AMAI

ALKALI MANUFACTURERS ASSOCIATION OF INDIA

PROCESS SAFETY

GUIDELINE DOCUMENT 2023

(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 process safety experts, compiling minimum safety requirements in various process equipment and related areas, based on their experience and the standard regulatory requirements.

We hope that this compilation will be useful as Reference Checklist Document for operating personnel in various process departments of chlor-alkali industry.

We acknowledge with thanks the valuable contributions made by AMAI Technical and Safety Sub-Committee Members, SHE Heads and Process experts, Plant Heads of member Units, in compiling the above document.

01.08.2023
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, Plant Heads and Technical & SHE Sub-Committee Members 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. Process Safety
2. Electrical Safety
3. Instrument Safety
4. Pipeline & Valves Safety

Fire is a major cause for chemical accidents. Fires are basically due to malfunctioning in monitoring of process parameters or faulty electrical systems. The gaps in process parameters and related systems lead to accidents. Industry needs to effectively manage these gaps through timely solutions so that accidents can be prevented. Most of the plants have mitigation plans in place but implementing the plans need a push. Discussions with experts were held for the adequate safety measures adopted and systems in place, minimum safety requirements and additional features adopted by various units for major process equipment and related areas.

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

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

1. SAFETY REQUIREMENTS IN CELL HOUSE

Cell House is heart of a chlor-alkali plant comprising of Electrolysers used to produce

- Caustic Soda
- Chlorine
- Hydrogen

through electrolysis process.

Recommended safety monitoring equipment as required in cell house are:

- Cl_2 Detector
- H_2 Detector
- Remote Operated/ On-Off Valve of N_2 supply to individual electrolyser for Cl_2 / H_2 purging
- Heat Detector
- Flame Detector
- N_2 supply to H_2 header in case of plant tripping and purging of remaining H_2 in common header
- PSV of Cl_2 connected to hypo system
- PSV of H_2 venting at safe location
- Online breathing system
- Individual electrolyser UPS battery back-up available for polarisation in case of power failure (5th Generation), depending upon technology supplier
- SCBA set for emergency escape

Individual Electrolyser Safety:

- Low Low (LL) Flow of Brine will trip individual electrolyser
- LL Flow of Caustic will trip individual electrolyser
- High High (HH) temperature of catholyte will trip individual electrolyser
- Electrolyser block HH Voltage Deviation will trip individual electrolyser
- HH electrolyser current will trip individual electrolyser
- Dilute Brine On/Off Valve switch over
- EDI HH/LL
- Electrolyser grounding from Rectifier
- EDI circuit failure/open condition
- Over current tripping

- Interlock for feedback of both brine & caustic outlet valve
- HH Electrolyser Voltage will trip individual electrolyser

Overall Cell Room Safety by providing Process Interlocks resulting in plant tripping

- HH Cell Drain Tank Pressure
- Tripping of all Cl2 Compressors
- LL or HH differential pressure between H2 and Cl2 headers
- LL Instrument Air Pressure
- HH Depleted Brine (Anolyte) Tank Level
- HH Catholyte Tank Level
- LL Pure Brine Head Tank Level
- LL Catholyte Head Tank Level
- HH Individual Cl2 Pressure
- HH Individual H2 Pressure
- Electrolysers grounding from Rectifier
- EDI circuit failure/open condition
- Emergency stop provided from Cell House and DCS
- Electrolysers Calculated Vs Actual Voltage difference alarm and interlock
- HH Vent Pot Temperature
- LL pH of pure brine will trip rectifiers

Recommended Other Safety Measures:

- Provision of Blower in case of non-availability of hypo system
- Natural ventilator is a must to exhaust high temperature air in cell room
- Electrolysers installed on first floor should be placed on press type concrete slabs, to avoid any incident on ground floor due to leakage in elements
- Online Analyser for H2 in Chlorine from Drying Tower outlet
- Online Analyser for Pure Brine Hardness
- SCBA set in cell house
- Total 3 No. of Entry and Exit ways during Emergency
- Chlorine Sensor between every two electrolysers

