तार- "विस्फोटक", नागपूर
Telegram: 'EXPLOSIVES', Nagpur
Website : http://peso.gov.in
Email: explosives@explosives.gov.in
दूरभाष/ Telephone : 0712-2510248
फ़ैक्स/ FAX : 2510577
कार्यालयीन उद्देश्य के सभी पत्रादि "मुख्य विस्फोटक नियंत्रक" के पदनाम से भेजे जाए उनके व्यक्तिगत नाम से नही.
All communications intended for this Office should be addressed to the 'Chief Controller of Explosives' and NOT to him by name.

भारत सरकार
GOVERNMENT OF INDIA
पेट्रोलियम तथा विस्फोटक सुरक्षा संगठन
PETROLEUM AND EXPLOSIVES SAFETY ORGANISATION
(पूर्व नाम – विस्फोटक विभाग)
(Formerly- Department of Explosives)
"ए-ब्लाक, पाँचवा तल, केन्द्रीय कार्यालय परिसर,
"A" Block, 5th Floor, CGO Complex,
सेमिनरी हिल्स, नागपूर - 440 006 (महा)
Seminary Hills, Nagpur- 440006

संख्या /No CVIII(3)125 CIR/MSIHC

दिनांक /Nagpur, dated : 02/07/2019

21 JUL 2019

MEMO

Sub: Guidelines for transfer of Chlorine through Pipeline – Regarding.

With reference to OM No. C-I-43012/4/2016-CHEM.I dated 10/04/2019 received from Ministry of Chemicals and Fertilizers, Department of Chemicals and Petrochemicals, the **Guidelines for transportation of Dry Chlorine Gas through Pipeline within Industrial Zone**" is enclosed herewith for information and necessary action.

21/7/19

(M.K. Jhala)
Jt. Chief Controller of Explosives (H.O.D.)

To,
Heads of Circle and Sub Circle, FRDC and NAPES-TS for information
(Through PESO Support site and email only)

C-I-43012/4/2016-CHEM. I
Government of India
Ministry of Chemicals and Fertilizers
Department of Chemicals and Petrochemicals

Shastri Bhawan: New Delhi
Dated:**10/04/2019**

OFFICE MEMORANDUM

Subject: Guidelines for transfer of Chlorine though pipeline-reg.

Please find enclosed herewith the "Guideline for Transportation of Dry Chlorine Gas Through Pipeline within Industrial Zone", for it's implementation, and further necessary action.

2. This issues with the approval of Secretary (C&PC).

(Sanjay Krishan Navhale)

Deputy Secretary
Tele. No.- 011-23380592

Encl: As above

Shri. M.K. Jhala
Chief Controller of Explosive
A Block CGO Complex Fifth floor Seminary Hills
Nagpur-(Maharashtra) -440006

Presented to me today.
2. Pl examine.

1st March 2019

Shri P Raghavendra Rao, IAS
Secretary
Department of Chemicals & Petrochemicals
Ministry of Chemicals & Fertilizers
Government of India
New Delhi

JS(C) pl put up 1/3/2019
05/3/19
AIA(RM)

Report of the Expert Committee constituted by the Department of Chemicals & Petrochemicals to develop Guidelines for Transportation of Chlorine through Pipeline

Sir,

I am pleased to present our Report and the Guidelines for transportation of Chlorine through Pipeline.

A representation was made by the Indian industry to your goodself for developing the guidelines. You had constituted an Expert Committee for the purpose headed by the Chief Controller of Explosives, Petroleum and Explosives Safety Organisation, GoI as Chairman of the Committee to specify the requirements for laying of pipelines for transportation of chlorine.

Composition of the Committee:

1. Chief Controller of Explosives, PESO – Chairman of the Committee
2. Shri D. Praveen, Director, DCPC – Member Secretary

Members

3. Representative from MoEFCC
4. Dr. Narender Sharma, Additional Director, CPCB
5. Shri Shirish M. Pathak, Vice President, Reliance Industries Limited
6. Shri D.B. Jain, Advisor to MD, GACL
7. Shri K. Srinivasan, Secretary General, AMAI

The Expert Committee held five meetings. The first meeting of the Expert Committee was held on 28th May 2018 and the final meeting held on 1st March 2019. The Minutes of four Meetings of the Expert Committee are **enclosed as Annexure 1a to 1d.**

The Expert Committee decided to engage the services of an independent expert/consultant with experience in execution of projects to develop the framework document. Based on the requirements, the Committee accepted the appointment of thyssenkrupp Industrial Solutions India Pvt. Ltd. (tkIS), Mumbai for preparation of the basic document.

The Expert Committee decided to undertake a Study Tour to a chlorine pipeline site to understand details of the requirements for laying, operation and monitoring of chlorine pipelines. Members of the Committee headed by the Chairman visited the chlorine pipeline site of AkzoNobel in Bitterfeld, Germany. The visit was facilitated by Euro Chlor through AMAI. The report based on this Study Tour is **enclosed as Annexure 2.**

I am pleased to enclose the final "Guideline for Transfer of Dry Chlorine Gas through Pipeline" as approved by the Expert Committee.

While this Guideline will not be statutory in nature, it is intended to supplement existing regulatory requirements.

