| FCX Department of Occupational Health and Safety | SOP # | | FCX - 26 |
|---|---|---|---|
| | Revision # | | 0 |
| | Supersedes | | |
| **Electrowinning (EW)/Electrorefining (ER) Electrical Safety Policy** | Task Risk | x | High |
| | | | Medium |
| | | | Low |
| | | | NA |
| **Approval Date: Feb. 20, 2017** | **Original Date: Feb. 20, 2017** | | |

# Contents

# 1.0 Policy

**This document establishes the minimum requirements for the health and safety of Freeport-McMoRan employees and contract personnel working in, and in connection with, the electrowinning and electrorefining processes.**

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| **Purpose** | The intent of this policy is to provide minimum specification for safe work practices and access for maintenance and operation of electrowinning and electrorefining processes with respect to electrical shock and arc flash hazards. |
| **Scope** | This policy applies to all Freeport-McMoRan employees, contractors, visitors and vendors who work in or around electrowinning tankhouses and/or electrorefineries and may be exposed to electric shock or arc flash hazards. This policy does not prescribe operation, maintenance or installation procedures specific to all electrowinning and electrorefining systems or system components. Other applicable standards must be reviewed and adhered to in addition to manufacturer specifications and training.<br><br>For the purpose of this policy the phrase "**work zone**" or "**working zone**" shall include all areas above the cells, in the basement and outside the tankhouse where a person could touch two or more surfaces (e.g. building columns, electrodes, bus bars, energized electrolyte pipes, etc.) that are at different voltage potentials either directly or indirectly through conductive tools or equipment. It does not typically include the area around the stripping machines or other areas totally away from energized surfaces. |

# 2.0 Responsibilities and Duties

## 2.1 Area Manager

**FCX Area Managers are responsible to ensure compliance with this policy, set expectations and critically review variances as outlined below.**

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| **Resources** | Ensure that sufficient resources (trained personnel, equipment in good working order, etc.) are available to facilitate employee awareness and control of electrical hazards in the tankhouse work zone. |
| **Critical Risks and Critical Controls** | Ensure that critical risks associated with the activities which occur within the tankhouse work zone are identified and controls to mitigate those risks are in place. |

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| **Audit Process** | Manager to ensure an audit process is in place and implemented and to follow up on action items resulting from inspections and audits to ensure timely completion. |
| **Engineering Reviews** | Ensure structural engineering reviews are conducted at least annually, or as required through audit observations or proposed design changes. The Management of Change (MOC) process **must** be used for formal review of proposed modifications to equipment, building structures, or processes. All risks associated with arc flash and shock hazards must be evaluated during the review process. |
| **Variance Review and Approval** | Area Manager, or delegate, is to review and approve, or reject, any long term variance, before work can be initiated. To obtain a long-term variance there must be a proposal of alternate means of controlling the risk that will provide equal or greater protection to employees than this policy, or diminish the risk to the lowest level reasonably possible. Refer to GSR FCX-21 Variance Policy for definitions and variance process details. |
| **Compliance** | Support compliance through working with subject matter experts in the areas of company procedures, regulatory, legal, or other relevant regulations related with the control of tankhouse electrical hazards. |

## 2.2 Area Superintendent

**FCX Area Superintendent is responsible to ensure compliance with this policy, set expectations and critically review variances as outlined below.**

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| **Resources** | Ensure that sufficient resources (trained personnel, equipment in good working order, etc.) are available to facilitate employee awareness and control of electrical hazards in the tankhouse work zone. |
| **Critical Risks and Critical Controls** | Ensure that critical risks associated with the activities which occur within the tankhouse work zone are identified and controls to mitigate those risks are in place. |
| **Engineering Reviews** | Ensure structural engineering reviews are conducted at least annually, or as required through audit observations or proposed design changes. The Management of Change (MOC) process **must** be used for formal review of proposed modifications to equipment, building structures, or processes. All risks associated with arc flash and shock hazards must be evaluated during the review process. |
| **Variance Review and Approval** | Temporary variances to be reviewed and approved by Area Superintendent. Refer to GSR FCX-21 Variance Process for definitions and variance process details. |

## 2.3 Health & Safety

| **H&S Department is responsible to support compliance with this policy and meet the expectations outlined below.** | |
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| **Audit Process** | H&S will participate on Tankhouse audits on a schedule agreed with local area leadership. |
| **Health Monitoring and Sampling** | When necessary, health and safety departments will be required to monitor exposure, and consult on appropriate controls and PPE selection. |
| **Variance Process** | H&S Manager will review and determine if approval will be granted for any long-term variance request received where compliance with this policy cannot be achieved. Sign-off is required before work can be initiated. Particular attention shall be given to the proposed alternative controls to ensure the work can be performed with equal or greater protection to employees, or that the risk is minimized to the lowest level reasonable possible.<br><br>A Temporary Variance Request will be reviewed and approved by a Sr. H&S Specialist or H&S Manager.<br><br>H&S Manager, or delegate, to verify that each variance is loaded to the appropriate Department of Occupational Health & Safety (DOHS) SharePoint location. |
| **Training** | H&S personnel who will perform activities in the tankhouse work zone will attend task training as specified in this policy. |

## 2.4 Tankhouse Area Supervisors

| FCX supervisors are responsible to ensure FCX employees are trained and comply with this policy, and to verify contractors have processes in place to ensure contract employee compliance with this policy, procedure and the expectations outlined below. | |
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| **Resources** | Ensure that sufficient resources (trained personnel, equipment in good working order, correct tool for the job etc.) are available to facilitate employee awareness and control of electrical hazards in the tankhouse work zone. |
| **Critical Risks and Critical Controls** | Verify that critical risks associated with the tankhouse work zone are identified and critical controls to reduce or mitigate those risks are in place. |