GENERAL CHECK LIST FOR PLANT START UP			
S.No.	**Activity**	**OK/Not OK**	**Remarks**
A. Availability of Utility			
1	Ensure Nitrogen pressure should be normal.(> 4.5 Kg/cm2)		
2	Ensure Cooling Tower is in operation with required pressure		
3	Ensure Instrument air pressure is available (>5.5.0 Kg/cm2)		
4	Ensure that at least 150 - 200 mmwc hypo suction available at cell house		
5	Ensure Chilled water is available, and chiller are operative		
6	Ensure DM water is available and sufficient pressure is available		
B. Readiness of DCS			
1	Ensure that no interlock is bypassed		
2	Ensure that no tag is on CAL mode		
3	Ensure that all alarm are set within prescribed limit (Please ensure if any change is required in alarm limit it must be through proper authorization)		
4	The condition of UPS is healthy		
5	If DCS is started after power failure / black out; ensure that all tuning parameter, alarm limit, interlocks are remained unchanged		
6	All critical instruments like PDI transmitters, brine and caustic flow meters, Voltage EDI etc. transmitter is functioning and calibrated		
7	Ensure operation of following controllers are operate normal & output of controller's match with DCS. -Main Chlorine Valve -Chlorine to Hypo Valve		

	-Main Hydrogen Valve -Hydrogen vent valve		
C. General Safety System			
1	Ensure that safety showers are working		
2	Ensure that SCBA are available and in operating condition		
3	All required PPEs like Helmet, safety shoes, goggles, hand gloves are available with operating team		
4	walkway are clear and free from slip & trip hazard		
5	Emergency siren system are working		
6	Communication system like phone, PA system, walkie-talkie system, mobile etc. are in working condition		
7	Al sensor's (H2/Cl2) etc., are working condition		
8	Stack monitoring system and its connectivity with pollution control board server is working		
9	ETP is ready to take load of any emergency condition		
10	pH of drains is within prescribed limit		
11	Prescribed medicine and accessories are available in First -Aid Box		
12	Firefighting system are in working condition		
13	Fire alarm system is in working condition		
14	Ensure the availability of fresh tank for circulation at sodium hypo plant.		

Overall Remarks.
Checked By Approved By

ELECTROLYZER START UP CHECK LIST FOR UHDE ELECROLYZER			
Electrolyzer No			
Cut Out Date / Time			
Cut In Date / Time			
Reason For cut out			
Major work carryout in the electrolyzer during cut out			
PRE-START UP CONDITION			
S.No.	**Activity**	**Values**	**Remarks**
1	Feed Brine flow rate	m3/Hr	
2	Feed Caustic Flow rate	m3/Hr	
3	Alkalinity of feed brine	ppm	
4	Alkalinity of anolyte outlet	ppm	
5	Hardness of feed brine	ppb	
6	Catholyte temperature	Deg C	
7	Catholyte concentration	%	
8	Nitrogen is ON in Anolyte header (Yes /No)		
9	Nitrogen is ON in A catholyte header (Yes /No)		
10	Polarization starts up time		
11	Polarization current	Amp	
12	Polarization Voltage		

13	Strainer of brine cleaned (Yes/No)		
14	Strainer of caustic cleaned (Yes/No)		
15	All interlocks are in healthy condition (Yes/No)		
16	Any material kept on Electrolyzer (Yes/No)		
17	Condition of insulator (OK/Noy OK)		
18	Water hose removed form Electrolyzer (Yes/No)		
19	Voltage Monitoring system connection for each elements done		
20	EDI connection done		
21	Orsat is ready		
START-UP CONDITION			
S.No.	**Activity**	**Values**	**Remarks**
1	Feed brine flow of individual element (OK/Not OK)		
2	Feed caustic flow of individual element (OK/Not OK)		
3	Anolyte overflow of all elements (OK/Not OK)		
4	Catholyte overflow of all elements (OK/Not OK)		
5	Any leakage in Electrolyzer at Brine side (Yes/No)		
6	Any leakage in Electrolyzer at caustic side (Yes/No)		
7	Average polarization voltage		
8	No. of Elements having > 300 mV polarization voltage than avg. pol voltage		
9	Element No and Voltage having> 300mV		
10	No. of Elements having < 300 mV polarization voltage than avg. pol voltage		
11	Element No. and Voltage having < 300mV		
12	Status of Element voltage at 0.5KA		

	a) Elements having voltage > 300mV		
	b) Elements having voltage < 300mV		
	c) Low / No Reaction elements		
13	Status of Element voltage at 1KA		
	a) Elements having voltage > 300mV		
	b) Elements having voltage < 300mV		
	c) Low / No Reaction elements		
14	Status of Element voltage at 2.7 KA(1 CD)		
	a) Elements having voltage > 300mV		
	b) Elements having voltage < 300mV		
	c) Low / No Reaction elements		
Abnormality (If any)			
Overall Remarks.			
Checked By Approved By			

