volts (e.g., electrical system operators, electricians, Power Distribution and Utilities Department technicians) shall be flame resistant clothing (FRC) that conforms to NFPA 70E Hazard/Risk Category 2 (has a minimum arc flash rating of 8 cal/cm²). See Supplement 2.721-2 and Supplement 2.721-3 of this GI.
- 8.2 Saudi Aramco proponents, electrical support organizations, and contractor companies shall provide a workweek's supply of everyday work clothing to their electrical workers who work on electrical equipment operated at higher than 240 volts. A workweek's supply of everyday work clothing typically includes five sets of Category 2 FRC pants/shirts or three FRC coveralls, along with an arc-rated face shield (minimum arc flash rating of 8 cal/cm²). If a belt is supplied, it shall not contain any conductive (metal) parts.

| | | | |
|--|--|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL | | G.I. NUMBER Approved 2.721 | |
| | | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | | APPROVAL AFW | PAGE NUMBER 8 of 15 |

| | |
|--|--|
| <p>8.3 An arc rated face shield (with a minimum arc rating of 8 cal/cm²) shall be worn by anyone working on electrical equipment operated at higher than 240 volts whenever Category 2 FRC is required. Face shields without an arc rating shall not be used when an arc flash hazard exists. The arc rating for face shields shall be as per ASTM F 2178.</p> <p>8.4 Saudi Aramco and contractor personnel shall wear the proper arc flash clothing (e.g., arc flash suit) and use the PPE listed in Supplement 2.721-2 and Supplement 2.721-3 when performing any of the tasks listed in Table 2.1 (e.g., as noted on any posted task warning sign) or when working within the Arc Flash Protection Boundary of energized electrical equipment operated at higher than 240 volts (e.g., as noted on any posted arc flash hazard warning sign).</p> <p>8.5 Saudi Aramco proponents are responsible for installing at least one properly rated, complete arc flash suit (including arc-rated flash hood and gloves) at each existing electrical equipment facility (e.g., substation, electrical room) where tasks are performed that require more protection than provided by Category 2 FRC.</p> <p>8.6 The capital project scope for new electrical equipment facilities (e.g., substation, electrical room) where tasks will be performed that require more protection than provided by Category 2 FRC shall include at least one properly rated, complete arc flash suit (including arc-rated flash hood and gloves) to be installed by the construction contractor at each facility.</p> <p>8.7 When Category 4 protection (minimum arc rating of 40 cal/cm²) is required, an acceptable option is to wear a Category 3 arc flash suit over Category 2 FRC (pants/shirt or coveralls). This provides a total protection of over 40 cal/cm² for the wearer's body. However, in this case, a Category 4 (not Category 3) arc flash hood shall be used.</p> <p>8.8 The user shall inspect all personal protective equipment (PPE), including flame resistant clothing (FRC), before each use. Any items that are contaminated or damaged to the extent their protective qualities are impaired shall not be used. PPE/FRC shall be dry during use.</p> <p>8.9 Proper eye protection (e.g., safety glasses marked as meeting ANSI Z87.1) shall always be worn under a face shield or arc flash hood.</p> <p>8.10 Regular "street" clothes and undergarments worn under FRC shall be made of 100% cotton fabric. Polyester, polyester-cotton blends, nylon, nylon-cotton blends, rayon or other meltable (thermoplastic) synthetic fabric shall not be worn, due to the possibility that melting clothing will increase the severity of a burn injury. However, an incidental amount of elastic used on nonmelting fabric underwear or socks is permitted. Also, garments worn as outer layers over FRC, such as jackets, shall be made from flame resistant materials.</p> <p>8.11 FRC garments shall cover potentially exposed areas as completely as possible. Shirt sleeves shall be fastened at the wrists, and shirts and coveralls shall be closed at the neck.</p> <p>8.12 Tight-fitting FRC garments shall be avoided. Loose fitting clothing provides additional thermal insulation. FRC garments shall fit properly such that it does not interfere with the work task.</p> | |
|--|--|

| | | |
|---|--|-------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 9 of 15 |

8.13 PPE and FRC garments shall be stored in a manner that prevents physical damage and damage or contamination from moisture, deteriorating agents, flammable materials, etc.

8.14 The FRC specified in the Safety Management Guide 06-001-2008 shall not be used for protection against arc flash hazards, since it does not provide the minimum Category 2 arc flash rating (8 cal/cm²) required for electrical workers. However, the FRC specified in Supplement 2.721-3 of this GI also meets the flash fire safety provisions of the FRC specified in Guide 06-001-2008.