I take this opportunity to thank all the Members of the Committee for their active involvement in the preparation of this document, Dr. Sanjay Kumar Singh, Controller of Explosives, PESO and Shri S N Sastry from Grasim Industries Ltd., Shri M A Hania from Meghmani Finechem as Special Invitees to the Committee, Shri Ranga Rao, independent expert from tkIS, Mumbai, Dr. Rohit Misra, Assistant Industrial Advisor, DCPC, Euro Chlor and AkzoNobel, the host company in Germany whose support have been valuable in the preparation of this Guideline.

Yours faithfully,

Dr. A. P. Singh
Dy. Chief Controller of Explosives, PESO
Officiating Chairman of the Expert Committee

Guideline for Transportation of Dry Chlorine Gas Through Pipeline within Industrial Zone

March, 2019

First Edition, March, 2019

Composition of Expert Committee:

Chief Control of Explosives, PESO, Chairman

Mr. D. Praveen, Director, C&PC, Member Secretary

Representative of MOEF&CC, Government of India, Member

Dr. Narender Sharma, Additional Director, CPCB, Member

Shri D.B. Jain, GACL, Member

Shri S.M. Pathak, RIL, Member

Shri K. Srinivasan, AMAI, Member

Special Invitees for Technical Advice

Dr. S.K. Singh, Controller of Explosive, PESO

Dr. Rohit Misra, Assistance Industrial Adviser, DCPC

Shri M.A. Hania, MFL

Shri S.N Sastry, GIL

Shri N. Ranga Rao, tkIS-India

Disclaimer:

This document only a guideline prepared for ensuring safe transportation of Dry Chlorine gas through pipelines. These guidelines do not offer any exemption from obtaining clearances under Environmental Act, Rules and other Regulations

FOREWORD

Chlor Alkali industry produces Chlorine in the ratio of 0.89 tons to each ton of caustic lye. Chlorine being a hazardous material, it requires and demands safe handling and utmost care.

Dry Chlorine Gas transportation through pipeline has been widely practiced within plant premises for several decades, fortunately without any major incidents of leakage or emission – the design, operational methodology, etc. are well established.

Chlorine transportation in liquid state, particularly over long distances and cross fences, is still not prevalent, though widely practiced in the US, Europe, China, etc., and proves to be the most economical means for bulk transport of liquid Chlorine.

Keeping this in view, an attempt is being made to prepare a document for easy reference; this guideline to cover all aspects of Dry Chlorine Gas transport through pipelines. We trust this will provide a ready reference beneficial to designers, contractors, operators and managers involved in the Chlor-alkali field.

PREFACE

Chlorine is co-produced with caustic soda but its consumption is more widespread and scattered.

Customers of Chlorine are located in a much wider area. With Chlorine gaining wider acceptance for drinking water disinfection and wastewater treatment, transportation of Chlorine will cover longer distances and traverse all types of terrain. In most of these cases, liquid Chlorine is transported in tonners. However, for customers who regularly consume large volumes, it is preferable to transport dry Chlorine gas through pipelines; it is safer and economical in the long run.

There was a need felt for developing a guideline document for transportation of dry Chlorine gas through pipelines over long distances.

Department of Chemicals and Petrochemicals, Ministry of Chemical and Fertilizers, Government of India took an initiative and constituted an expert committee.

Expert committee took up the task of developing a document for the Indian industry as there is no reference guideline presently available. In developing this guideline document, we have largely relied on The Chlorine Institute's pamphlet on Chlorine pipelines and the EuroChlor document on transportation of dry Chlorine gas by pipelines. The US and Europe have large volumes of Chlorine transported over long distances by pipelines for many years. We have attempted to address the peculiarities of the Indian conditions in this document.

We hope the Chlorine producers, consumers and those connected with pipeline logistics will find this a useful reference document.

Delhi

March, 2019

ACKNOWLEDGEMENT

Expert committee gratefully acknowledges the assistance received from The Chlorine Institute and Euro Chlor in the preparation of this document. The contents of this document are largely based on the following documents:

- The Chlorine Institute Pamphlet 60 (7th Edition) on Chlorine pipelines
- Euro Chlor document number GEST 73/25 (11th edition) on Transport of Dry Chlorine by Pipelines.

We are thankful for the support from Mr. Robyn Kinsley, Vice President, Transportation & Emergency Preparedness, The Chlorine Institute, Washington and Mr. Ton Manders, Technical & Safety Director, Euro Chlor, Brussels in allowing us access to the above documents which were invaluable inputs for this publication.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 SCOPE

- This document provides guidelines for the design, construction, operation and maintenance of Carbon Steel pipelines that transport dry Chlorine gas. The guidelines are applicable to pipelines that terminate outside the Chlorine producers' premises or cross premises not owned by the producer or consumer of Chlorine. However this guideline may not be applicable for pipelines entirely within a plant, these are provided by the Chlor-Alkali technology supplier and or Chlorine plant designer.
- It is recognized that pipelines built prior to the publication of this edition of this document may be operating successfully without adhering to all guidelines contained herein. Designers of such facilities should evaluate discrepancies and validate to ensure they do not pose disproportionate risks to safe operation or the environment. Continued operation without adhering to all aspects of this document is generally acceptable provided

  1. Previous, successful, long-term operation, coupled with periodic hazard evaluations, show that risks to safe operation and the environment are sufficiently low.
  2. The system does not violate applicable codes or regulations
  3. Consideration is given to modifying the system to meet guideline contained in this document when redesign or replacement projects are planned.