ELECTROLYZER START UP CHECK LIST FOR AKC ELECROLYZER			
Electrolyzer No.			
Cut Out Date / Time			
Cut In Date / Time			
Reason For cut out			
Major work carryout in the Electrolyzer during cut out			
Pre-Start-Up Check List			
SR. NO.	**CHECK POINTS**	**OK/ Not OK**	**Remarks**

1	Hydraulic pressure is **70 kg/cm^2** & Lock nuts are **25mm away**.		
2	Guide notch of cell arm fit side bar correctly installed.		
3	Side bar surface is not wet.		
4	All terminal cell clamps are taken out.		
5	All chains, clamps etc. used for holding the cell are removed from both sides & from top.		
6	Cables of terminal cell are not touched with any metal parts		
7	All locking pins are inserted between arms.		
8	All hoses are setup in parallel.		
9	Cap nuts for surplus nozzles are set with correct material.		
13	Electrolyzer earthling has removed.		
14	Nothing is remaining in on the Electrolyzer.		
15	Sample of anolyte outlet alkalinity - (It should be < 1000ppm)		
16	Feed and overflow all elements are OK		
17	Leakage from feed brine nozzle/tube		
18	Leakage from feed caustic nozzle /tube		
19	Leakage from return caustic overflow nozzle \ tubes		
20	Leakage from return brine overflow nozzle \ tubes		
21	Voltage Monitoring system connection for each elements done		
22	EDI connection done		
23	Orsat is ready		
24	Removal of blinds installed in chlorine header and depleted brine header.		
25	Installation of siren net in feed brine line for FC Electrolyzer		
26	Installation of Ni mesh in feed caustic, DM water line		
27	Electrolyzer trip switch is released		
28	Reduce the load in other Electrolyzer to ensure no tripping due to over current		

Start-Up Check List			
SR. NO.	**CHECK POINTS**	**OK**	**SIGN**
1	Ensure Hydraulic pressure is 90 Kg/cm^2 for NC		
2	Catholyte Temper (> 50 Deg C)		
3	Catholyte Conc. (30-32.5%)		
4	Polarization is ON(For E & H) /NA for others		
5	Element No and Voltage having < 300mV		
6	Status of Element voltage at 0.5KA		
	a) Elements having voltage > 300mV		
	b) Elements having voltage < 300mV		
	c) Low / No Reaction elements		
7	Status of Element voltage at 1KA		
	a) Elements having voltage > 300mV		
	b) Elements having voltage < 300mV		
	c) Low / No Reaction elements		
8	Status of Element voltage at 2.7 KA(1 CD)		
	a) Elements having voltage > 300mV		
	b) Elements having voltage < 300mV		
	c) Low / No Reaction elements		
Abnormality (If any)			
Overall Remarks.			
Checked By Approved By			

2. PROCESS SAFETY CONTROLS IN CHLORINE COOLING, COMPRESSION AND LIQUEFACTION AREA

- Secondary Chlorine Chiller Outlet Chlorine temperature indication for continuous monitoring to prevent formation of hydrate crystals at temperature below 13degC 14degC and to avoid moisture carryover in chlorine at high temperature.
- Drying tower sulphuric acid cooler acid/chlorine outlet temperature indication to prevent formation of hydrate crystals at temperature below 13degC 14degC and to avoid moisture carryover in chlorine at high temperature.
- Chlorine Drying tower sulphuric acid cooler chilled water outlet pH indication and continuous monitoring to identify cooler plate leakage and contamination of acid in chilled water.
- Chlorine Drying tower differential pressure indication required to avoid channelising of tower packings and back pressure in Chlorine header.
- Hypo blower suction hood arrangement in equipment floors to mitigate chlorine leak to atmosphere by keeping suction hoods.
- Chlorine sensors provision in chlorine handling areas for early detection and quick response in case of chlorine leak
- Chlorine compressor acid circulation cooler chilled water outlet pH indication required to identify cooler tube leakage and contamination of acid in chilled water.
- Monitoring chlorine purity in liquefier will help to detect hydrogen presence in chlorine.
- Chlorine liquefier high pressure interlock for plant trip is required to avoid back pressure of chlorine.
- Flange guards for Sulfuric acid lines required to avoid splash of sulfuric acid.
- Temperature indication for sulfuric acid inlet and outlet of acid cooler in chlorine compressor will help in monitoring moisture content in acid cooler to prevent corrosion of the compressor internals.

