

Prevention First 2002

*Prevention and Safety Through
Process Management*

Electrical System Safety Audits

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Objectives Of An Electrical Safety Audit

- The primary objective of an Audit is to determine the safety and condition of a facility through inspection and examination.
- Obtain and review the available electrical system drawings and verify their accuracy through field inspection.
- Prepare a list of applicable Codes and Standards which will be referenced and cited during the Audit.
- Determine the existing conditions of the facility electrical system including power, control, instrumentation, alarm and shutdown systems.
- Verify all electrical systems are properly installed, include the required system components and function properly and reliably.
- Prepare a list of deficiencies. Prioritize them in terms of severity. In addition to potential operating hazards, electrical system audits must identify fire and shock hazards.



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Facility Document Requirements

- In order to conduct an Audit, it is necessary to first request and obtain pertinent facility electrical documents. The documents required will be determined based on the process systems to be included in the Audit.
- When preparing a drawing request, the inspector should first obtain a drawing list from the facility operator. Alternately, the inspector may be required to visit the facility and identify specific drawings to be provided by the operator for use by the inspector during inspections.
- If the drawings are not available, it may be necessary for the inspector to work with the operator's personnel to create "field schematics" in order to proceed with the audit.



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Facility Document Requirements

The following types of drawings will be needed during the Audit:

Electrical Single-Line Diagrams
(including normal power and emergency power)

Electrical Area Classification Drawings

Standby Power Drawings (including batteries, chargers and uninterruptible power supplies)

Safety Control System Diagrams
(including shutdown logic diagrams)

General Alarm System Diagrams

Gas Detection Diagrams

Fire Detection Diagrams

Communication Equipment Power Drawings

Fire Pump Diagrams

Lighting Power Diagrams

Cathodic Protection Diagrams

Aids to Navigation Diagrams

Piping and Instrument Diagrams
(for reference only)

SAFE Charts
(if applicable)



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Reference Codes, Standards and Regulations

- Codes, Standards and Regulations establish the parameters and basis for evaluations of any electrical system evaluation.
- It is necessary to determine which Codes and Standards apply to the facility. An understanding of the location and processes will aid in identification of applicable standards. For instance, inspection of a platform will require the use of API RP 14F, Recommended Practice for Electrical Systems for Fixed and Floating Offshore Petroleum Facilities...
- Research and identify the applicable Codes, Standards and Regulatory requirements for the subject facility. Provide a list of reference documents to be used in the Audit to the operator.



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Reference Codes, Standards and Regulations (continued)

- For Petroleum Production Facilities, the following partial list of Codes, Standards, recommended practice and regulations may be applicable:
 - National Electrical Code, NFPA 70
 - California Electric Code, CEC
 - API RP 500, Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2.
 - API RP 14F, Recommended Practice for Design Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations.



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Applicable Standards (continued)

- API RP 540, Electrical Installations in Petroleum Processing Plants.
- API RP 505, Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Zone 0, Zone 1 and Zone 2.
- API RP 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents.
- ANSI Standards for Switchgear (C37) and Transformers (C57).
- IEEE Standard 141, Electric Power Distribution for Industrial Plants.
- IEEE Standard 142, Grounding of Industrial and Commercial Power Systems.
- IEEE Standard 242, Protection and Coordination of Industrial and Commercial Power Systems.
- ISA Standard S.5.1.1 Process Instrumentation Technology



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Applicable Standards (continued)

- ISA Standard RP12.1 Recommended Practice for Electrical Instruments in Hazardous Atmospheres.
- NFPA 30, Flammable and Combustible Liquids Code
- NFPA 70B, Recommended Practice for Electrical Equipment Maintenance.
- NFPA 70E, Electrical Safety Requirements for Employee Workplaces.
- NFPA 20, Standard for the Installation of Centrifugal Fire Pumps.
- NFPA 110, Standard for Emergency and Standby Power Systems.
- NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations.
- OSHA, Code of Federal Regulations Part 1910, Subpart S, Electrical
- Other Codes and Standards as applicable.



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Electrical Inspection Methodology

- The findings of any inspection or audit must be presented to the operator in a usable format.
- An EXCEL spreadsheet or other spreadsheet/data base program should be used for presentation of findings. Editing and sorting will be required.
- The file should be presented in landscape format and should have columns with headings as follows:
 - **Team**
 - **Location**
 - **Item**
 - **Item Description**
 - **Technical Reference**
 - **Priority**
 - **Recommended**
 - **Status**



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Typical Clearance Matrix

CLEARANCE MATRIX

Action Item Priority Definitions:

- 1 - High risk potential for injury, oil spill, other adverse environmental impacts, or significant property damage. Facility or equipment may exhibit serious degradation or misuse.
- 2 - Moderate risk potential for injury, oil spill, other adverse environmental impacts, or property damage.
- 3 - Low risk potential for injury, oil spill, other adverse environmental impacts, or property damage. Plans, drawings, manuals, or other documentation may be incorrect or outdated. Maintenance needed.