1.2 ABBREVIATIONS USED AND DEFINITIONS

ASME	American Society of Mechanical Engineers
ANSI	American National Standards Institute, Inc
API	American Petroleum Institute
BIS	Bureau of Indian Standards
CI	The Chlorine Institute
CCoE	Chief Controller of Explosives
DCPC	Department of Chemicals & Petrochemicals, GOI
DCS	Distributed Control System
Dry Air or Nitrogen	Air or Nitrogen dried to a dew point of (-)40° C or below measured at the operating pressure
Euro Chlor	European Federation represents producer of Chlorine and its primary derivatives
OSHA	Occupational Safety and Health Administration, U.S. Department of Labor
Operator	Chlorine Producer and Chlorine Consumer
PESO	Petroleum and Explosives Safety Organization
PTFE	Polytetrafluoroethylene
SIL	Safety Integrity Level study
HAZOP	Hazard and Operability study
HAZID	Hazard Identification study
HAZAN	Hazard Analysis study
EIA	Environmental Impact Assessment study
RA	Risk Analysis study
QRA	Quantitative Risk Analysis study
HDD	Horizontal Directional Drilling system
SCADA	Supervisory Control and Data Acquisition system
ESD	Emergency Shutdown System

1.3 APPROVAL

Expert Committee approved this Edition of the document on Transportation of Dry Chlorine Gas through Pipeline

1.4 REVISIONS

Suggestions for revision should be directed to the expert committee.

2. GENERAL

2.1 BASIC CONSIDERATION

Chlorine is essential in the chemical industry and consequently there is a need for Chlorine to be produced, stored, transported and used. Chlorine can be transported safely by a long distance pipeline, either in the gas or liquid phase, provided the appropriate design and operating conditions is satisfied. All precautions should be taken such that, in a pipeline designed for the transport of dry Chlorine gas, nothing should lead to the formation of liquid or condensate. Specific precautions required for the same is described in this document.

- **GAS AND LIQUID PHASE CHANGES**

  Phase changes are generally most difficult to handle during start-up. Suitable steps must be taken in design and operation to ensure adequate control of the process temperature and pressure. It is essential that a study of operating conditions be thoroughly carried out, because unusual equipment design and pressure ratings may be required to address the potential for condensing in the pipeline.

  Dry Chlorine vapour introduced into a pipeline may expand, cool, and partially condense. When this happens, sudden pressure swings may occur in the line pressure. A phase change can also be caused by pipeline cooling due to ambient conditions. For pipelines exposed to ambient conditions lower than the process temperature, regulated electric heat tracing and/or insulation should be considered. Changes in ambient conditions can also cause a phase change.

  Pressure reduction points, such as pressure control or regulating valves, are the most likely locations for phase changes in a pipeline. In gas pipelines the refrigeration effect of expanding Chlorine gas may cause a portion of the gas to condense into the liquid phase.

- **DESIGN CONSIDERATION**

  Suitable consideration of the consequences of a leak and suitable means of minimizing or handling leaks must be undertaken in the early stages of design.

- **DIAMETER OF PIPE LINE AND FLUID VELOCITY**

  It is preferred to select pipeline diameter so as to have gas velocity less than 20 m/s. This also depends on the length of the pipe line and pressure drop across the pipe line. Possibility of condensation of gas due to pressure drop to be reviewed while selecting the pipeline diameter.

- **PIPE WALL THICKNESS**

  The minimum nominal wall thickness for pipeline shall be as per ASME B31.8.

Higher thickness may be used if required to reduce stresses or for providing stability during installation and service.

2.2 ROUTING

While choosing a route for a pipeline, special consideration must be given to environmentally sensitive areas and avoid populated area. Minimise the public access as much as possible while routing a pipeline. Consideration should also be given to potential pipeline damage due to adjacent pipelines, soil conditions, traffic, vandalism, and other conditions along the route. These considerations are especially important when the pipeline traverses ground not under direct control of either the producer or the consumer. Each case has to be treated appropriately and suitable studies to be conducted on case by case basis.

Pipeline shall be located and routed considering following aspects:

a. Pipeline should be installed in the notified industrial area / SEZ / Industrial zone located in PCPIR
b. Pipeline hydraulic requirement.
c. EIA, RA and QRA study for the pipeline.
d. HAZOP, HAZID study and HAZAN Study for the pipeline.
e. Approachability, water table, flood level and natural drainage
f. Habitation
g. Availability of electric power

The route for Chlorine pipe line should:

a. Provide the shortest and least complicated design, minimizing the Chlorine inventory in the line, while maintaining the ability to satisfactorily accommodate thermal movement
b. Provide the maximum protection to the pipeline from all risk of external damage (mechanical, corrosive, fire or explosion etc.), whether such risk exists at the time of installation of the pipeline or is brought about by subsequent installations; potential risks created by the proximity of other pipelines or high voltage electric cables should be controlled
c. Avoid, whenever possible, any risk of the normal line temperature being affected by an external source of high heat output, such as adjacent steam pipelines, pipelines containing flammable gases or liquids, etc. and if a high temperature risk exists the Chlorine line should be protected (physical isolation, fire resistant barrier, fire resistant insulation, etc.)
d. Allow sufficient access for inspection even though permanent facilities are not necessary
e. Consider potential risks from natural disasters like earthquake, flooding, storm, etc.

Marking visible at distance or colour-coding of pipes is recommended, particularly on pipe racks or pipe bridges where immediate access is not possible.

If the pipeline is above ground, it should be protected from any risk of mechanical damage such as falling objects, collisions, etc.