1 CHLORINE SECTION PROCESS SAFETY CHECK LIST

Cl2 washing tower	Level	30-40%
	Temperature	40 ^{0}C
	NaCl gpl	weekly by Lab
Cl2 chilling tower	Temperature	14-17 ^{0}C
Wet mist Filter	PDI	150 mmwc Max
Drying Tower -1	H2SO4 conc.	74-78%
	Level	30-35%
Drying Tower -2	H2SO4 conc.	95-98%
	Level	30-35%
Drying Tower -3	H2SO4 conc.	98%
	Level	30-35%
	Moisture in Cl2	Monthly By Lab
Cl2 compressor	H2SO4 conc.	98%
	H2SO4 Temperature	30-40 ^{0}C
	H2SO4 Level	30mm
	suction pressure	1500 mmwc
	Discharge pressure	3.5 kg/cm2
Dry mist filter	PDI	150 mmwc Max
Liquefier	outlet liquid temp	+3 to -3 ^{0} C
Liquefier	pressure	3 to 3.2 kg/cm2
Liquefier	Sniff Purity	weekly check by Lab (min 75 %)
freon	suction pressure	30 PSI
	discharge pressure	max 210 PSI
	Suction temperature	-1 to -4 ^{0}C
	Discharge temperature	90 ^{0}C max
	oil PDI	min 14 PSI

2 Section Interlock

Condition	Interlock
All Electrolyzer tripped	All Cl2 Compressor tripped, and Liquefier Outlet valve closed
All Cl2 Compressor tripped	All Electrolyzer tripped and Liquefier Outlet valve closed

2 MINIMUM SAFETY REQUIREMENTS IN LIQUID CHLORINE STORAGE & FILLING AREA

Safety checks required in liquid chlorine storage area

- Gas detector with hooter & beacon and alarm in control room
- Two layers insulation is required on tanks; cold insulation inside & hot insulation outside to protect tanks from heat, if any fire takes place in the vicinity. Old plants may adopt at the time of hydraulic testing.
- Minimum four fire monitors required at each corner of fencing which should be installed outside the fence. Old plants may install as per space available.
- High weight and high-level alarm in control room with isolation of production tank on auto mode. Old plants may adopt by installing on/off valves with interlock to close inlet valve as per margin available in piping.
- Rupture disc before safety valve and pressure gauge/pressure transmitter between safety valve and rupture disc to detect failure of disc.
- NRV in hypo line for back protection from wet chlorine
- Low pressure & high temperature alarm in control room with isolation of air padding valve in auto mode.
- Emergency blower for arresting any gas leakage; discharge connected to hypo plant.
- Flexible hoses with hood between two tanks long enough to cover valves & piping of two tanks.
- Shed with sides open over storage tanks for protection in rainy season; some old plants are having only shed for operator's platform; total tanks should be covered.
- Staircase at both ends.
- Breathing apparatus at storage tanks
- Portable fire extinguishers
- Sign board displaying minimum requirements of PPEs in hazardous area
- Windsock at suitable location clearly visible from storage tank area so that people can move to safe assembly point against wind direction, in case of leakage.

IMPORTANT PESO GUIDELINES ARE TO BE INCLUDED SEPARATELY IN EACH SECTION

Safety checks required in liquid chlorine filling area.

