

**AMAI**

**ALKALI MANUFACTURERS ASSOCIATION OF INDIA**



**ELECTRICAL SAFETY**  
**GUIDELINE DOCUMENT 2021**  
(BASIC MINIMUM COMPLIANCE)

## AMAI MISSION

Represent the Indian Alkali and Chloro-Vinyl industries Nationally and Globally and facilitate the industry's Technological and Economic Growth, continuous improvement in protecting Human Health and Environment, guided by Sound Science, Technology and Risk Management principles. AMAI will achieve this by proactively promoting the industry through practices that are Fair, Inclusive and Sustainable.

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## **FOREWORD**

Chlor-alkali industry, a key segment of the chemicals sector, deals in some of the hazardous and explosive chemicals such as Chlorine and Hydrogen manufactured as by-products. As a new protocol, Chlor-alkali units are reviewing and tightening the safety measures, including SOPs for verifying the validity of licenses held by their consumers/dealers for products such as Hydrogen and Chlorine. Industry is also keeping a track if the consumers/dealers have adequate facilities/infrastructure for safe handling and storage of these chemicals.

This document has been prepared in consultation with chlor-alkali industry electrical safety experts, compiling minimum safety requirements in various electrical equipment and related areas, based on their experience and the standard regulatory requirements.

We hope that this compilation will be useful as Reference Basic Minimum Compliance Checklist Document for operating personnel in electrical departments of chlor-alkali industry.

We acknowledge with thanks the valuable contributions made by AMAI Technical and Safety Sub-Committee Members, SHE heads and electrical engineers of members units, in compiling the above document.

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New Delhi

## **BACKGROUND AND OBJECTIVE**

In the AMAI Executive Committee Meeting held on 25 June 2020, members discussed the occurrence of frequent chemical industry accidents when industry restarted after Covid lockdown. Members suggested that an interactive session with plant safety heads and Technical & SHE sub-committees be organised by AMAI.

Virtual Meetings were organised with Plant Safety Heads, Technical & SHE Sub-Committee Members. Mr. Devanand Jajoo, Chairman, AMAI SHE Sub-Committee was in Chair and Mr. Ravindra Sitani co-chaired the meetings. They expressed the need to address three important areas while reviewing safety measures.

1. Electrical Safety
2. Process Safety
3. Pipeline & Valves Safety

Fire is a major cause for chemical accidents. Fires are primarily due to malfunctioning in monitoring of process parameters or faulty electrical systems. There are gaps in electrical systems and industry needs to effectively manage them through timely solutions so that accidents can be prevented. Most of the plants have mitigation plans in place but implementation needs to be strictly monitored. Major electrical equipment and related areas were discussed in meetings with experts for adequacy of the systems in place, minimum safety requirements and additional features adopted by various units.

Area Task Groups were constituted to prepare draft recommendations for various electrical equipment and related areas. The draft reports were discussed in the meetings before compiling this AMAI Electrical Safety Guideline Document,

**Based on the Minimum Safety Requirements and the practices followed by industry in various important electrical areas of the plant, recommended safety requirements are given in the following pages.**

## **1. ELECTRICAL SAFETY IN RECTIFIER TRANSFORMER & POLARISATION RECTIFIER**

We can categorise the measures taken for electrical safety in Rectifier and Polarisation Rectifier System in the following three parts:

### **(A) Measures to avoid any incident/fatal accident:**

- Entry should be restricted for Authorised Personnel only
- Appropriate access control measures for entry into the designated area should be used like biometrics, physical registration, identity check and record, cautionary messages, etc.
- Use of relevant PPEs & Standard Operating Procedures while carrying out operation and maintenance of Rectifier
- Use insulated tools
- Positive isolation from both AC and DC side before any maintenance activity in Rectifier
- Use of suitable insulated polycarbonate sheet installed on DC totalizer bus bars with FRP supports or double insulated MS busbar supports for DC bus bars in cell house, is recommended for personnel safety
- Use of proper FRP structures for mounting of DC breakers and DC isolators
- Use of polyurethane insulated sheet on DC bus bars with different colour paint (red and black)