If the pipeline is laid in a pipe trench, it must be provided with sufficient support, together with drain provisions to remove water or possible corrosive liquids from the trench. The trench should also permit access for inspection of the pipeline. Any crossing which is unstable or susceptible to earth movement like land sliding, underground buried pipeline is not preferred.

It is recommended not to consider Chlorine pipeline for Seismic zone IV and V

3. BASIC DESIGN AND INSTALLATION

3.1 GENERAL DESIGN CONSIDERATIONS

The material selected for pipeline shall be suitable for handling of dry Chlorine gas. Possibility of condensation of Chlorine gas shall be considered while selecting the material for pipe line. For the minimum specifications for materials used in dry Chlorine gas service refer Annexure II – Piping Specification. Design specifications need to be determined based on the potential range of operating conditions of the pipeline system including start-ups, abnormal operating conditions, shutdowns, and system evacuation. In selecting materials careful consideration should be given to the minimum temperature to which any part of the system may be subjected. Additional cold service charpy testing as per ASME Code may be required if API Specification 5L piping is used. It should be noted that the boiling point of Chlorine at atmospheric pressure is -34°C. This is the temperature a pipeline may be subjected to when a liquid Chlorine pipeline is vented to atmospheric pressure. Refer Annexure I – Chlorine vapour pressure curve[1].

The maximum recommended temperature to which any section of a carbon steel pipeline should not exceed 120°C in order to avoid Chlorine-Iron fire.

The designer should review and consider applicable regulations.

Points to be considered while design and operation of dry Chlorine gas pipeline system are as follows:

a. The pipeline to be designed in a manner that ensures adequate safety under all condition likely to be encountered during installation, testing, commissioning and operating conditions.
b. The operating pressure to be considered which is technically achievable
c. The minimum ambient temperature and corresponding Chlorine vapour pressure shall be taken into account while defining the operating pressure in pipeline to avoid the condensation of gas. Associated hazard due to the same to be studied while designing and laying the pipe line. During winter the operating pressure and temperature are adjusted in such a way that no condensation is accrued due to low ambient temperature. For above ground pipeline, operating pressure should be $\leq$3 bar.g and for underground pipeline, operating pressure should be $\leq$5 bar.g.
d. Requirement of insulation / electrical heat tracing to be reviewed in order to avoid condensation / liquefaction of Chlorine. In case heat tracing to be provided, ensure that at no point metal temperature shall exceed 120°C. For underground buried pipeline avoid insulation and heat tracing.
e. If insulation to be provided, the material shall be non-flammable, chemically inert to Chlorine, totally sealed against ingress of moisture, protected against mechanical damage. Aluminium

[1] From Chlorine Institute Pamphlet number 1

cladding shall not be used over the insulation as it is reactive with Chlorine, Galvanised Iron sheet / Stainless steel sheet / Cementing cladding to be chosen. The bare pipeline shall be coated with anti-corrosive painting before application of insulation.

f. Design Pressure:

- While estimating the wall thickness, following condition shall be taken into consideration;

  Maximum Operating Pressure + margin as per ASME B31.8 for design pressure + 1.5 mm Corrosion Allowance.

- For dry Chlorine gas pipeline complete pipeline system should be design for minimum pressure of 1.5 times maximum operating pressure.
- In case possibility of condensation of Chlorine gas in pipeline, pipeline should be design for a maximum operating pressure equivalent to vapour pressure of Chlorine at the maximum operating temperature chosen.
- It is recommended to consider 26 bar.g for pipeline design, even if calculated pressure from the above case is less than 26 bar.g

g. Design temperature of Chlorine pipeline to be considered based on maximum temperature being attained and minimum temperature possible in system. In case possibility of condensation of Chlorine in pipeline, the pipeline shall be designed for minimum temperature of -40^{0}C.

h. Adequate control of pressure and temperature to be ensured at producer end.

i. Evacuation plan for the quantity of Chlorine contained in the pipeline system.

j. Material of construction for pipe line, valves, instruments suitable for handling the dry Chlorine gas. The metal used for the flanges, nuts, bolts shall be of same characteristics as that of pipeline.

k. Minimum corrosion allowance of 1.5 mm should be considered.

l. Type of manual isolation valve and control valve suitable for handling the Chlorine.

m. Pipelines may be installed above ground or below ground. The entire system should be evaluated to determine the preferred method.

n. Consider isolation valve at producer end and at consumer end. If offsite isolation valves are required by risk modelling studies like QRA study etc., they should be located and protected to prevent access by unauthorized persons. Preferably, isolation valves should be located within an industrial site and also ensure that the evacuation system is available for the Chlorine inventory between the onsite isolation and offsite isolation valves

o. Intermediate flange is not recommended in order to avoid the leakage point.

p. Site survey from public safety point of view.

q. The pipeline should be protected from all risks of external fire or explosion, whether such risk exists at the time of installation of the pipeline or is brought about by subsequent installations.

r. Suitable consideration of the consequences of a leak and suitable means of minimizing or handling leaks must be undertaken in the early stages of design.

s. In case line is routed above ground, it is preferred to have Chlorine detector at regular intervals less than 60m distance away in order to monitor the pipeline leakage.

t. Leak detection system like optical fibre can be considered for underground pipeline.

u. For underground pipeline it is preferred to consider earth excavation monitoring system like "Perimeter Intrusion Detection System (PIDS)" to avoid uncontrolled excavation and damage of line due to excavation.

v. Chlorine transfer equipment

- For gaseous Chlorine, the choice of compressor for feeding the pipeline system is a function of the characteristics required (throughput, operating pressure, maximum pressure). A non-return system should be installed on the downstream side of the compressor and particular attention must be paid to its reliability, the choice of an automatic valve is recommended.
- If the gas supply comes from vaporization of liquid Chlorine, and if the working pressure is high enough, it is possible to work without any additional transfer equipment.

w. If two parallel Chlorine pipe lines need to be run then the gap between the two pipe lines to be maintained as per good engineering practice or as per maintenance requirement, applicable for both underground and above ground pipe lines.

x. All valves used for Chlorine service are Euro Chlor designed and Euro Chlor certified valves.