Team	Location	Item	Item Description	Technical Reference	Priority	Recommended	Status	When	Who	Work Order
ELC		3.1.01								
ELC		3.1.02								
ELC		3.1.03								
ELC		3.1.04								
ELC		3.1.05								
ELC		3.2.01								
ELC		3.2.02								
ELC		3.2.03								
ELC		3.2.04								
ELC		3.2.05								
ELC		3.3.1.01								
ELC		3.3.1.02								
ELC		3.3.1.03								
ELC		3.3.1.04								
ELC		3.3.1.05								
ELC		3.3.2.01								
ELC		3.3.2.02								
ELC		3.3.2.03								
ELC		3.3.2.04								
ELC		3.3.2.05								
ELC		3.3.3.01								
ELC		3.3.3.02								
ELC		3.3.3.03								
ELC		3.3.3.04								
ELC		3.3.4.01								
ELC		3.3.4.02								
ELC		3.3.4.03								
ELC		3.3.4.04								
ELC		3.3.4.05								
ELC		3.4.1.01								
ELC		3.4.1.02								
ELC		3.4.1.03								
ELC		3.4.1.04								
ELC		3.4.1.05								
ELC		3.4.1.06								
ELC		3.4.1.07								
ELC		3.4.1.08								
ELC		3.4.1.09								
ELC		3.4.1.10								
ELC		3.4.1.11								
ELC		3.4.1.12								
ELC		3.4.1.13								
ELC		3.4.1.14								
ELC		3.4.1.15								



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Electrical Inspection Methodology (continued)

- The Matrix should consist of sections which are based on the inspection activity and will result in logical groupings of findings. The grouping should assist the operator in planning corrective action in an efficient and cost effective manor.
- Typical Matrix sections for a platform might consist of the following:
 - Electrical Area Classification
 - Electrical Power Distribution System, Normal Power
 - Electrical Power Condition and Functionality
 - Emergency Power, Standby Power, Generation
 - Electric Fire Pump System
 - Process Instrumentation Wiring Methods, Materials, Installation
 - Lighting Systems



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Electrical Inspection Methodology (continued)

- Matrix Sections (continued)
 - Special systems
 - Safety Control Systems, Electrical Shutdowns
 - Gas Detection System
 - Fire Detection System
 - Aids to Navigation
 - Communication Equipment
 - General Alarm Systems
 - Cathodic Protection



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The Inspectors “Tools”

- In addition to proper clothing and a voltage tester you will want to have other items to be prepared for inspection:
 - Digital camera with spare battery and memory. Bring 35mm camera as backup.
 - Tape measure and non-conductive ruler
 - Hand tools including flat screwdriver, phillips screwdriver, crescent wrench, socket set, ratchet, cordless drill, etc.
 - Flashlight with spare batteries
 - Backpack or other case to carry tools and paperwork
 - Clipboard
 - Pens, pencils, eraser, whiteout
 - Vernier calipers
 - Code book, standards, reference material
 - Facility drawings and plans



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Observe Safe Work Practices

- Be aware of the potential hazards and ask yourself what can be done to protect personnel from injury or death.
- Work only on de-energized equipment and circuits where possible.
- Determine if energized equipment can be approached from a safe distance without risk of accidental contact.
- If you need to touch a component part of an electric circuit, first verify it is de-energized using a properly rated, functional voltage tester. Never accept the word of a co-worker or by observing that a circuit breaker is open.
- Observe proper Lock Out-Tag Out procedures at all times.



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Observe Safe Work Practices *(continued)*

- Always use an indicating voltage tester which is properly rated.
- Never use a voltage tester until you are sure the circuit voltage does not exceed the maximum rating of the tester.
- Suitable testers include “Tic-Tracers” and indicating (audible and light) voltage tester, voltmeters, and the like. Know the operating ranges of your instrument and the circuit voltage present! Solenoid-type testers are not recommended for use. Be careful to verify the correct function is selected before using a multi-meter.
- Verify the tester used is functioning properly every time it is used! Never trust a meter or tester until you have verified it is operating properly.