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| | Evaluate area of responsibility for new hazards or changes that could pose risk and ensure critical controls are in place to mitigate risk. Ensure a Management of Change (MOC) and applicable risk review is completed for any modification to procedures, process, facilities, piping, entry points, and equipment.<br><br>Ensure that any new hazards identified are communicated to area senior leadership and are passed on to incoming crews.<br><br>Enlist help from engineering, health and safety or other resources as necessary to improve critical controls.<br><br>Must enforce PPE and access requirements of area.<br><br>Ensure that employees understand which controls **must** be in place in order to safely proceed with work. |
| **Contractor Compliance** | Engage with contractors working in the supervisor's area of responsibility to ensure appropriate information is shared and training on the area-specific hazards has occurred. Periodically monitor contractors for compliance. |
| **Variance Process** | Recognize when a variance will be required and initiate the process. |

## 2.5 Global Supply Chain (GSC) Management

Global Supply Chain (GSC) Management are responsible to ensure elements of this Policy are included in the contract language for contractor qualification, bidding and selection for work on FCX property.

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| **Contractor Selection and Bidding** | Ensure that contractors understand the requirements of this Policy and the training necessary to conduct work within Electrowinning/Electrorefining areas. |
| **Tankhouse material purchases** | Materials of construction of any item introduced to the tankhouse work zone must meet a strict criteria. Introduction of any new or substituted material must be reviewed using the Management of Change (MOC) process. |

## 2.6 Employees

**FCX employees and contract employees are responsible to complete proper training, demonstrate safe work behaviors, and comply with this policy. Employees must understand critical controls that are required to proceed with work tasks assigned. Employees are empowered and expected to STOP if critical controls are unknown or missing.**

**All tankhouse personnel, contractors, and visitors must be vigilant to identify potentially grounded equipment within the tankhouse that is within reach of energized cells or components because this poses a shock hazard. While working in and around the tankhouse, any indication of stray current,**

**such as an electrical shock or abnormal corrosion of equipment, must be reported immediately to a supervisor.**

# 3.0 Program Elements and Requirements

**Each site will ensure that site-specific procedures comply with this policy at a minimum. All employees, contract employees, and visitors will comply with site-specific procedures**.

## 3.1 Stray Current

**FCX employees and contract employees accessing Electrowinning/Electrorefining working zones must comply with the following items related to stray current.**

**Housekeeping**

Due to stray current potential, daily housekeeping is required to prevent puddles of electrolyte and sulfate buildup around or below electrowinning/electrorefining equipment. Standing in puddles of electrolyte and touching energized surfaces can create a shock hazard. Build-up of electrolyte and sulfate around and below tankhouse cells can create unexpected paths for stray currents and must be prevented by timely repairs of leaks and wash-downs with water. Timeliness of repairs shall be scheduled based on severity and risk of exposure to employees. Temporary barricades may be required to prevent access until leaks are repaired. Utilize the Electrical Testing Protocol in Appendix A.

Tankhouse floor and handrail surfaces must be maintained clean from electrolyte. Tankhouse floor and handrail surfaces are to be checked for wear or deterioration following the site structural/infrastructure inspection schedule because these surfaces can become conductive when saturated with electrolyte.

Cell or piping leaks must be repaired as a priority.

Walkways shall be maintained clear of:

- Hoses or hose reels,
- old structural pieces (brackets),
- blanks and cathodes,
- parts of insulators,
- racks or storage containers,
- metal material and other conductive clutter

Slip, trip and fall hazards should be identified and eliminated to help prevent inadvertent exposure to shock hazards.

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| | Tankhouse cell lines and walkways shall not be used for long term storage of mobile equipment, racks, electrodes, etc. Fiberglass (FRP) is used for support beams and grating in tankhouse platforms because it provides electrical insulation. However, it is not as strong a flooring as steel. Therefore, equipment weights and structural integrity must be evaluated by an engineering group to make sure the safe working load of the flooring is not exceeded. |
| **Insulator Integrity** | Insulators must exist between the tankhouse cell line/tankhouse work zone and the building ground; including between copper bus, electrolyte piping and electrowinning/electrorefining equipment and the building ground.<br><br>To ensure insulator integrity, a quarterly visual inspection must occur to detect sulfated, missing or damaged insulators and to determine if cleaning or replacement of insulators is needed. More frequent inspection may be required if insulators are continuously being coated with sulfate.<br><br>Installation of drip caps on top of insulators that are exposed to dripping electrolyte should be considered. |
| **Concrete, Coatings, Liners and Foundation** | The integrity of the concrete, coatings, liners and foundation must be inspected and maintained to ensure they provide the desired electrical insulation between the operator and the building ground. Damage and/or cracking is to be reported to supervision. Wetted surfaces become more conductive, accelerate deterioration, and provide a direct path to ground. Repairs to be scheduled as appropriate and tracked to completion.<br><br>Foundation inspection shall be included as part of internal and external structural inspection as defined in Section 6.0 Audit Requirements. |
| **Metal Surfaces** | Metallic surfaces, such as building columns, conduit, piping, eye wash / shower stations, hose reels, etc., shall be placed at a safe distance away from the tankhouse cell line or adequately insulated to ensure they do not provide a path to ground and create a shock hazard. |
| **Cell Line Electrical Receptacles** | Electrical receptacles present on a cell line **must be ungrounded** and distinctively marked as per the NFPA 70 Article 668.21. Grounded receptacles provide a path to ground and may create a shock hazard to anyone touching a grounded power tool or equipment within the working zone. |
| **Battery Effect** | The action of the rectifier is to create a lead oxide battery on the surface of the lead anodes. It is important to stress that the same potential electrical hazard is present whether the rectifier is on or off due to this battery effect. |
| **Floating Rectifier Circuit** | The rectifier DC circuit, including electrolytic cells and associated copper bus, is totally isolated from the main building ground by insulators. |