### **(B) Measures for Protection of Equipment:**

#### **(a) Rectifier Transformer:**

- It is recommended to have BDV (Break Down Voltage) test on quarterly basis and all other tests to be carried out annually, like DGA (Dissolved Gas Analysis), Water Content in ppm, Furan Analysis (if transformer ageing above 15 years) and other testing of transformer oil to be carried out through NABL accredited lab to ascertain the development of any type of partial discharge/electrical fault inside the Rectifier Transformer
- It is preferable to use double tube type oil cooler with water leakage detector (1 operating + 1 standby) for oil cooling of Rectifier Transformers
- Use of DM water for cooling of AC/DC hollow bus bars of Diode/Thyristor Rectifiers

- Online monitoring must be provided for measurement of pH and conductivity of DM water used for cooling of AC/DC hollow bus bars of Diode/Thyristor Rectifiers
- Fast acting numerical relay used for immediate isolation of Rectifier in case of any electrical fault
- There must be Hot stand by PLC based controls for safe & smooth operations of Rectifier
- Alarm/Tripping signals of one fuse (diode/thyristor) failure, two fuse failure, oil & winding temperature, Buchholz oil level, oil flow, DM water flow, cubicle temperature, bus bar temperature, etc., must be taken on PLC/DCS system
- Oil level, oil and winding temperatures, oil flow, DM water temperature, etc. checks to be carried out in each shift on daily basis as per the scheduled rounds to monitor healthiness of Rectifier
- Baffle wall between two transformers with four-hour fire rating shall be provided
- Transformer of 10 MVA or above rating or in case of oil filled more than 2000 litres are provided with firefighting system as per IS 3034: 1993 or with Nitrogen Injection Fire Prevention System (NIFPS)
- Interlock for tap at minimum positions during tripping of Rectifier on any fault must be provided and always ensure Tap position of Rectifier Transformer on position '1' (minimum tap) before every start of Rectifier Transformer
- Proper cooling arrangement for Diode/Thyristor cubicles to ensure safe operation of Rectifier system
- In case, where cable is laid underground, where water content is high, the cable shall be used with the technical specifications of insulation screening. Semiconducting swellable tape to be wrapped below copper tape and plain swellable tape to be wrapped over armour which is having a property to absorb moisture ingress in cable and will not allow moisture to reach to conductor. This will increase the life of conductor and avoid the chances of water ingress up to the conductor and hence the possibility of electrical fault.
  - Use of Tree Retardant XLPE compound instead of Plain XLPE. This will increase the AC voltage breakdown strength over a long period of time in case of the water immersed cables      OR

- PEAL PE coating over inner sheath – it is a 0.2 mm aluminium sheet laminated with 0.2 mm Polyethylene material on both sides. It will form as a tube over conductor and will not allow water to enter further
- Graphite coating on outer sheath can be applied to maintain the condition of sheath
- B-armouring can be selected for the cable as normal armour is having size of 4x0.8 mm but in B-armouring, the size of armour will be 6.1x1.4 mm, which provides the additional mechanical strength and can increase the fault current withstanding capacity
- After any shutdown or long outage of Rectifier Transformer, following procedures/testing should be carried out before starting Rectifier,
  - Checking operations of all protection devices and signal checking
  - Ensuring tap on position '1'
  - Measurement of IR and PI value
  - Measurement of BDV and PPM of Transformer oil
  - Checking of oil level
  - Checking of HT terminations
  - Checking of oil leakage of Rectifier Transformer, if any
  - Checking condition of silica gel and replacement, if required
  - Cleaning of HT/LT bushings of Rectifier Transformer and Diode / Thyristor cubicles
  - Recommending primary charge with low voltage and check voltage ratio
  - Back charge the transformer with 415 Volts/low voltage and check primary voltage in HMI for healthiness of cable and transformer
  - Thermal switch (55 °C, Bimetal) to be provided on bus bar inside the rectifier panel so that we can get alarm when busbar temperature goes beyond 55 °C
  - Grounding protection to be provided on DC side for any ground/earth fault on bus bar/electrolyser
  - Auto start provision required for additional oil cooler unit (Oil pump & Cooling fans) with help of additional oil temperature controller which will start additional cooler unit at 55 °C & stop at 45 °C
  - Check the inter-lock function for tripping of Rectifier by process fault