- Emergency blower for arresting any gas leakage; discharge connected to hypo plant.
- Flexible hoses with hood between two filling points long enough to cover two filling points.
- Emergency tool kit to handle & arrest any leakage from filled tonners.
- Gas detector with hooter & beacon and alarm in control room
- Minimum two numbers of self-contained breathing apparatus and two canister type gas masks in filling area
- Portable fire extinguishers
- Sign board displaying minimum requirements of PPEs in hazardous area.
- Weathercock at suitable location clearly visible from filling area so that people can move to safe assembly point, in case of leakage against wind direction.
- Minimum four fire monitors required at each corner of building.
- Remote operated shut off valve in liquid chlorine line coming from storage tank to isolate in case of severe leakage.
- Remote operated switch to shut all filling posts valves in case of severe leakage.
- Tonner filling automation to shut post valve to protect tonner from over filling.
- All cranes should be with weigh scale for counterweight checking.
- As per new PESO guidelines, cylinder hydraulic testing area must have dedicated crane & weigh scale for cylinders which are to be hydrotested.
- Standard weight should be available for cylinder weigh scale calibration.
- Filled cylinders must be kept within premises for 24 hours prior to loading/despatch.
- Before loading of filled cylinders, temperature & leakage must be checked, and valve's cap and protection cover must be placed.
- Cylinder details should be clearly visible and painting to be done at regular intervals to protect cylinder from corrosion.
- Cylinder original name plate should be applied grease as and when required to protect from corrosion.
- NRV in hypo line for back protection from wet chlorine
- Liquid trap in degassing line to trap any liquid chlorine going into hypo. Trap must have temperature transmitter to give alarm in control room to take further steps.
- No plastic line before liquid chlorine trap

3 RECOMMENDED SAFETY CHECKS FOR HYDROGEN GAS HANDLING AND BOTTLING

Some of the unique Hydrogen properties that contribute to potential hazards (flammability and explosivity) are:

- Hydrogen is a colourless, odourless, tasteless, flammable non-toxic gas which is flammable over a wide range of concentrations.
- Hydrogen is combustible over a wide range of concentrations. At atmospheric pressure, hydrogen is combustible at concentrations from LEL = 4% and UEL= 74.2% by volume, NFPA Rating
- Hydrogen has very low ignition energy
- Hydrogen burns with a non-luminous flame which can be invisible under bright light.
- Due to its small molecular size, Hydrogen can easily passthrough porous materials and can be absorbed by some containment materials.
- Hydrogen gas cylinders must be separated from oxidizing gases during storage and use by a distance of at least 20 ft (NFPA). Protect cylinders against heat and direct sunlight.
- Hydrogen can leak from apertures through which other gases cannot pass due to its small molecular size.
- Always ensure that there is adequate ventilation to handle the largest anticipated hydrogen leaks or spills. Ventilation with large quantities of air will dilute small hydrogen leaks to below the lower flammable limit of 4% in air
- Use of flammable gas detection alarm systems, alarms will be triggered at a specified concentration of Hydrogen.
- Ensure that alarms / flammable gas detection systems are calibrated regularly as per manufacturer's recommendations.

SAFETY PRECAUTIONS DURING HYDROGEN HANDLING AND BOTTLING

- Keep the hydrogen handling area free from flame and spark.
- Use non spark tools in H_2 Handling & bottling area.
- Venting of hydrogen is to be done only through water or flame arrestor.
- Hydrogen vessels/piping are to be purged with nitrogen prior to opening/maintenance
- Work on hydrogen line/vessel shall not be started unless it is confirmed safe by an explosion detector

- In case of fire in Hydrogen vent, isolate hydrogen inlets to vent and open out steam
- Fire hydrant system, portable fire extinguisher provided
- Fire water showering system is provided
- All requirements made as per PESO
- Heat/Smoke detectors, pressure relief valve, water seal is provided
- Flame proof electrical apparatus, earthing pit, static jumpers provided
- Instrumentation for various interlocks provided
- Railings are earthed
- Earthing / Static Jumper are provided
- Safety valves provided
- Explosive meters for leakage detection provided
- Restricted unauthorized entry

SAFETY PRECAUTIONS FOR H_2 BATTERY FILLING

- Check physical condition of truck and its wheels, health of mounted Hydrogen bank cascade, manifold, and its isolation valves healthiness and if ok then proceed further. If observe any improper fittings of cylinders and its accessories, loosen support of bank and manifold then reject and send back to Marketing with reason of rejection on DO and inform to Shift In-charge
- Battery received from party is to be checked first for Cylinder Birth certificates (Manufacturing certificates), CCE certificates, Hydro test certificates
- Check battery cylinders filling capacity 150 kg/cm2 or 200 kg/cm2, Marketing
- D.O. is to be accepted as per design filling capacity only
- Check cylinders certificates with GACL master file and if HT is not due then QCD slip is to be filled for gas content analysis
- Check battery must have positive pressure, if pressure is zero, inform Shift
  in-charge and marketing department. Zero pressure battery may contain air and other gases, so it is not to be filled without clearance from superior and QCD
- After QCD Ok, connect battery on filling header
- Wooden blocks are to be placed on both sides of Battery truck tyres, to prevent it to move forward and reverse during filling and leak testing jobs