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| | If the floating rectifier DC circuit becomes electrically connected with the building ground it may create a potentially deadly electrical hazard.<br>NOTE: It should always be assumed that the presence of one leg of the electrical path to ground exists. Take every precaution to prevent personnel from becoming the second path to ground thus completing the electrical circuit and creating a shock hazard.<br><br>This is the reason for maximum tool length specifications, good housekeeping activities, Special Use Checklist, insulating material, non-conductive materials and proper PPE. The entire overhead crane, including the crane block and hoist cables, can also create a dangerous path to ground and must not be contacted by employees while standing on the cell line.<br><br>The tankhouse crane hook is to be insulated; photo examples are located in the Appendix A. Tankhouse crane hooks shall be adequately isolated from ground, and scheduled tests shall be conducted to ensure insulators have sufficient resistance. |
| **Rectifier Yard** | Access must be locked and entry allowed to authorized personnel only. Maintain bus guarding and fence grounds to NEC code 110.31(D). |
| **Tankhouse Piping** | Electrolyte is a liquid conductor and will transmit current from the rectifier if a path to ground becomes available. Metal pipe fittings such as flanges and valves must be considered a potential shock hazard if exposed to electrolyte.<br><br>Energized metal surface exposure shall be controlled as specified in this policy or if not specified, through any of the following means:<br>• Installation of non-conductive covers<br>• Restricted area policy<br>• Physical barriers<br>• Replacement with non-conductive components<br><br>A process needs to be in place to ensure these controls are effective. Utilize the Electrical Testing Protocol in Appendix A to gather data and determine adequate controls. |

## 3.2 Arc Flash

Arc Flash is a hazard that can occur within tankhouse operations. Evaluation of tankhouse tasks that could result in arc flash shall be assessed to ensure adequate safety controls are identified and correctly utilized. Below are specific examples; each site may have others. Individuals with activities within the tankhouse work zone must be informed and follow this policy and site-specific procedures.

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| **Bus Bar / Guards** | The rectifier bus must be guarded to prevent contact. The insulators must be inspected and cleaned on a scheduled interval to check for damage. |

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| | Inter-cell bus (sometimes referred to as the 'dog-bone') sits on an insulating cap board and is exposed on top for electrode contacts. The electrical potential from adjoining cells in series is approximately two volts or less and does not require guarding. However, care must be taken to avoid contact across the tankhouse center walkway from one cell line to another as the voltage difference at this location can be up to full rectifier voltage. |
| **Crossing Center Walkway** | To prevent bridging from one side of the cell line to the other, proper procedures must be followed when working over or between energized cell lines. Carts, aspirators, storage racks, retention ball baskets, and other moveable metal objects may create opportunities not readily apparent to bridge the cell lines. The length of device or any metal hand tool shall not be long enough where an individual can inadvertently short the two cell lines. |
| **Crane Operation** | Never trolley a bridge crane from one side of the cell line to the other with a strongback, jumper frame, inter-cell bus or any conductive material capable of bridging from one side of the cell line to the other.<br><br>Crane block insulated covers are to be installed on all tank house crane blocks that operate over the cell lines (cranes with double insulation do not require a cover). |
| **Breaking Cell Contact** | Cell contact is normally broken for planned maintenance or during a power outage to prevent the battery effect of lead anodes and copper dissolution in a lead anode system. In this instance, ensure rectifier is off and power sources have LOTOTO in place per site procedures before breaking cell contacts.<br><br>This does not apply to electrorefinery cells. |
| **Lowering cell electrolyte level (rectifier on)** | As the electrolyte breaks contact with the electrodes, an arc flash will occur. Procedures must be in place to prevent inadvertent draining of the cell.<br><br>When lowering electrolyte levels for planned outages to stop electrolyte overflow, the rectifier shall be off.<br><br>Cell labelling shall be maintained on both the cell line and below the cell line to prevent unintended drainage of the wrong cell. |
| **Jumper Frame Placement & Shunt Operation** | Each site shall have a written operating procedure for jumper frame placement and shunt operation. The specific jumper frame or shunt shall be engineered based on current capacity, and maintained to meet design specifications. Procedures shall address the inherent arc flash and shock hazards of jumper frame operation. |

## 3.3 Personal Protective Equipment

**Standard PPE required by site policy for all individuals working on site shall be worn, details can be found in on-boarding material, area SOPs or the Contractor Health & Safety Manual.**

**In addition, area specific PPE, listed in this section, is required for each individual involved in activities within the tankhouse work zone.**

**Tankhouse Footwear**

Rubber footwear (specifications below) are required PPE for individuals entering or working on or below the cell line working zone. They will not be required in crane bays or stripping machine areas. However, consideration for this PPE requirement shall be documented for individuals that may periodically have to enter the cell line working zone (Ex., maintenance personnel, stripping machine operators, support group employees, visitors, etc.)