3.2 INSTALLATION AND CONSTRUCTION

3.2.1 Design Considerations

Pipelines may be installed above or below ground. The entire system should be evaluated to determine the preferred method.

For gaseous Chlorine, a buried pipeline should be considered where operating conditions do not necessitate either heat tracing or thermal insulation to avoid risk of condensation; this means only in circumstances where the pipeline is operated at a sufficiently low pressure.

- It is easier to monitor an aboveground system, but overall safety considerations may indicate an underground pipeline is preferred. Underground piping should be installed in a dedicated concrete casing with sand fill or buried at a level below the normal frost line and not less than that required by regulation. Consideration should be given to burying the line deeper to prevent accidental impact and also allow for warning indicators to be buried/fixed above the pipeline. Refer Annexure – II & III for typical pipeline cross section.
- Special attention should be given to protecting the pipe from corrosion, especially at points where buried lines enter and leave the ground. Thick walls should be considered on Chlorine

pipelines to allow for corrosion and provide mechanical strength. Use of thick walled pipe allows the pipeline to be used beyond the normal life of plant process piping. Pipeline should be designed for a life of minimum 25 years.

- Provision must be made to evacuate the Chlorine gas in the pipeline to a safe location. This includes an absorption system at producer and consumer ends of the pipeline. Capacity of Chlorine absorption unit to be decide based on capacity of Chlorine inventory to be evacuated and time required to evacuate the inventory, based on risk modelling studies like QRA study etc.
- Where necessary to cross right-of-way, roadway, railway tracks, highway or waterway (river/Nala & Canal), the pipeline must be designed with sufficient protections such as height above grade to preclude vehicular damage or be installed below ground. When crossing navigable waterways the pipeline should be buried well below the bottom so the line cannot be impacted by passing vessels or dredging activities. Open cut, Auger boring or HDD method can be used for such crossings.
- Underground piping can suffer 3rd party damage due to poor excavation techniques. The design should consider means to reduce any major damage to the pipeline. Underground excavation monitoring system to be established.
- Design techniques that have been used should include increased depth of cover, increasing wall thickness, and concrete coating of the pipe.
- Vents and drains outside the supplier's or consumer's property should be avoided if possible. Vents, drains, or other small protrusions from main lines that must be installed should be protected from potential damage or tampering.
- Consideration should be given to underground line marking tapes to notify excavators of the existence of an underground line and/or SCADA fiber-optic alarm cable installed above the pipeline. (Refer Part V of Chapter III under Petroleum Rules, 2002).
- "Double walled pipe" or "Pipe in Pipe" construction to be considered for situations such as pipe section running above ground in populated area, casings under roads, railways crossing etc. In cases where double walled pipe is used, steps should be taken to prevent moisture accumulation in the annular space. In such case annular space to be padded with Dry Air or Nitrogen gas. Annular space pressure shall be monitored continuously in producer and consumer DCS.
- All pipelines should be well supported and supports should be capable of withstanding hydraulic forces that can result from starting and stopping flow.
- Leak detection systems are required. Consideration should be given to install an automated leak detection system on Chlorine pipelines. This could be something as simple as measuring mass flow on each end of the line or a leak detection system which employs both pressure

analysis, temperature analysis and mass balance to verify the line is not leaking or Chlorine detection system at every 60 m for above ground portion or fibre-optic measuring method.

- Underground pipeline shall be provided with sufficient support, together with drain provisions to remove rain- and drain water, or possible corrosive liquids from the trench. The trench should also permit access for inspection of the pipeline.

3.2.2 Welding

The welding of carbon steel pipelines must be performed in accordance with written welding procedures that have been qualified under Section IX of the ASME Code (11.4.2) or Section VI of API 1104 (11.5.1). Welders must be certified for each procedure. The welding has to be inspected by a third party.

- If required by ASME B31.8 welds must be preheated and/or stress relieved.

3.2.3 Inspection and Records

Visual inspection of all welds is required. Non-destructive testing procedures must be used in accordance with ASME B31.8. This procedure includes radiography, dye penetrate, or other test methods recognized by ASME.

All butt welds are to be 100% radiographed. A combination of radiography and/or dye penetrate testing procedures should be used for all welds depending on the weld configuration. The weld area and pipe should be thoroughly cleaned after dye penetrate testing.

Radiographic techniques will identify many types of weld defects but are not fully effective for all weld configurations. Dye penetrate testing will sometimes locate weld defects including some not identified by radiographic techniques.

3.3 INSULATION AND LINE PROTECTION

3.3.1 Aboveground Piping – Insulation/Heat Tracing

The necessity to keep the Chlorine pipe line contents at the intended phase is the primary consideration in determining the need to insulate a system. Insulated pipes should have an appropriate exterior painting system similar to an uninsulated pipe. A reflective outer jacketing should be considered when covering insulated piping. This would reduce heat pick-up from ambient sources. Recommended insulation is polyurethane foam or foam glass block protected by an adequate outer fire resistant weather barrier.