- As per CCE rule, double earthing for each battery is to be given during filling, one earthing for Cascade (H_2 cylinder battery) and second for truck body
- Verification must be done by green LED (healthiness of earthing) earthing meter. If find any LED red (un-healthiness of earthing), then fix earthing crocodile pin properly to make it green LED. Still observe red LED then inform electrical to check earthing meter and its probe. Do not start filling with red LED
- Open battery filling valves and all cylinders' individual isolation valves and line up with main filling header but do not open the header filling valves before flushing of header
- Vent valve of header is to be kept open, start water in seal pot
- Check oil level of compressor, H_2 pressure at receiver and Interlock healthy indication at H_2 cabin panel (No alarm bulb glow means all interlocks are healthy)
- Ask for clearance to Main control room for compressor start up
- Start compressor, flush header with hydrogen by closing vent valve of header and open it when header pressure reaches 50kg/cm2. Perform this exercise minimum two times and finally close the vent valve and open the filling valve
- Take leak test on every 25, 50, 75, 100, 125, 150 kg/cm2 pressure, in case of 200 kg/cm2 battery further pressure testing is to be continued at 175 and 200 kg/cm2 with dense soap solution, during this intermediate leak test, if any part of cascade or fitting, connecting tubes, pig tails, valve-cylinder bushing and valve gland leakage is observed, battery filling is to be stopped immediately
- Inform Main control room, Shift In-charge, Marketing Dept., and bottling foreman. If leakage is in increasing trend, inform CCR, Fire Dept. and Security.
- Leakage battery is to be transferred to another battery at slow rate (Rate not more than 220 Nm3/hr because all headers and filling tubes designed for this optimum flow) and battery which is leaking, is to be kept wet with constant water spray with the help of Fire Dept., The header which is in operation for battery transfer is not to be used for any other battery filling with compressor. Header temperature is to be measured periodically with temperature gun. After complete transfer, empty battery with zero pressure is to be sent back to marketing department for repair
- Take readings of all parameters for each running compressor during battery filling. Also check that condensate drain cycle must operate at

every 20 to 22 minutes for its specified time (Time set by Instrument department as per actual condensate quantity), condensate pot is to be drained as per level in its two sight glasses, its level should not go below bottom side middle portion of sight glass during draining

- Compressor Trip Interlock is as under:
    - Low Suction Pressure.
    - High Discharge pressure
    - High Discharge temp
    - Lube Oil pressure low
    - Overload Trip
    - Rectifier Trip

Work Instructions to carry out Hydraulic Testing of Hydrogen Gas Cylinders

- Connect the empty H_2 Cylinder to Hydrogen vent Header. Release H_2 pressure to zero through water check for any damage to valve bushes of cylinder
- Fill the water in the hydrogen cylinder
- Fit new/tested hydrogen valve
- Connect the cylinder with Hydraulic Testing Machine
- Raise the pressure to 225 kg/cm2 gradually
- Hold the pressure for 1-2 minutes
- Check the leakage, if any
- Release the pressure. Drain water and punch the Hydraulic test date on the neck of the cylinder
- Reject the cylinder, if the permanent expansion is 10% or more and weight loss is 5% or more
- Cylinder can be used for filling after it passes in hydrotest