Specifications for the Tankhouse Working Zone specialized footwear are as follows:

- Chemical resistant (PVC/rubber/etc.)
- Electricity hazard rated or dielectric rated
  - "EH" rated under ASTM F2413-11 – protective footwear constructed or manufactured with electric shock resisting "EH" soles
- Steel-toe
- Metatarsal – ("Mt" designation)
- Mid-calf or higher

**Gloves**

A double glove solution is necessary to provide protection for both the electrical and chemical exposures possible in the tankhouse working zone. Within the tankhouse working zone, as defined in this document, personnel who will be exposed to 50 V ac/dc or greater, an electrically rated underglove will be required*. Within the tankhouse working zone, as defined in this document, personnel who will be exposed to less than 50V ac/dc, an electrically resistant glove (blue nitrile) will be acceptable for use as an underglove.

Personnel working **below** the cell line must wear the appropriate electrical glove (rated or resistant as described above) with an outer glove to provide chemical resistance.

Personnel working **on** the cell line must wear the appropriate electrical glove (rated or resistant as described above) with a rubber dipped Kevlar outer glove. This double glove combination is to provide both chemical, electrical and cut resistant properties.

*Note: When electrically rated gloves are utilized, a formalized testing program must be in place to verify that no pin holes are present and confirm

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| | that electrical current will not pass through the glove. Seek advice from site electricians for details on electrically rated glove testing requirements.<br><br>All gloves must be inspected prior to use to ensure no obvious defects are present that could lead to a shock hazard. |
| **Protective Eyewear** | Any individual entering the tankhouse must wear clear or indoor/outdoor safety glasses; no dark glasses are permitted.<br><br>Any individual entering under tankhouse cell line requires goggles or face shield. These areas shall be signed stating PPE requirement.<br><br>Individual sites must determine if goggles or face shield protective equipment are needed in other areas and provide adequate signage stating specific PPE requirements. |
| **Chemical Resistant Jumpsuit** | Certain tasks will require the use of a chemical resistant jumpsuit giving full body protection. This is important when working around energized electrolyte pipes in the center walkway in the basement. These pipes operate at full rectifier voltage differential at the rectifier end of the cellhouse. |
| **Jacket** | Shock hazards exist below the tankhouse when it is possible to simultaneously touch two energized surfaces with shoulders or elbows. Since such contact will bypass the protection of rubber gloves and rubber boots, wearing of a non-conductive jacket should be considered. |
| **Insulating Material** | Insulating materials, such as rubber blankets, or insulating mats could be used as a short-term alternative control for performing specific tasks. Employees should be vigilant for tasks or situations that can bypass critical PPE of boots and rubber gloves, such as kneeling or sitting on the cell line or tankhouse floor to perform a task that could expose them to stray current. In these situations an insulating mat should be utilized. |
| **Bypass Protection (Jewelry)** | Jewelry—including finger rings, chains, bracelets, nose, lip, eyebrow and other facial jewelry—is prohibited where there is a hazard of contact with tools and machinery. Earrings cannot extend beyond the outer edge of the ear, and protective backs must be present. There is potential for these items to bypass the protection factor of PPE. There is an additional hazard that jewelry can become a severe burn hazard when placed between an energized anode and cathode, even at a voltage difference of only two volts. |
| **Respirator** | Follow site policy for respirator use. |
| **Hearing Protection** | Follow specific task SOP, and site policy for hearing protection requirements. |
| **Personal Medical Devices** | Persons with personal medical devices such as pacemakers, defibrillators, or other implanted life critical devices shall not be allowed in the tankhouse work zone. Signage is to be placed to warn those having these medical devices of |

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| | the health hazard. Personal medical devices can be adversely affected by electromagnetic fields. This hazard warning shall also be included in visitor and contractor safety communications. |

## 3.4 Controlled Access

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| **Tankhouse Work Zone (On or below cell lines)** | Cell line control access at a minimum will include:<br>• Designation of appropriate PPE<br>• Radio communication present in the area (control room or other)<br>• Visitor to be accompanied by authorized personnel<br>• Signage including appropriate warnings and necessary PPE<br>• Site specific training suitable for task to be performed<br><br>Below cell line access is to be **restricted to authorized personnel only**. Non-conductive physical barriers will be installed and secured with an access policy established, communicated and enforced. |
| **Bus Bars** | Perimeter chain link and / or fiberglass reinforced plastic (RFP) fencing, with locked gates, shall be used to guard and restrict access to main bus bars. Consideration needs to be given to using non-conductive fencing where shock hazards are present. |
| **Lean, Commercial and Electrorefinery Process Pipelines** | Commercial (supply), lean (return), and electrorefinery process electrolyte pipelines shall be clearly identified and labeled with its service and "Energized Pipeline".<br><br>While working around electrolyte pipelines refer back to PPE requirements.<br><br>Metal flanges and components (e.g. valves, couplings, other pipe fittings) on electrolyte pipelines must be considered a shock hazard and tested. If a shock hazard is found to exist then it must be controlled in one of the following manners:<br>• Installation of non-conductive flange or component covers<br>• Replace metal component with non-conductive material<br>• Restricted area policy<br>• Physical barriers<br><br>Management of Change (MOC) process must be utilized for any modifications to the equipment. |