**(b) Polarisation Rectifier (wherever provided):**

- Use of constant current, parallel redundant type Polarisation Rectifiers for each Electrolyser
- ON/OFF control of Polarisation Rectifier along with its total annunciation system must be provided on DCS system in process/electrical control room
- Redundant UPS system with sufficient battery back-up must be provided for Polarisation Rectifiers. Life of batteries to be ensured properly
- Redundant UPS system must be fed by DG Set back-up supply
- Polarisation rectifier current & voltage feedback to be provided on DCS for monitoring and fine tuning/control of current
- UPS system should be dedicated for the polarisation rectifier only. It should not be clubbed for any other equipment

**(C) Measures to avoid any fire/to handle the fire incident:**

- Provision of heat/smoke/fire detection sensors in Rectifier rooms, connected with its alarm panel in centralized control room/fire department and to be checked periodically with proper recording
- Arrangement of Fire Fighting System/sufficient Fire Extinguishers/Sand Buckets/NIFPS (Nitrogen Injection Fire Prevention System)/ Pressurised Water Sprinkle Systems in each Rectifier room
- Use of proper insulation between AC and DC bus bars of Diode/Thyristor cubicles to eliminate the possibility of electrical short circuit
- Provision of safety net (Jali) at each opening of Rectifier rooms to avoid any bird entry into the room
- Necessary hot work/cold work/electrical safety work permit shall be taken from competent authority & safety officer before carrying out hot/cold work in Rectifier rooms
- Possibility can be explored to install CCTV camera to watch entire location along with equipment in field

## 2. ELECTRICAL SAFETY IN DC BUS BARS

- DC bus bars consist of the main feeder bus bars from the rectifiers/transformers to the cells, which are connected to the cell top bus bars by means of riser bus bars
- A DC bus bar system carries electrical current around a plant
- These systems usually carry very large electrical currents up to 1,00,000 amps
- Due to the large currents involved, the systems use heavy sections of copper and aluminium to conduct the electricity
- With the heavy sections of copper/aluminium involved, a significant insulated support structure is required
- DC bus bars are made up of copper or aluminium
- Support insulators use in between current carrying structure and supporting structure to isolate electrically from ground/earth
- The main feeder bus bar consists of positive and negative runs which conduct the DC electrical current to the tank house. The cross-over bus bars connect the row of cells to the next row of cells completing the circuit from the rectifier, which is positive, to the transformer which is negative
- Bus bar also supplies current to the cell top bus bars where the anode and cathode hanger bars are suspended from
- The cell top bus bars vary in size and shape depending on the operating current and the requirements of the specific project



**Recommended Periodic Maintenance Schedule for DC BUS BARS**

| <b>S. No.</b> | <b>Activity</b>  | <b>Frequency</b>  |
|---------------|--|---|
| 1             | Physical inspection of DC bus bar system in view of visual damage observation  | Weekly  |
| 2             | mV drop test at bolted joints at load current to be carried out on monthly basis keeping all safety aspects intact for the personnel attending the job or alternatively thermography can be done on regular monthly intervals. However, the mV drop test will have better accuracy | Monthly   |
| 3             | mV drops at various sections of positive & negative bus bar sections of cell   | Monthly   |
| 4             | Insulation resistance checking between<br>- current carrying bus bar & supporting structure<br>- supporting structure & ground   | Opportunity shutdown and on startup of the plant        |
| 5             | Physical inspection of supporting insulators & SMC sheets  | Quarterly   |
| 6             | Painting of metallic supporting structure  | Conditional based or once in 4 years                    |
| 7             | Painting of DC bus bars  | Conditional based or once in 8 years                    |
| 8             | Cleaning of DC bus bars  | On opportunity of shutdown but at least once in 3 years |
| 9             | Thermography of DC bus bar bolted & welded joints  | Quarterly   |
| 10            | DC bus bar maintenance   | On opportunity of shutdown but at least once in 3 years |
| 11            | Improvement of IR value in support insulator & SMC sheet with hot air blowing & drying   | When low IR value detected                              |
| 12            | All earth pits values and continuity testing are carried out as per Electrical Inspectorate  | Yearly  |
| 13            | Testing and Overhauling of 11KV circuit breakers and protection relays   | Opportunity shutdown or at least once in a year         |