8.15 The FRC garment manufacturer's instructions for care and cleaning of FRC apparel shall be followed, including the maximum number of laundry cycles before replacement (e.g., every 3 years). Saudi Aramco proponents, electrical support organizations, and contractor companies shall make provisions to ensure that these instructions are followed; for example, by providing contracted laundry services or facilities to appropriately clean FRC garments, including arc flash suits. To preserve garment strength and prolong its life, chlorine bleach shall not be used with FRC garments. FRC garments shall not be laundered at the employee's home if they are contaminated with hydrocarbons or other hazardous materials.

8.16 Contracted laundry services shall use proper laundering procedures for FRC garments, including eliminating the chance of exposing other customers' clothing to hazardous materials during cleaning. These laundering procedures include having dedicated equipment used only to clean Saudi Aramco's FRC garments.

8.17 When FRC garments are repaired, the same flame resistant materials used to manufacture the garment shall be used for the repair.

8.18 FRC garments shall be replaced when irreparably damaged or worn out (e.g., every 3 years).

9.0 OTHER PROTECTIVE EQUIPMENT

9.1 Personnel shall use insulated/insulating protective equipment and hand tools when working on exposed electrical conductors or circuit parts. Table 2.1 in Supplement 2.721-2 provides further information for tasks that require insulated and insulating hand tools. Insulated tools shall be protected to avoid damage to the insulating material.

9.2 Electrical insulated/insulating protective equipment and hand tools, such as the following, shall be maintained in a safe working condition and stored in a manner to prevent damage:

- grounding equipment and test devices,
- hot sticks,
- rubber gloves, sleeves, and leather protectors,
- voltage test indicators,
- blanket and similar insulating equipment,
- insulating mats and similar insulating equipment,
- protective barriers,
- external circuit breaker rack-out devices,
- safety grounding equipment,

| | | | |
|--|--|--|--------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL | | G.I. NUMBER Approved 2.721 | |
| | | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | | APPROVAL AFW | PAGE NUMBER 10 of 15 |

- bypass jumpers, and
- insulated and insulating hand tools.

- 9.3 Only electrical testing equipment (e.g., digital multimeters and digital clamp meters) that have been certified by a recognized third-party organization (e.g., Underwriters Laboratories [UL], Council of Europe [CE]) in accordance with IEC 61010-1 shall be purchased and used.
- 9.4 Proponents and electrical support organizations shall develop and implement procedures to ensure that insulated/insulating protective equipment, electrical testing equipment, and hand tools are periodically tested and/or calibrated/labeled by a testing laboratory in accordance with the manufacturer's recommendations and/or internationally accepted standards.
- 9.5 The user shall visually inspect insulated/insulating protective equipment and hand tools before each day's use and immediately following any incident that could have caused damage. Any electrical testing equipment that is damaged, malfunctioning, or has a calibration sticker that is out-of-date, missing or not legible shall be removed from service and repaired/re-calibrated. Insulating gloves shall be given an air test, along with the visual inspection.


10.0 TRAINING AND CERTIFICATION

- 10.1 Proponents and electrical support organizations, working together with Training and Career Development (T&CD), shall implement a formal, uniform, company-wide, training, certification/re-certification program for Saudi Aramco and contractor employees who work on electrical equipment operated at higher than 240 volts. This certification/re-certification program shall be in accordance with GI 1809.001.
- 10.2 Saudi Aramco and contractor employees who work on electrical equipment operated at higher than 240 volts shall receive formal safe electrical work training, which includes the following:
- arc flash hazards and prevention of injuries,
 - reading and understanding arc flash hazard and task warning signs,
 - proper selection, inspection, use of arc flash PPE/FRC, and
 - safe work procedures for electrical isolation, switching, voltage testing, etc.
- 10.3 After December 2011, a valid Saudi Aramco Electrical Hazards Recognition (EHR) Certificate is required to perform any work on electrical equipment operated at higher than 240 volts (including any of the tasks listed in Table 2.1 of Supplement 2.721-2).
- 10.4 After December 2011, a valid Saudi Aramco Hazardous-Duty Potential Testing (HDPT) Certificate is required to perform hazardous-duty potential (voltage) testing.
- 10.5 After December 2011, a valid Saudi Aramco Corporate Electrical System Operator Certification/Recertification (CESOR) certificate is required to perform hazardous-duty switching.

| | | | |
|--|--|---|-------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL | | G.I. NUMBER Approved 2.721 | |
| ISSUING ORG. POWER DISTRIBUTION DEPARTMENT | | ISSUE DATE 10/05/2009 | REPLACES NEW |
| SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | | APPROVAL AFW | PAGE NUMBER 12 of 15 |