3.3.2 Aboveground Piping – Fire / Heat Protection

Where the risks for elevated temperatures exist, including fire or any other undesirable heat source (e.g. hot vent streams, adjacent steam lines or combustible materials), the Chlorine line should be protected. The designer may consider physical isolation from other pipes in the pipe rack, erection of a fire resistant barrier between the lines, or insulation of the Chlorine line.

Insulation in this case should be fire retardant material such as foam glass with a fire resistant barrier on the outside.

3.3.3 Buried Lines - External Protection

All new buried pipelines, as well as repairs to existing lines, must be coated and wrapped. All buried pipelines must be evaluated to determine the need and adequacy of cathodic protection. Special precautions to be taken where high voltage electrical cables area present. Any change to conditions along the route may require modifications to the external protection of the pipeline.

3.3.4 Electrical Isolation

Pipeline shall be installed such that the buried pipelines are not in electrical contact with any foreign piping system or other metallic structures. This shall not preclude the use of electrical bonds where necessary. In case any shorting is observed, suitable additional corrosion protection measures should be considered

Insulating devices shall be protected against induced voltage due to lightening or ground fault at nearby high-voltage electrical cable. Such protection can be achieved by providing surge diverter or grounding cell across insulating joints or other suitable grounding technique etc.

3.4 HEAT TRACING OF CHLORINE GAS PIPELINE

According to operating pressures, the length of the pipeline and other ambient conditions, heat tracing and thermal insulation can be used to avoid condensation of the gaseous Chlorine. All precautions must then be taken to ensure the permanent availability of the heating system as long as the pipe is in operation and to avoid any localised overheating to prevent local corrosion or Chlorine-Iron fire.

If an electrical heating system is used, it should be equipped with self-limiting/self-regulating heat tracing cables which shall be attached to, but insulated from, the Chlorine pipe to avoid localized hot spots. The elements should be armoured and externally protected against corrosion and the ingress of moisture. The heating power should be calculated as a function of the thermal losses and not as a function of the heat input required to re-vaporize any Chlorine which may have condensed in the pipe work. An independent high temperature safety system will be foreseen; several temperature sensors could be used along the pipeline for alarm.

Electrical heat tracing installation should be designed to avoid overheating by suitable calculation of the heat density, so that at any point the metal temperature should never exceed 120°C, taking into account the worst possible climatic conditions.

3.5 MATERIAL FOR THERMAL INSULATION

The insulation materials to be applied for thermal insulation of Chlorine pipeline should meet the following criteria:

- Chemically inert to Chlorine
- Not flammable or combustible

For dry Chlorine gas, following insulation materials are used satisfactorily:

- polyurethane foams
- foam glass

Except for insulation material with closed cells, vapour barriers must be utilized to prevent the accumulation of moisture on the insulation of any insulated pipe that operates at temperatures below ambient temperature.

For the cladding used to protect externally the insulation layer and to prevent as far as possible ingress of water, several materials can be used, according to the local environment (coated carbon steel, plastic, resin, fibre reinforced resin, etc.). A sufficient spacing should be foreseen between cladding and the liquid barrier to avoid damaging this one.

For double wall pipes, no insulation will be installed in the inner space.

3.6 THERMAL PIPE EXPANSION

Provision must be made for thermal pipe expansion in the system. It is recommended that aboveground pipelines be designed utilizing stress analysis. If drains or vents are present, these must be taken into account when designing for expansion.

3.7 PROTECTION AGAINST OVERPRESSURE OF THE GASEOUS CHLORINE

Over pressuring the pipeline, a pressure interlock or a relief device must be installed. These relief devices (bursting discs, relief valves or a combination of both) should always be connected to an absorption system or a point of use in the liquefaction. Overpressure protection relief devises should be calibrated periodically and should be replaced in every 10 years once.

3.8 VALVE LOCATION

Regulations sometimes require the use of valves at locations along a pipeline to minimize the consequences from accidental discharge. In balancing this against environmental concerns for fugitive emissions, which can occur at each valve location, and the possibility of blocking in a section of line, it is recommended that valves may be located at both ends of a pipeline i.e., inside supplier's and customer's locations.

If offsite isolation valves are required by risk modelling studies like QRA study etc., they should be located and protected to prevent access by unauthorized persons. Preferably, isolation valves should be located within an industrial site and also ensure that the evacuation system is available for the Chlorine inventory between the onsite isolation and offsite isolation valves

Isolation valves may be closed manually, remotely and/or automatically when a leak is detected. For automated remotely activated valves, valve position should be monitored. Remote operated valves require an energy source to close and should be equipped for manual as well as automatic operation.

3.9 VENT AND DRAIN BRANCHES

The use of vent and drain branches in a Chlorine pipeline should be limited to the minimum number necessary for operation. Branches increase the risk of a leak and are difficult to insulate, allowing a location for corrosion to initiate.

Vents and drains should be located inside the producer's or consumer's plant site.

4. MARKING

4.1 LINE MARKERS

Underground pipelines should be provided with aboveground markers at public road crossings, at railway crossings with sufficient number along the pipeline so that its location is accurately known to reduce the possibility of damage or interference. Above ground pipelines should be provided with markers over long sections of the pipeline that are in areas accessible to the public. The markings may be made using a combination of pictorial representation and wordings. Pipeline marking shall be as per local regulation, if applicable.