# 4.0 Equipment

## 4.1 Tools

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| **Use of any tools within a tankhouse must adhere to specific criteria which is unique to the tankhouse. All employees involved in activities within the tankhouse work zone must comply with this policy to mitigate and control risk of exposure to stray current, arc flash, and other hazards.** | |
| **Metal Hand Tools** | Conductive or metal tools are potentially hazardous for creating short circuits in the tankhouse. A particular hazard is to create a short circuit that bridges one side of the cell line to the other.<br><br>Metal tools that are long enough to create a cell line bridge are not to be used unless properly insulated. As tankhouse dimensions differ, sites shall define the appropriate length of their tools, unless properly insulated and maintained. |
| **Battery Operated** | Battery operated power tools must be used in and around the tankhouse work zone because they do not provide a pathway for current to ground. A Special Use Checklist is not required for battery operated tools. |
| **Electrical Power Tools or Equipment** | Work activities (planned or unplanned) when corded electrical power tools or equipment are needed in the tankhouse work zone (such as welders, power water spray, generator, extension cords, etc.) require a Special Use Checklist to be performed, found in Appendix A. Each Special Use Checklist will be completed by an Electrical Supervisor, or designee, to determine if a Variance is required before work commences. |
| **Camera** | Sites should consider installation of strategically placed surveillance cameras tied into Control Rooms. |

## 4.2 Fixed and Portable equipment

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| **Water/Air Hoses** | Water hoses, air hoses and pressure wash hoses pose a hazard if they are bridging one cell to another. Nonconductive hoses must be used in the tankhouse working zone. When gas powered pressure washers are used they should be located on the cell line as close to the operator as possible. The hose should never cross over the center walkway as this increases the shock hazard for the operator that is holding the hose end.<br><br>Hose reels should be constructed with nonconductive materials, or insulated by using a non-conductive supply line between header and hose reel and between the hose reel and metal structure (if mounted on a grounded tankhouse structure). |

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| | Mobile water hose, air hose and pressure wash hose equipment use inside the working zone should be made from, or coated with, non-conductive materials wherever practical. |
| **Shower/Eye Wash** | Shower and eye wash devices should be constructed with nonconductive materials. Where constructed with metal piping, the eye wash and shower devices shall be placed at a safe distance (cannot touch cell line and shower simultaneously for example) or adequately insulated to ensure they are not a grounding hazard to individuals working on the cell line.<br><br>Each site shall develop and execute a Preventive Maintenance (PM) schedule for showers, eye wash stations and water supply systems to ensure requirements are met and to ensure operational readiness. PM on Showers/Eye Wash stations within the tankhouse work zone will include inspecting to ensure no modifications have been made which introduce conductive materials. These PM procedures will be verified by programmed audits. |

## 4.3 Mobile Equipment

Mobile equipment pose potential bridging hazards across cell lines or from one cell line to the building ground. Individuals are expected to understand and follow safe operating procedures.

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| **Mobile / Temporary Use Equipment** | Equipment weights and structural integrity must be evaluated by an engineering group to make sure the flooring safe working load is not exceeded. FRP structures are not as strong as steel structures and are easier to overload.<br><br>The following is a list of mobile or temporary use equipment (this may not be a complete list.)<br><br>• Single-lift jib crane<br>• Manlifts<br>• Metal Scaffolding – ensure adequate isolation<br>• Pumps<br>• Ladders – all ladders used in tankhouse will be constructed of fiberglass or non-conductive material |

## 4.4 Design Change

**Any tankhouse design, equipment, structural, or process change shall be evaluated by a formal Management of Change (MOC) process to ensure potential hazards are appropriately identified and controlled.**

## 5.0 Training

**Affected employees, contractors, and visitors who enter the tankhouse work zone must be trained in accordance with this policy.**

**Training shall include the hazards associated with this policy, and how to identify areas of risk in need of electrical testing and mitigation.**

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| **Visitor Awareness Training (Hazard Awareness)** | Must be provided to all visitors who have or may have the potential to be present in the tankhouse work zone. This training shall include an overview of the hazards of the area. All visitors must be accompanied by authorized personnel.<br><br>Note: visitors can include employees, contractors, regulators, emergency responders, others – see definition. |
| **Electrowinning (EW)/ Electrorefining (ER) Electrical Awareness and Access Policy (Technical Training)** | Must be provided to all employees and contractors who are authorized, affected, competent or qualified and assigned to perform tasks in the tankhouse work zone. This training shall be completed upon initial assignment prior to work commencing.<br><br>Refresher training shall be provided annually as detailed below.<br><br>This training must comply with this policy and with local, state and federal regulations. |
| **Technical Training Format** | Technical training will be interactive and consist of classroom, video, and/or field demonstration of the hazards. Employees must demonstrate competency (both verbal and visual) to assess understanding. |
| **Documentation** | All training will be documented and kept readily available/accessible. |
| **Refresher Training** | Annual GSR refresher training must be provided to affected employees, and contractors who are authorized, competent or qualified to perform tasks associated with activities within the tankhouse work zone. It must include a review of existing policies and regulations and shall review any new or existing hazards and mitigations. |
| **Electrowinning/Electrorefining Electrical Testing Protocol** | Training will be provided to site determined electrical personnel on the standardized electrical testing protocol defined in Appendix A. |

## 6.0 Audit Requirements

**Periodic unannounced audits and scheduled audits are expected to ensure compliance with the policy and safety of personnel. All audits are to be documented, an action plan developed to address**