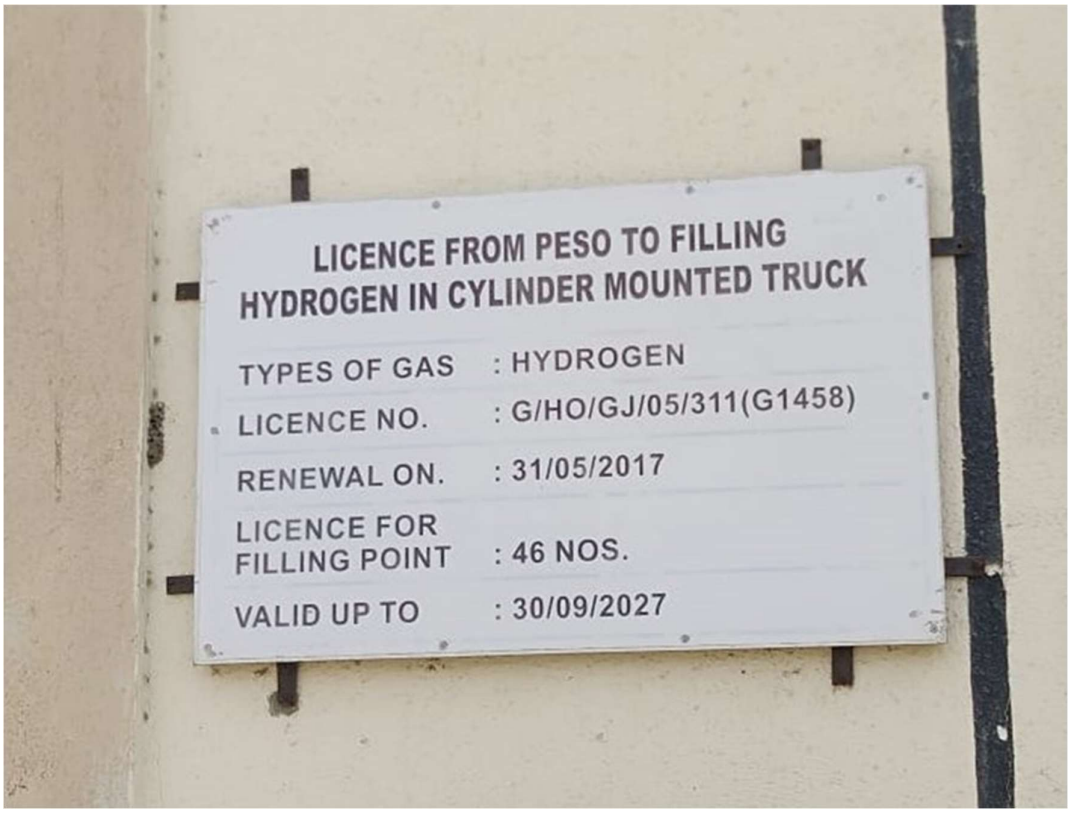
Work Instructions to carry out Hydrogen Gas filling in cylinders

- Check the analysis of oxygen content in the hydrogen gas before every start-up of filling operation
- Check previous hydraulic testing date, if last hydraulic testing was done more than five years back, send the cylinder for hydraulic testing after degasification
- If hydraulic testing is not required depending on position at 2, take the cylinder for hydrogen gas filling and connect to hydrogen filling header
- Check and record cylinder no. and volume Nm3 to be filled
- Start hydrogen gas compressor and open hydrogen cylinder valve as well as hydrogen header valve gradually

- Purge the connected hydrogen cylinder by keeping purge valve and filling valve open for 5 minutes
- Close the purge valve
- Raise the Hydrogen pressure in cylinder to 150 or 200 kg/cm2 as per requirement
- Disconnect the cylinder at the above pressure and release the pressure in purging header. Keep the cylinder in a separate filled area. Dispatch the cylinder after achieving ambient temperature

Compressor Area

Filling Hydrogen License



H2 Battery Loading Area

H2 Battery Double Earthing

4 HYDROCHLORIC ACID PLANT SAFETY REQUIREMENTS

- Adequate condensate removal systems for Cl_2 and H_2 inlet pipelines. Adequate seal height as per operating pressure in Cl_2 & H_2 pipes for auto drain & its collection
- Hydrogen pipe should be provided with earthing strip (one bolt each side should relate to Cu connector) Jumpers to be provided at flange joints
- On/off valves should be provided in Cl_2 and H_2 inlet lines
- Nitrogen purging system
- Flow meters for Feed, Chlorine, Hydrogen, Cooling water flow measurement
- Stack monitoring system for HCl vapors with digital display at site & DCS along with high level alarm
- Low nitrogen pressure alarm
- Following essential safety interlocks should be in place:
    - Flame failure
    - Hydrogen and Chlorine low & high pressure
    - Feed flow
    - Cooling water flow
    - Emergency trip button at a strategic location
    - Unit high chamber pressure