### **3. ELECTRICAL SAFETY IN CABLE CELLAR**

- Cable tray tag number, painting/letter writing for proper identification
- Cable/cable tray supports should be in healthy condition
- Sharp edges of cable trays should not be allowed
- Proper dressing of cables
- Availability of fire extinguishers with zebra painting required for easy identification
- Availability of cable identification tags
- Emergency Exit should be accessible
- Openings (open cable entry holes) are closed properly
- Cable joints (if available) are tagged and painted with fire retardant paint
- Fire retardant paint is applied at cable entry in cable cellar
- Cable Cellar lighting should be sufficient
- No storage of combustible material, chemical and unwanted material, etc., inside cellar. General housekeeping to be taken care of
- Physical condition of cable is good. No mechanical stress on the cable
- Sufficient head room available below cable trays (especially above walkways). Locations with less headroom (Head Bangers) are identified and painted with yellow colour as a cautionary measure
- Cable joints must present in cellar. PD testing to be done once in a year, in case of cable joint
- Alternative emergency power supply to be provided in exhaust fan to extract smoke from cellar if in case blackout and fire happen at the same time
- In cable cellar/trench area, we can explore the installation of smoke detectors/LHS cables
- Procurement of FRLS cable should be started for any new requirement/for old cable, we can go for fire retardant paints

#### **4. ELECTRICAL SAFETY CHECKS IN EARTHING SYSTEM**

##### **Checks should cover earthing system of following**

- Transformer body and neutral earth
- Generator body and neutral earth
- Structure earthing
- Lightning arresters earthing
- Building lightning protection earthing
- Sunshades
- Structural cable tray earthing
- Electrical installation earthing
- Individual instrument and electrical earthing
- Substation/Switch yard fencing, gates, and doors

##### **Checks and Measurement**

- Check earth electrode and earth mat terminations for loose connection, contact, pitting and flash marks
- Inspect all terminations for salt formation and cleaning
- Ensure moisture level is maintained in earth pit
- Inspect the earth pit brick/concrete lining and pit cover for good condition
- Ensure all pits have unique identification
- Measure earth resistance value of earth electrode/earth mat
- Maintain a register and record values and observations
- Apply thin layer of petroleum jelly at earth electrode terminations
- For individual earth pit, if any reading is more than 4 ohm and earth pit connected with grid is more than 1 ohm, inform EIC and arrange for reconditioning the pits as per procedure
- List out and arrange for cement works and identification, as required
- Ensure all the pits covers are in position
- Ensure all checks are done once a year

## **5. ELECTRICAL SAFETY CHECKS IN MCC PANELS**

- Entry should be restricted for Authorised Personnel only
- Appropriate access control measures for entry into the designated area should be used like biometrics, physical registration, identity check and record, cautionary messages, etc.
- In MCC Panel rooms, ARC flash boundary with incident energy should be identified and marked as per arc flash study
- MCC panel should be procured from registered and licensed vendor
- Panel shall be compatible with relevant standards
- All cable entry points shall be provided with proper glands and sealed. No holes should be left open
- All doors should be in closed condition
- Yearly preventive maintenance shall be performed as per SOP and SMP
- Fire detection and suppression system should be installed
- Quarterly thermography shall be carried out to identify hotspot if any
- Yearly verification of relay setting
- Ensure working of panel heaters to avoid moisture
- Proper lugging and crimping of all terminations
- No loose and unwanted materials shall be kept inside panel
- Only authorized person should be allowed to work on panel
- Ensure proper isolation of supply before starting any work on panel
- Always wear arc flash suit during feeder isolation and restoration
- Ensure proper double earthing to panel
- Trouble gum pad shall be placed near by panel to trap rat and insects
- Panel shall be installed in well ventilated room
- Panel incoming power source feeders either single or multiple shall be marked with a different colour
- Insulation coating of bus bars of HT/LT panels to avoid ingress of foreign particles like rodents, vermin's, etc.
- Always ensure availability of insulating rubber mat of proper voltage rating surrounding the panel