4.2 LINE MARKER WORDING

The wording on the line marker should be "WARNING - CHLORINE GAS UNDER PRESSURE" and should include the name of the Producer and Consumer and contact details like telephone numbers where the third party can be reached at all times. The wordings should be in local state language, Hindi and English.

5. PREPARATION FOR USE

Information specific to preparing Chlorine pipelines for use is listed in this document.

5.1 PRESSURE TESTING

Chlorine Gas Piping

New, relocated or replaced Chlorine gas pipelines and modified sections of existing gas pipelines are to be pressure tested in accordance with ASME B 31.8 until all leaks have been located and eliminated. Process piping testing requirements should be applied as a minimum standard. There are two types of acceptable testing methods: hydrostatic testing and pneumatic testing. Following hydrostatic testing, it is essential that Chlorine pipeline systems be thoroughly dried prior to service.

Dry Air or Nitrogen may be used as a test medium. The operation of a Chlorine gas piping system, tested in this manner, may be limited to lower stress conditions. Care should be taken to limit personnel exposure while conducting tests with these media.

5.2 CLEANING

The aqueous and abrasive cleaning methods are most commonly used on large pipelines. The solvent cleaning method is not normally used for cleaning Chlorine gas pipelines because of the need to address the environmental and industrial hygiene risks associated with most solvents. If moisture is introduced into a pipeline, all moisture absorbing gaskets and valve packing should be replaced. Consideration should be given to removing valves prior to introducing moisture.

The preferred method for removal of dirt, weld spatter, Chlorine, etc. from a Chlorine pipeline is with a pig. Pigging in the context of pipelines refers to the practice of using devices known as "pigs" to perform various maintenance operations. These operations include but are not limited to cleaning and inspecting the pipeline. In this system of cleaning a pig is forced through the pipeline by Dry Air or Nitrogen pressure.

If a pigging system will be used for cleaning or if a smart pig will be used for inspections, the following features should be included at a minimum. Additional features may be required for use of pigs or smart pigs:

- Radius of curvature must allow passage
- Pig catcher at one end and a launcher at the other
- Guide bars in piping tees

5.3 DRYING

Chlorine piping systems must always be dried before being placed in service. Even if water has not been purposely introduced into the system for hydrostatic testing or cleaning, drying is required because moisture may enter the system from the atmosphere or other sources. The purge gas flow should be started at high volume rates to sweep the moisture out of the piping system, and then

reduced. The system should be dried until the entire vent gas streams leaving have a -40^0 C dew point, measured at normal system operating pressure, or reasonably close to the entering purge gas dew point.

The purge rates should be at an absolute minimum, allowing adequate time for the purge gas to reach equilibrium when the dew point is taken.

5.4 TESTING FOR LEAKS

Leak testing should be done once the piping system is completely assembled. The purpose of a leak test is to ensure all connections and components will not leak Chlorine when pressurized. Leak testing is not a substitute for pressure testing. If the system was not disassembled and reassembled as part of the pressure testing and drying process, the Nitrogen/Dry Air test (i.e. Step 1) may be omitted.

- Step 1

Pressurize the system to 110% of design pressure with Dry Air or Nitrogen. Use a soap solution to test for leaks at joints.

- Step 2

Introduce Chlorine gas into the system and raise the pressure to approximately 0.2 bar.g.

- Step 3

Test the system for leaks with aqua Ammonia. Care must be taken that Chlorine has diffused throughout the piping system before leak checking with Ammonia. The reaction of ammonia vapor with escaping Chlorine forms a dense white cloud. The most convenient way to use ammonia for this purpose is to direct the vapor from a plastic squeeze bottle containing 26 degree Baume' aqua (ammonia solution) at the suspected leak. Do not squirt liquid aqua ammonia on pipe fittings.

Never attempt to repair leaks by welding until all Chlorine has been purged from the system. When detectable leaks have been repaired, the line should be retested by repeating Step 3. Any effort to detect the source of a leak should be carried out with full consideration for potential hazards. Appropriate protective equipment must be used.

- Step 4

Slowly increase the Chlorine pressure and continue to check for leaks at several intermediate pressures until the operating pressure is obtained. If leaks are detected repairs should be made and step 4 continued until the operating pressure is achieved.

6. OPERATION AND MAINTENANCE GUIDELINES

6.1 GENERAL

The pipeline operator, the person who is operating the pipelines, must have procedures for the operation and maintenance of Chlorine pipelines. For new pipelines, the procedures must be prepared before the start of pipeline operation. Persons handling/operating the pipeline must be trained.

The procedures must include start up, shutdown, abnormal process operations, normal operation, maintenance and inspection procedures, and address procedures to be used in case of emergencies.

The procedures must be reviewed and updated once per calendar year and kept at locations where operations and maintenance activities are conducted.

6.2 OPERATION GUIDELINES

6.2.1 Before placing a pipeline in service ensure the following:

a. Clean the line and ensure it is free of oil and grease. Chlorine will react vigorously with hydrocarbon-based lubricants.
b. Dry the line with oil-free Dry Air or Nitrogen.
c. Leak test of pipeline
d. Check on the quality of Chlorine introduced, especially the concentration of Hydrogen in Chlorine and moisture in Chlorine
e. Purge of the pipeline with Chlorine gas to eliminate all inert before putting it under pressure.