SUPPLEMENT 2.721-1

STANDARD ARC FLASH AND SHOCK HAZARD WARNING SIGN

| | | |
|--|---|--|
|  |  DANGER Flash & Shock Hazard with covers or doors open Appropriate PPE Required |  |
| Arc Flash Protection Hazard/Risk Category _____ Incident Energy: (cal/cm ²) _____ Flash Protection Boundary _____ PPE: _____ | Shock Protection _____ Shock Hazard when: covers removed Limited Approach Boundary _____ Restricted Approach Boundary _____ Prohibited Approach Boundary _____ PPE: ♦ Class _____ ♦ V-rating _____ | |
| Equipment ID: _____ | | |

| | | |
|---|--|--------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 13 of 15 |

SUPPLEMENT 2.721-2, TASKS REQUIRING SPECIFIC ARC FLASH PPE & INSULATED TOOLS

TABLE 2.1 – TASK WARNING SIGN

| Tasks Performed on Energized Electrical Equipment | Hazard/Risk Category PPE Req'd | Rubber Insulating Gloves | Insulated & Insulating Hand Tools |
|--|--------------------------------|--------------------------|-----------------------------------|
| Panelboards or Switchboards Rated at > 240 V and up to 600 V | | | |
| Work on energized electrical conductors and circuit parts, including voltage testing | 2* | Mandatory | Mandatory |
| 600 V Class: Switchgear, Motor Control Centers (MCCs), Other Equipment | | | |
| Work on energized electrical conductors and circuit parts, including voltage testing | 2* | Mandatory | Mandatory |
| Work on control circuits >120 V with exposed energized parts | 2* | Mandatory | Mandatory |
| Application of safety grounds, after voltage testing | 2* | Mandatory | - |
| Insertion or removal (racking) of circuit breakers or individual starter “buckets” | 4 | Mandatory | - |
| Removal of bolted covers to expose bare, energized parts | 4 | - | - |
| NEMA E2 (fused contactor) Motor Starters, Rated 2.3 kV through 7.2 kV | | | |
| Perform infrared thermography or non-contact inspection not closer than 0.8m (2.5ft) | 3 | - | - |
| Opening hinged covers to expose bare, energized parts | 3 | - | - |
| Work on control circuits >120 V with exposed energized parts | 3 | Mandatory | Mandatory |
| Application of safety grounds, after voltage testing | 3 | Mandatory | - |
| Work on energized electrical conductors and circuit parts, including voltage testing | 4 | Mandatory | Mandatory |
| Insertion or removal (racking) of starters from cubicles | 4 | - | - |
| Removal of bolted covers to expose bare, energized parts | 4 | - | - |
| Metal Clad Switchgear and Metal Enclosed Interrupter Switchgear, Rated 1 kV through 38 kV | | | |
| Work on control circuits with energized parts 120 V or below, conductors exposed | 2 | Mandatory | Mandatory |
| Opening hinged covers to expose bare, energized parts | 3 | - | - |
| Perform infrared thermography or non-contact inspection not closer than 0.8m (2.5ft) | 3 | - | - |
| Circuit breaker operation with enclosure doors open | 4 | - | - |
| Work on energized parts, including voltage testing | 4 | Mandatory | Mandatory |
| Insertion or removal (racking) of circuit breakers from cubicles | 4 | - | - |
| Application of safety grounds, after voltage testing | 4 | Mandatory | - |
| Removal of bolted covers to expose bare, energized parts | 4 | - | - |
| Opening voltage transformer or control power transformer compartments | 4 | - | - |
| Other Equipment, Rated 1 kV through 38 kV | | | |
| Outdoor disconnect switch operation (gang operated mechanism, from grade) | 2 | Mandatory | - |
| Insulated cable examination in open area | 2 | Mandatory | - |
| Outdoor disconnect switch operation (hot/hook stick operated) | 3 | Mandatory | Mandatory |
| Insulated cable examination in manhole or other confined space | 4 | Mandatory | - |

Note: This table is based on the maximum short-circuit capacities and fault clearing times noted in NFPA 70E-2009, Table 130.7(C)(9). For tasks not listed or for power systems with greater than the assumed short-circuit capacity and/or fault clearing time, an arc flash hazard analysis is required in accordance with NFPA 70E, Art. 130.3.