## 6. ELECTRICAL SAFETY CHECKS IN HT/LT CABLES

- Cable should be selected as per proper voltage and current required for a particular application
- Cable should be procured from reputed manufacturer
- Cable should be of FRLS (Fire Retardant Low Smoke) type
- High temperature fire retardant paint coating shall be applied over cable at strategic locations
- Proper tagging and marking on cables for identification
- Avoid non-standard joints in cables
- Installation of cables in proper and standard way
- Damaged cable should be replaced
- Earthing of cable trays
- Cables shall be laid in cable tray in proper order without any overlapping
- VLF (Very Low Frequency) test shall be carried out on high voltage cables to check healthiness of cables
- No unwanted, loose, and flammable material shall be placed on cable trays
- Always use non-contact type voltage detector and insulating hand gloves before working on cable
- In Cable Cellar/Trench area we can explore the installation of smoke detectors/LHS (Linear Heat Sensor) cables
- Procurement of FRLS cable should be started for any new requirement/ for old cable we can go for fire retardant paints

## 7. ELECTRICAL SAFETY CHECKS IN PFIC

(or alternatively refer PFIC as Harmonic Filter Banks HT Yard i.e. HFB Section)

- Entry should be restricted for Authorised Personnel only
- Appropriate access control measures for entry into the designated area should be used like biometrics, physical registration, identity check and record, cautionary messages, etc.
- In PFIC section, we should check the reactor & capacitance values and insulation resistance of lightning arrestors.
- Gravel shall be spread in PFIC yard
- As PFIC is an outdoor installation, there is problem of build-up of grass and vegetation. Therefore, this should be removed at regular intervals

- In PFIC area, we can explore the possibility of PCC to avoid vegetation
- High voltage danger sign board shall be displayed at the entrance of PFIC
- Fencing shall be provided around the PFIC yard
- Earthing shall be provided to all the structures
- Yearly preventive maintenance shall be performed as per SOP and SMP
- Proper power isolation and earthing of line and capacitor shall be ensured before working on PFIC

## **8. ELECTRICAL SAFETY CHECKS IN SUB-STATION**

- Entry should be restricted for Authorised Personnel only
- Appropriate access control measures for entry into the designated area should be used like biometrics, physical registration, identity check and record, cautionary messages, etc.
- It should be well ventilated with adequate lighting
- In switchyard/sub-station area, we can explore the possibility of PCC to avoid vegetation
- Fire rated door shall be installed
- Provision of emergency lighting
- Escape route marking shall be done
- Sub-station layout shall be displayed at entrance
- All cable entry points shall be properly closed
- Fire detection and suppression system should be installed
- Proper tagging and marking on all installations for identification
- Proper temperature should be maintained inside sub-station with the help of HVAC (Heat Ventilation Air Conditioning) system
- Emergency preparedness plan shall be displayed
- Housekeeping and 5S shall be maintained inside and around the sub-station

## **9. GENERAL SAFETY REQUIREMENTS**

- Easily accessible emergency exit with adequate signages
- In Earthing System, overall layout and section wise layout should be updated as per requirement from time to time



- Rubber mats IR value should be checked periodically and if required should be replaced.
- Battery banks maintenance/replacement life cycle and redundancy should be considered.
- UPS Redundancy/Maintenance/life cycle should be maintained
- DG sets servicing/monitoring and replacement of critical spares as recommended by OEM
- Lightning arrestor installation as per new standard IS 62305 should be installed in hazardous areas like Zone 0 and Zone 1
- Recommended use of microprocessor-based protection relays/numerical relays/electromechanical relays in HT System and their annual testing
- It is recommended to use microprocessor-based protection relays/numerical relays in place of bi-metallic relays in LT System
- Calibration of metering equipment
- All electrical equipment installed in hydrogen area should preferably be of gas group II C as per HAC (Hazardous Area Classification) Study

*Note: The above measures are proposed as Basic Minimum Requirements based on inputs/suggestions received from various caustic soda industries. However, individual industry can adopt appropriate safeguard measures based on their experience.*