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| **any identified gaps, and actions assigned and tracked to completion. Documents will be retained per the FCX Corporate Record Retention Policy.** | |
| **Weekly** | Crane hook insulators will be tested and inspected weekly by qualified electricians. Follow site procedure and document readings and any actions taken through completion. |
| **Monthly** | A minimum of one monthly audit is to be scheduled and led by a site leader. Audit should review general housekeeping, cleanliness of grating and tankhouse floor, build-up of sulfate on surfaces, general leaks and other elements of this policy. |
| **Quarterly** | Cell insulators and bus insulators will be visually inspected to detect missing insulators and to determine if cleaning or replacement of insulators is needed.<br><br>Action items will be generated, as needed, and tracked to completion. |
| **Electrical Testing Protocol** | To be performed quarterly until analysis of data trends determine frequency. In any case, electrical testing should never exceed a twelve month frequency. See Appendix A for Electrical Test Protocol. |
| **Annual** | An annual general tankhouse and tankhouse electrical safety audit will be conducted by a Freeport-McMoRan cross-functional team.<br><br>Audits will include review of compliance with FCX policies, training, site SOPs, and field practices. Follow-up audits may be conducted more frequently depending on site performance.<br><br>A standard format will be used for the annual site audits. |
| **Structural Review** | Structural reviews will be conducted annually involving qualified site engineers. All sites to conduct structural review with a third party on at least every two years. |

## 7.0 Variance

**If any part of this policy cannot be followed, an approved variance is required. The FCX Variance Policy will be followed.** GSR Variance Process.pdf. **Seek assistance from site H&S as needed.**

## 8.0 Definitions

| **Definitions** | |
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| **Acid Mist** | An electrolyte aerosol that is created when the bubbles of oxygen evolved from the face of the anode rise to the surface of an electrowinning cell and |

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| | burst. Acid mist coating on surfaces can be electrically conductive and produce a shock. |
| **Alternating Current (AC)** | An electrical current in which the flow of electricity periodically reverses direction. |
| **Ampere (amp)** | The unit of electrical current flow. One ampere is the current that will flow through a one ohm resistance when one volt DC is applied across it. |
| **Anode** | The positive electrode in an electro-chemical cell where the oxidation half of the chemical reaction occurs. In electrowinning, the anode is typically lead or coated titanium. In electrorefining the anode is copper. |
| **Arc Flash** | An undesired electric discharge that travels through the air between conductors or from a conductor to a ground. The resulting explosion can cause fires and serious harm to equipment and people. |
| **Battery Effect** | A voltage that exists on the cell line after the power supply is disconnected. |
| **Blind Flange** | Is a plate that can be placed between pipe connections or at the end of a pipe to stop flow. A blind flange, if metallic, can conduct electricity when in contact with energized electrolyte. |
| **Building Ground** | A traditional earth ground tied back to AC power system. |
| **Cathode** | The negative electrode in an electro-chemical cell where the reduction half of the chemical reaction occurs. Cathodes can either be stainless steel or copper. |
| **Cell Line** | An assembly of electrically interconnected electrolytic cells supplied from a DC power source. |
| **Conductivity (electrical)** | Measures a material's ability to conduct electric current. |
| **Direct Current (DC)** | Is the unidirectional flow or movement of electric current. |
| **Dog Bone (D-Bar)** | An inter-cell bus bar that allows current to flow from one commercial electrowinning cell to the adjacent cell. Its name comes from the cross-section profile that resembles the shape of a dog bone. |
| **Electric Shock** | The physiological reaction, characterized by pain and muscular spasm, to the passage of an electric current though the body. It can affect the respiratory system and heart rhythm. The longer the current passes through the body, the smaller the chance of survival. |
| **Electrical Bus** | A metallic strip or bar, typically copper, that conducts electricity. |

| | |
|---|---|
| **Electrical Insulator** | A material that does not easily allow flow of electric current. |
| **Electrolyte** | The aqueous solution that contains the concentrated and purified copper (in solution) that has been extracted from the PLS and stripped from the Loaded Organic. Its primary components are water soluble copper sulfate, sulfuric acid and water. |
| **Electrowinning cell** | The generic term for an Electrowinning or Electrorefining tank. |
| **Floating Rectifier Circuit** | A circuit that is totally isolated from the main building ground by insulators. All the components are floating, the rectifier, bus bar, and the cells. NOTE: It should always be assumed that the presence of one leg of the electrical path to ground exists. Take every precaution to prevent personnel from becoming the second path to ground thus completing the electrical circuit and creating a shock hazard. |
| **Insulated Tools** | A tool that is wrapped or made of a material that does not easily conduct electrical current. Insulated tools must be approved by site management or go through the Management of Change process. |
| **Multimeter** | An measuring instrument that combines several measurement functions (volts, Ohms, amps) |
| **Ohm's Law** | A physical law relating to the voltage difference between two points, the electrical current flowing between them, and the resistance of the path of the current. |
| **Pipe Component** | Any pipe, valve or fitting in the piping system. A metal pipe component can conduct electricity when in contact with energized electrolyte. |
| **Pipe Flange** | A method of connecting pipes, valves, pumps and other equipment to form a piping system. A metal pipe flange can conduct electricity when in contact with energized electrolyte. |
| **Power Decade Box** | A type of electrical test equipment that can be used to simulate different values of electrical resistance. |
| **Rectifier** | An electrical device which converts alternating current (AC) to direct current (DC). |
| **Resistance (electrical)** | A property that quantifies how strongly a given material opposes the flow of electric current. Low resistance indicates a material that readily allows the flow of electric current. Resistance is usually measured in Ohms. |
| **Stray Current** | For purposes of this policy, a DC current that does not flow through the designed electrowinning/electrorefinery circuit. |

| | |
|---|---|
| **Tankhouse Work Zone** | The area or "bubble" where operations and/or maintenance is normally performed in the vicinity of exposed energized surfaces of electrolytic cell line or their attachments. This includes areas on and below the cell line. |
| **Visitor** | Any person who is a non-authorized person for work in the EW/ER facility. |