Note: The personal protective equipment (PPE) required for HRC 2* is the same as for HRC 2, except that a HRC 2 arc-rated balaclava (sock hood) shall be worn under the HRC 2 arc-rated face shield. See Table 2.2.

| | | |
|---|--|--------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | G.I. NUMBER Approved 2.721 | |
| | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | APPROVAL AFW | PAGE NUMBER 14 of 15 |

SUPPLEMENT 2.721-2 (CONTINUED)

TABLE 2.2 – Hazard/Risk Category Flame Resistant Clothing (FRC) and PPE

| Hazard/Risk Category (HRC) | FRC and PPE |
|--|--|
| Hazard/Risk Category 2 (Category 2 and 2*) FRC, Minimum Arc Rating of 8 cal/cm ² <i>(electrical workers' everyday work clothing)</i> FR PPE | Arc-rated pants and long-sleeve shirt, or coveralls Arc-rated face shield (Note 2) or arc flash hood Arc-rated jacket (AN) Hard hat Safety glasses Hearing protection (ear canal inserts) Leather gloves (Note 1) Leather safety shoes |
| Hazard/Risk Category 3 (Category 3) FRC, Minimum Arc Rating of 25 cal/cm ² FR PPE | Category 3 arc flash suit, including arc flash hood Hard hat with FR hard hat liner Safety glasses Hearing protection (ear canal inserts) Arc-rated gloves (Note 1) Leather safety shoes |
| Hazard/Risk Category 4 (Category 4) FRC, Minimum Arc Rating of 40 cal/cm ² FR PPE | Category 4 arc flash suit, OR Category 3 arc flash suit worn over Category 2 pants/shirt or Category 2 coveralls (Note 3) Plus, Category 4 arc flash hood (Note 3) Hard hat with FR hard hat liner Safety glasses Hearing protection (ear canal inserts) Arc-rated gloves (Note 1) Leather safety shoes |

Notes for Table 2.2:

FR = Flame resistant AN = As needed

1. If rubber insulating gloves with leather protectors are required by Table 2.1, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.
2. For Hazard/Risk Category 2 (Category 2), a face shield with a minimum arc rating of 8 cal/cm², with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck, is required. For Hazard/Risk Category 2*, an arc-rated face shield shall be worn together with a balaclava (sock hood), which shall also have an arc rating of at least 8 cal/cm².
3. For Hazard/Risk Category 4 (Category 4), the total clothing system consisting of FR shirt and pants or FR coveralls and/or arc flash coat/pants and hood shall have a minimum arc rating of 40 cal/cm².

| | | | |
|---|--|--|--------------------------------|
| SAUDI ARABIAN OIL COMPANY (Saudi Aramco) GENERAL INSTRUCTION MANUAL ISSUING ORG. POWER DISTRIBUTION DEPARTMENT SUBJECT: ELECTRICAL ARC FLASH HAZARD MITIGATION | | G.I. NUMBER Approved 2.721 | |
| | | ISSUE DATE 10/05/2009 | REPLACES NEW |
| | | APPROVAL AFW | PAGE NUMBER 15 of 15 |

SUPPLEMENT 2.721-3

ARC FLASH FLAME RESISTANT CLOTHING (FRC) SPECIFICATIONS

| Hazard/Risk Category 2 FRC (Everyday Work Clothing for Electrical Workers) | | | | |
|--|-------------------------------|------------------------|--|--------------------------|
| Garment Type | Fabric | Fabric Style and Weave | Fabric Weight | Garment ATPV |
| Pants | Westex INDURA® Ultra Soft® | Style 451 Twill | 9 oz/yard ² (305 g/m ²) | 12.4 cal/cm ² |
| Shirts (option 1) | Westex INDURA® Ultra Soft® | Style 130 Knit | 6 oz/yard ² (203 g/m ²) | 10.9 cal/cm ² |
| Shirts (option 2) | Westex INDURA® Ultra Soft® | Style 301 Twill | 7 oz/yard ² (237 g/m ²) | 8.7 cal/cm ² |
| Coveralls | Westex INDURA® Ultra Soft® | Style 301 Twill | 7 oz/yard ² (237 g/m ²) | 8.7 cal/cm ² |

| Hazard/Risk Category 3 FRC | | | | |
|-----------------------------------|-------------------------------|------------------------|--|--------------------------|
| Garment Type | Fabric | Fabric Style and Weave | Fabric Weight | Garment ATPV |
| Arc Flash Suit | Westex INDURA® Ultra Soft® | Style 301 Twill | 7 oz/yard ² (237 g/m ²) (2 layers) | 27.2 cal/cm ² |

| Hazard/Risk Category 4 FRC | | | | |
|-----------------------------------|---------------------------|--------------------------|--|------------------------|
| Garment Type | Fabric | Fabric Style and Weave | Fabric Weight | Garment ATPV |
| Arc Flash Suit | DuPont NOMEX® Comfort™ | High Energy Suit (Twill) | 6.5 oz/yd ² (220 g/m ²) & 3.3 oz/yd ² (110 g/m ²) (2 layers) | 44 cal/cm ² |

ATPV = Arc Thermal Performance Value as defined by ASTM F 1959