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Observe Safe Work Practices (continued)

- Before conducting an inspection remove all jewelry including rings, watches, necklaces and earrings. Anything loose or conductive should be removed.
- Eyeglasses should have ties to hold them in place and safety glasses should be worn over metal frames to provide insulation. Eyeglass lenses should be made from ANSI approved material for impact resistance and flammability.
- Clothing should be free of metallic buttons and should be made of cotton or be certified as non-flammable. Nomex coveralls, shirts and pants are highly recommended to provide arc protection. Long sleeve cotton or Nomex shirts also offer added insulation in case of accidental contact.



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Observe Safe Work Practices (continued)

- Wear work boots with thick rubber soles
- Purchase 2000V rated work gloves if you will need to touch components of low voltage (660V) circuits for examination. Alternatively, soft, dry, leather gloves may be worn but only on de-energized circuits.
- Wear safety glasses with side shields.
- Always work with an electrician who is familiar with the equipment being inspected and knows its construction and operation.
- Do not open doors or remove covers unless you know what is behind them. The clearances between covers and live parts at 480V may be as little as 1 inch and the live parts may be unprotected or bare.
- Wear a hardhat and other PPE required by the facility operator.
- Verify Combustible Gas, Oxygen and H₂S detectors are calibrated and operating properly.



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Scheduling an Inspection

- Determine the best time of the day and week to conduct inspections through discussion with your facility contacts. Try to arrange inspections of electrical equipment during outages for maintenance or when the equipment can be taken out of service.
- Electrical equipment in an operating facility is usually in operation on a 24/7 basis. Be prepared to inspect energized equipment! Advise the operator that you will require equipment doors opened and covers removed where possible.
- Determine the operators requirements for site access including safety orientation, training, clothing and Personal Protective Equipment (PPE). Be sure you meet all requirements for access including badges, cards and stickers. Note the expiration/renewal date for training and access.



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Site Orientation Prior to Detailed Inspection

- Request a site tour of a facility with the site representative who is knowledgeable about the facility electrical system. Be sure to learn and use the names of the areas, processes and equipment familiar to the operator.
- During the tour, make general observations and take notes on areas of concern to be revisited during a detailed inspection.
- Be sure you have up to date facility one-lines, area class, ESD and other electrical diagrams. Make notes on the types of electrical systems installed.
- Determine, if possible, new equipment and systems installed which may not be documented. Make notes on the extent of these installations and request additional documentation.
- The facility condition will usually be a good indicator of the work practices and extent of problems to be discovered during inspection.
- Site Orientation is worthwhile to help the inspector organize an efficient approach to conducting the inspection.



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Conducting the Facility Audit

The Audit is conducted based on the pre-planning and Matrix development. The inspector must be aware of all potential issues which might require documentation. It is best to focus on individual systems rather than attempt to identify all issues for all systems at the same time. This may result in multiple visits to the same area.

• Electric Power Distribution System

- Components and enclosures should have adequate mechanical strength and durability. All openings shall be closed.
- Corroded enclosures, supports, fittings and hardware should be identified for repair or replacement.
- Adequate work space is required about all equipment.
- Adequate space inside equipment for wire bending and terminations is required.



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Conducting the Facility Audit *(continued)*

• Electric Power Distribution System *(continued)*

- Protection of personnel from shock hazards is required. All openings must be guarded.
- Is equipment properly grounded and bonded?
- Are one-line diagrams accurate?
- Are overcurrent devices properly sized and rated?
- Are conductor color codes observed?
- Is equipment properly rated for circuit voltage and load requirements?



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Conducting the Facility Audit (continued)

- Area Classification
 - Is the Area Classification drawing correct?
 - Are conduit seals provided at enclosures, area class boundary changes, at process connected equipment?
 - Are conduit seals packed and poured?
 - Is equipment properly rated for the environment?



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Conducting the Facility Audit (continued)

- Electric Power Equipment Condition and Functionality
 - Is equipment installed suitable for the installation and use in accordance with the NEC and other standards?
 - Is equipment listed or labeled by an NRTL for its use and application?
 - Is equipment rated for the environment? Indoor, outdoor, nonhazardous, hazardous.
 - Is protection provided from excessive heat during normal operating conditions?
 - Is equipment in good condition and properly supported?
 - Are flexible cords being used as a substitute for permanent wiring methods?



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Conducting the Facility Audit *(continued)*

- Electric Power Equipment Condition and Functionality *(continued)*
 - Equipment should be identified. In addition to rating and application data, the circuit, circuit ID, device ID and any operating “caution” or “warning” or “danger” signs.
 - Lockout/Tagout provisions on all motors and circuits requiring locks.
 - Look for test labels applied by a third party testing laboratory or qualified contractor as an indication that an effective maintenance program exists and is being implemented on a regular basis. Check for dates.
 - Examine documentation on file regarding maintenance activity.
 - Examine drawing stick files or record drawings to determine if they are complete and up to date.