## 9.0 References

**OEM Operation Manuals**
**Government Regulations**
**Professional Standards (i.e., IEEE, NEC)**
**FCX and Site Specific Policies and Procedures**
**Related Events**

## 10.0 Records

**The following records must be retained according to the FCX Records Retention Policy**

- Annual program review
- Variance Documents
- Training Records
- Electrical Measurement Test Form

## 11.0 Revision History

| | |
|---|---|
| **02.20.17** | Initial Release |

# Appendix A Forms and Permits

# 12.0 Special Use Checklist

## *Special Use Checklist*

*For portable electrical tools and/or equipment*

**The order for preference for energy sources of portable handheld equipment is:**
**1) Battery powered; 2) Pneumatic; 3) Portable Generator; 4) Double Insulated Tools**

| Request Date | Authorized Individuals (those using equipment) | Location | Project Duration (start & end date) | Impacted Cells/Area |
|---|---|---|---|---|
| | | | | |

Identify type of equipment in each applicable category below and answer each related question. If no equipment is to be used for named category, write **NONE** or **N/A** in space provided and proceed to next section.

| **AC POWER SYSTEMS** | Type: | Yes | No |
|---|---|---|---|
| Is it possible to supply power to portable equipment within the tankhouse work zone without the use of an AC Power system? | | ☐ | ☐ |
| Will power system be ungrounded with an approved overcurrent device of proper rating in each circuit? | | ☐ | ☐ |
| Are special, ungrounded, two-pronged single receptacles with unique pole configuration in place? | | ☐ | ☐ |
| **PORTABLE GENERATORS** | Type: | Yes | No |
| Is the generator frame isolated from earth potential? | | ☐ | ☐ |
| Is the generator shell ungrounded and placed as close to the work as possible (on the grating/decking, but not on or in contact with the cell)? | | ☐ | ☐ |
| Are all tools in use with the portable generator double insulated tools? | | ☐ | ☐ |
| **OTHER PORTABLE EQUIPMENT (power washers, man lifts, etc.)** | Type: | Yes | No |
| Are frames and enclosures of portable equipment used within energized cell line working zone ungrounded and double insulated? | | ☐ | ☐ |
| **ARC WELDING MACHINES** | Type: | Yes | No |
| Will the machine be placed OUTSIDE the cell line working zone? | | ☐ | ☐ |

Requestor Name

Electrical Supervisor Name (Print & Sign) Date

If answer to any question above is **NO**, a GSR Variance is required before work commences. Follow GSR FCX-21 Variance Policy and attach completed checklist for appropriate approvals.

Checklist valid only for equipment described. Any additional or new equipment for Project requires separate Special Use Checklist.

# 13.0 Electrical Testing Protocol

## 13.1 Scope

This document provides a protocol for performing electrical measurements to determine the presence of any stray voltages around electrowinning/electrorefining facilities. The protocol involves performing the following electrical measurements between selected locations:

- Open-circuit voltage
- Current

Some potential measurement locations may be exposed to water and/or electrolyte solutions. A characterization of the conductivity of these solutions should also be performed as part of the overall measurements.

The locations in and around the facility where the measurements are to be performed should be identified prior to performing the measurements. Measurements should also be performed

- Between two identified points even if they belong to different circuits provided that they are in close proximity to each other;
- Between all identified measurement locations and the ground surface.

All variables that may potentially affect the presence of any stray voltages should be identified prior to the measurements. The range of these variables should be well understood and considered as part of the overall measurement protocol. This protocol only considers the following variables:

- Flow rate of electrolyte in the pipes as controlled by the rectifier output current
- Condition of the ground surface (dry, flooded with water, flooded with electrolyte)

This protocol assumes that individuals performing the measurements will have the necessary protective and measuring equipment and are qualified to perform the measurements. All individuals performing work within the Electrowinning/Electrorefining work zones must be qualified to enter and work in this area and work in accordance with all FCX policies and procedures.

## 13.2 Limitations

The measurement protocol in this document is based on available information about the facility where the measurements are to be performed. The protocol assumes that the measurements will be performed to evaluate the presence/absence of DC voltages around electrowinning facilities. The concentration of electrolyte and the flow rate of electrolyte in the pipes at facilities are two of the variables that may affect the measurements. There may be other variables that may also affect the magnitudes of the measured resistances, voltages and currents. All the variables should be fully characterized to ensure that the measurements are also performed under the worst case conditions. The protocol detailed in this document should only be used as a guide for performing

the measurements. The exact protocol for the measurements, and resulting actions based on the outcome of the measurements, will be dependent upon the facility where the measurements are performed.

## 13.3 Procedures

### 13.3.1. Open-Circuit Voltage Measurements

**The purpose of these measurements is to characterize the open-circuit voltage between identified measurement locations.**

#### Instrumentation

- Calibrated DC multimeter

#### Test Setup

Figure1, below, shows the test setup for the open circuit voltage measurements.