    - Closer of inlet Chlorine valve -on/off valve immediately (in best possible minimum time say ~20 milli seconds) after unit tripping
- To ensure on/off feedback system of inlet on/off valves are functional all the time
- Lightening arrestor installation at appropriate location
- Nitrogen injection facility in HCL final stack
- Flashback Arrestor placement in the Hydrogen pipeline prior to combustion burner
- Nitrogen Valve to be immediately open as soon as unit trips in any one of the mentioned interlocks, less than a second
- Hydrogen flow should always be higher than chlorine during Start -Up and during varying load conditions of the unit
- Rupture disc placement with proper pressure rating
- HCl production day tank level monitoring system
- HCl tanks (process/storage) carries Hydrogen. Proper permit system /vessel entry should be in place

5 SODIUM HYPOCHLORITE PLANT SAFETY REQUIREMENTS

- ORP METER: - ORP METER should be there to check the Chlorine flow variation
- Chlorine Sensors: - Chlorine sensors should be there
- Emergency Plant Tripping: - Plant should be tripped in case of high temperature (More than 38 degree) to avoid the decomposition of hypo
- Emergency Caustic Tank: - Caustic tank of 18% Caustic should be there (for emergency), when plant tripped due to any reason. Caustic should go in absorption tower automatically
- Minimum Capacity: - Hypo plant should run for minimum 20 minute in case of tripping, at full load of Main plant
- Stack Monitoring: - Alarms should be there for monitoring the stack conditions
- Minimum GPL: - Minimum 20 gpl & below 25 degree of Caustic should be there in Absorption tower before transferring to the storage tank, to maintain the stability
- VFD: - Variable frequency drives should be there in blower system
- Cooling System: - The hypo is cooled to less than 38 degree by means of chilled water. In case of un-availability of chilled water, cooling water system should be opened

- Storage Duration: - Hypo stored in storage tank should be dispatched at regular interval of time. It should not store for long time in storage tank to avoid decomposition due to high ambient temperature
- Proper co-ordination should be there between main plant & hypo plant

CHECKLIST DURING POWER FAILURE (BLACK OUT) IN CAUSTIC SODA PLANT:

Cell house

- Catholyte circuit healthy.
- Ensure Lean brine circulation healthy.
- Pure Brine circulation healthy.
- Electrolyser's flow is healthy
- N2 flushing in electrolyser.
- H2 to H2 holder valve completely closed (0% open).
- Cl2 to hypo control valve open.
- Cl2 to compressor valve fully closed (0% open).
- Differential pressure of Cl2 & H2 to be maintained 200 mmwc.
- Polarisation rectifier healthy.
- Catholyte discharge to intermediate tank valve is closed and DM Water addition to CSL 32% is closed.

Sodium Hypochlorite Plant.

- ☐ Ensure Sodium Hypochlorite Recirculation pump started on Emergency power supply (DG set).
- ☐ Check All Caustic soda 32% tank level should be maintained.
- ☐ Confirm Vacuum in the system to be maintained -200 to -250 mmwc

Utility

- ☐ Ensure Emergency Power supply (DG Set) immediately ON
- ☐ Confirm Emergency cooling water pump started
- ☐ Confirm Startup of Instrument Air compressors to maintain Air pressure (> 6 bar)
- ☐ Ensure N2 PSA started.
- ☐ Start Unloading Air compressor.
- ☐ Confirm Startup of EG brine pump.
- ☐ Take Chlorine Evaporator from Bullet.
- ☐ Start Chilled water pump.

Brine

- ☐ Clarifier racer arm ON.
- ☐ Brine circuit established.
- ☐ All tank level maintained.
- ☐ Agitation air blower ON.

Secondary Brine

- ☐ Confirm Vacuum pump is started.
- ☐ Ensure 78% and 98% H2SO4 dosing on.
- ☐ DM water flow in Cl2 seal, wet Cl2 filter, H2 filter started
- ☐ Start lean brine pump.

Cl2 Compressor

- ☐ Suction and discharge valve closed
- ☐ Guide vane closed
- ☐ Recycle valve open
- ☐ Auxiliary oil pump ON

Freon Compressor

- ☐ Compressor is in manual mode
- ☐ Expansion valve is in manual mode
- ☐ Auxiliary oil pump is ON

Chlorine Bullet

- ☐ Chlorine Production valve closed.

Chlorine Bottling Plant

- ☐ Confirm Stoppage tonner filling.

HCl Plant

- ☐ Confirm all Chlorine and Hydrogen valves are closed
- ☐ Confirm N2 purging is done in all furnaces.
- ☐ Ensure DM water valve is closed.