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Petroleum Production Facility Inspections

Emergency and Standby Power Systems

- Emergency and Standby Power Systems have different installation and performance requirements according to the NEC, CEC and NFPA Standards (NFPA 110) depending on the classification.
- Identify and classify the type of system(s) installed and review with operator.
- Verify equipment, ratings and wiring methods are in compliance with standards.
- Verify system testing is scheduled and completed on a regular basis and as required by Code.
- Confirm that facility essential loads, including lighting, life safety and shutdown systems are supplied by an alternate source of power. Verify the source availability and duration during an outage.



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Petroleum Production Facility Inspections

Electric Fire Pump System

- Verify supply circuit, starter equipment and controls are configured in accordance with NFPA 20.
- Verify the starter and controls are NRTL listed and Fire Marshal approved.
- Wiring is to be segregated and have 30 minute fire rating.
- Witness a functional test of Fire pump and verify adequate flow.



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Petroleum Production Facility Inspections

Lighting Systems

- Verify fixtures are properly rated for area classification. Verify the Temperature Identification Number is correct.
- Verify fixture wire type is correct based on fixture marking.
- Measure lighting levels at night (in darkness) and confirm minimum foot-candle levels for tasks comply with IES recommendations.
- Confirm lighting is provided in the event of a power outage.



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Petroleum Production Facility Inspections

Special Systems

- Review test records of Alarm and Shutdown systems and conduct random testing of selected Alarm and Shutdown devices.
- Verify detectors and instruments are calibrated and functional.
- Confirm the Fire Detection systems wiring is segregated from all other system wiring in accordance with CEC or NEC Article 760.
- Confirm Fire Detection devices and Shutdown devices are properly installed and located where required.
- Verify Safety systems have a backup power supply such as UPS or generator with adequate time duration under full load conditions.
- Review Cathodic Protection System test records to determine effectiveness of system.



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Petroleum Production Facility Inspections

Audit Report

- Prepare and issue a final report that includes specific information.
- Identify deficiencies by using equipment identification, location and Code citation.
- Avoid general statements.
- Review the report with the operator and clarify issues which are questioned.



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Audit Report Matrix

Company A

All Locations

Administrative Team

Action Item Priority Definitions:

- 1 - Serious degradation or misuse of facility/high potential for injury, oil spill, other adverse environmental impact, or significant property damage.
- 2 - Continuing operation of facility or equipment in its present condition could have a moderate potential for injury, oil spill, other adverse environmental impact, or property damage.
- 3 - Potential for oil spill, other adverse environmental impact, or some property damage.

Administrative Team									
Area	Sec.	Item	Deficiency	Technical Reference	Priority	Recommended	Status	When	Who
5.2 Operations Manual									
		1	Operations Manual does not accurately reflect operations personnel and operating parameters.	MRMD Article 3.6 Operations Manual & Emergency Planning, Paragraph 2175. Manual Content, PRC 8758	3	Revise to accurately reflect current operating parameters and personnel.			
		2	Operations Manual is not available for reference at operating locations libraries.	MRMD Article 3.6 Operations Manual & Emergency Planning, Paragraph 2175. Manual Content, PRC 8758	3	Manual needs to be distributed to central library on all operating locations.			
5.3 Spill Response Plan									
		1	Most current revision of the Oil Spill Contingency Plan is not centrally located and available to all operating personnel at each production site.	MRMD Article 3.6 Operations Manual & Emergency Planning, Paragraph 2175. Manual Content, OSPR Title 14 CCR 817, MMS Title 30 CFR Sections 254.5, DOT 49 CFR 194	3	Need to verify complete most current revision is available at locations library. Also need to remove all obsolete copies from library.			
5.4 Required Documents & Records									
		1	Most current revision of the Safety Manual (Injury and Illness Prevention Plan) is not centrally located and available to all operating personnel at each production site.	Cal OSHA 5189, Fed OSHA 1910.119	3	Need to verify complete most current revision is available on all operating locations. Also need to remove all obsolete copies from library.			
		2	Most current revision of the Gas and Oil Pipeline Operating Maintenance Manual is not centrally located and available to all operating personnel at each production site.	DOT Title 49 CFR Part 192 & 195	3	Need to verify complete most current revision is available on all operating locations. Also need to remove all obsolete copies from library.			
		3	Most current revision of the Emergency Procedures Manual is not centrally located and available to all operating personnel at each production site.	Cal OSHA 5189, Fed OSHA 1910.119	3	Need to verify complete most current revision is available on all operating locations. Also need to remove all obsolete copies from library.			