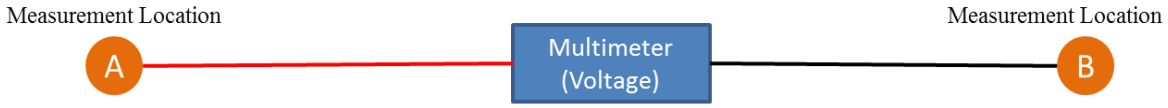


Figure 1

#### Protocol

The following protocol is suggested for open-circuit voltage measurements:

1. Identify the measurement locations (locations A and B in Figure 1 above)
2. Connect the positive multimeter probe to measurement location A and the negative multimeter probe to measurement location B
3. Record the open-circuit voltage
4. Reverse the multimeter probe connection (i.e. connect the negative multimeter probe to measurement location A and the positive multimeter probe to measurement location B)
5. Record the open-circuit voltage

Note: When making measurements with respect to the ground surface, ensure that the probe makes good electrical contact with the surface. Moving the probe around and monitoring the

stability of the measured open-circuit voltage on the multimeter can provide a guide on the connection made with the ground.

The attached Appendix A Test Form provides an example matrix that can be filled out for the identified measurements.

### 13.3.2. Current Measurements

**The purpose of these measurements is to characterize the current flow as a function of resistance between identified measurement locations.**

## Instrumentation

- Two (2) calibrated DC multimeters
- Calibrated power resistor decade box

## Test Setup

Figure **Error! Reference source not found.**2, below, shows the test setup for the current easurements.

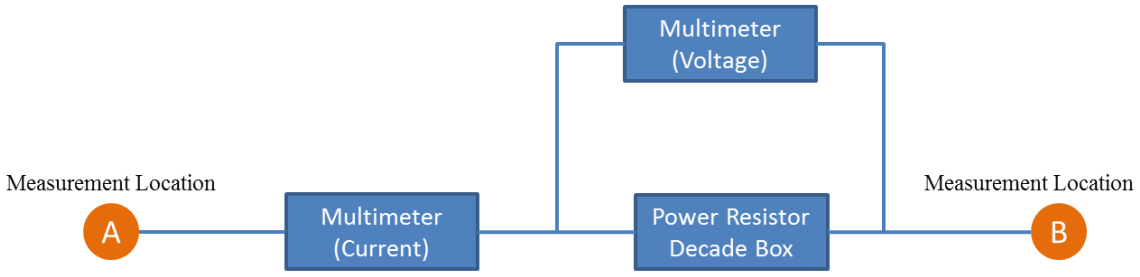


Figure 2

## Protocol

The following protocol is suggested for the current measurements:

1. Identify the measurement locations (points A and B in Figure 2)
2. Set the power resistor decade box to a high resistance setting (> 500 kΩ)
3. Connect the power resistor decade box and a multimeter (set to measure current flow) between the two identified measurement locations

4. Connect the second multimeter across the power resistor decade box to measure the voltage drop across the decade box (this will be used to verify the current measurements and the applied resistance)
5. Measure and record the current flow and the voltage drop across the decade box
6. Repeat step 5 for different resistance settings on the decade box

The attached Appendix A Test Form provides an example matrix that can be filled out for each identified measurement location to characterize the current flow under different operating conditions

### 13.3.3. Equipment

**The following equipment will be required for the measurements outlined in this document**

- Two (2) calibrated DC multimeters
  - Voltage rating of at least 500 V
  - Current resolution 0.1 mA or better
- Calibrated power resistor decade box
  - Power rating at least 100 W
  - Voltage rating at least 500 V

# Appendix B – Electrical Measurement Test Form

| Cell Line / Tankhouse Electrical Test Measurement Form | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOCATION** _____ | | | **CONDITION** Wet or Dry | | | | **ECTIFIER CURRENT** _____Voltage_____ | | | | **DATE** _____ | | |
| **Leads - Positive/Negative** | | **Test Points** | | | | | **Leads - Negative/Positive** | | **Test Points** | | | | |
| Resistance Setting | DC | **Cell Line** | **"A"** | **"B"** | **"C"** | **"D"** | Resistance Setting | DC | **Cell Line** | **"A"** | **"B"** | **"C"** | **"D"** |
| **500,000** | Volts | | | | | | **500,000** | Volts | | | | | |
| | A/mA | | | | | | | A/mA | | | | | |
| **5000** | Volts | | | | | | **5000** | Volts | | | | | |
| | A/mA | | | | | | | A/mA | | | | | |
| **1,500** | Volts | | | | | | **1,500** | Volts | | | | | |
| | A/mA | | | | | | | A/mA | | | | | |
| **1,000** | Volts | | | | | | **1,000** | Volts | | | | | |
| | A/mA | | | | | | | A/mA | | | | | |
| **500** | Volts | | | | | | **500** | Volts | | | | | |
| | A/mA | | | | | | | A/mA | | | | | |
| **Always start at highest voltage point on the cell line.** | | | | | | | | | | | | | |
| **Always start testing at the highest resistance setting, to insure you are not metering a direct short.** | | | | | | | | | | | | | |
| "A" through "D" indicate test points, which will be similar at every tank house, but usually doesn't consist of more than five per location. | | | | | | | | | | | | | |
| First test point is Cell Line TEST POINT EXAMPLES: Commercial feed line, Lean return line, Drain valve, Pipe hangers, FRP supports, Grating, Netting, Floor, Etc. to Ground | | | | | | | | | | | | | |
| Cell Line "A"_____"B"_____"C"_____"D"_____ | | | | | | | | | | | | | |
| Follow site specific SOP for Tankhouse Testing and Multimeter Use. | | | | | | | | | | | | | |
| All current readings will be in DC mA, unless indicated otherwise on test sheet. Indicate Positive (+) or Negative( -) by each reading | | | | | | | | | | | | | |