6.2.2 During Operation

a. The line should be maintained at conditions that ensure the proper state to avoid condensation at all times.
b. Only dry Chlorine gas should be introduced into carbon steel pipelines.
c. Operating data should be obtained and continuously evaluated to assure the integrity of the system.
d. Proper precaution to be taken at producer end to avoid liquid Chlorine ingress into the gas line. A liquid Chlorine trap with temperature sensor can be considered immediate after evaporation of liquid Chlorine.

6.2.3 Removing Pipelines from Gaseous Chlorine Service

a. Special attention is required during transient phases and shut down operations.
b. Reduce line pressure and flow to ensure that the gaseous state is maintained. The design must be such that Chlorine gas can be vented into a suitable installation (absorption unit or

compression and liquefaction plant of adequate capacity). All equipment associated with the operation, therefore, should be suitable for the actual temperatures which will arise.

c. If line is to be emptied, isolate the pipeline. If works have to be performed on the pipeline, or if the duration of the shutdown is too long to guarantee a correct continuous surveillance, the electric heat tracing, if any, will be kept off, and the Chlorine in the pipeline will be replaced by Dry Air or Nitrogen, venting and purging towards absorption unit. This operation should be continued until the residual Chlorine content within the system permits its opening or dismantling without risk of corrosion or gassing of personnel.

d. For a few hours shutdown of a gaseous Chlorine pipeline, the internal pressure should be lowered; the pressure may not fall below atmosphere to avoid Air ingress but, whenever possible, stay below the Chlorine vapour pressure corresponding to the pipeline temperature, to prevent the risk of liquefaction; before restart, all efforts must be made to confirm the absence of any liquid phase Chlorine.

6.2.4 Purging

- Dry Air or Nitrogen of adequate quality, quantity and pressure should be permanently available. All precautions will be taken to avoid contamination by oils, grease or other contaminants that could react with Chlorine.
- The system will be designed to avoid back flow from Chlorine side to the Dry Air or Nitrogen gas network; this can be realised by dedicated purging system, if its pressure is at least 2 bar higher than the maximum pipeline pressure, or a backflow protection.
- Purged gas should be passed through a absorption unit to remove Chlorine, before being vented to atmosphere.

6.3 MAINTENANCE GUIDELINES AND PRECAUTIONS

For all maintenance operations the pipeline shall be isolated upstream and downstream by the installation of blind flanges, or the removal of a spool piece provided for this purpose. However, the pipeline should not be left open to moist atmosphere to prevent corrosion, the $FeCl_3$ layer will attract moisture and become corrosive liquid

6.3.1 Welding

Do not attempt to repair Chlorine piping by burning or welding until all Chlorine and traces of Chlorine-associated residues have been purged from the system. Burning or welding can cause carbon steel to react rapidly with Chlorine and even burst into flame. Hot work of any kind must not be performed on an in-service Chlorine pipeline. After hot work, lines should be cooled prior to introduction of Chlorine, Refer to Section 3.2 for welding guidelines.

6.3.2 Moisture

Every effort should be made to prevent the introduction of moisture into a dry Chlorine gas piping system. Pipelines not in service should be sealed, dried, and padded with Dry Air or Nitrogen. Wet

Chlorine is very corrosive to carbon steel piping. "Moisture in Chlorine" analyser shall be installed to check moisture content in Chlorine gas.

6.3.3 Lubricants and Seals

All materials used as lubricants, greases, packing, seals and gaskets must be nonreactive with Chlorine. Chlorine will react vigorously with hydrocarbon based lubricants.

Fluorocarbon grease may be used as a gasket dope but care should be taken to ensure it will not degrade the gasket. Where thread dope is used, care must be taken to prevent the material from entering the piping system. Thread dopes may include PTFE tape, PTFE paste, white lead paste, litharge and glycerine. Special Chlorine compatible lubricants are used in the assembly of valves for Chlorine service.

6.3.4 Protective Coatings

The integrity of protective coatings on pipelines must be preserved. Corrosion under insulation may damage Chlorine piping, particularly if it is subjected to freeze-thaw cycles. Any damage to the coating should be promptly and completely repaired.

6.3.5 Valves

Each valve necessary for the safe operation of the system shall be inspected and operated in accordance with manufacturer's instructions and applicable regulations.

7. INSPECTION, TESTING, AND MONITORING

7.1 GENERAL

Due to the characteristics of Chlorine, the guidelines listed below are in some cases more rigorous than those required by regulation. The producer / consumer shall have written procedures for inspection and surveillance. All activity must be documented to verify adherence to procedures as required by regulation

List of critical activities with respect to pipeline inspection, testing and monitoring to be followed as per following table:

Sr. No	Critical Activity or Process	Recommended time period
1	100% Radiography of pipeline	After erection / after any pipeline modification
2	Pneumatic Testing of pipeline	After erection of pipeline / after any modification / once in two year
3	Corrosion testing of pipeline or thickness checking	Once in a year
4	Pipeline cathodic protection record	Every month
5	Pipeline as built record review	Once in a year
6	Pipeline, valves visual survey	Once in a week
7	Dew point check record	Before start up / after maintenance
8	Insulation record / Electric heat tracing	Every month
9	External painting record	Every month
10	Underground trench inspection	Once in a week
11	Underground marking record	Once in 2 month
12	Instrument calibration like Cl2 detector Flow meter, temperature transmitter, etc.	 Every month Once in a year
13	Safety valve calibration	Once in a year
13	Leak detection system record	Every month

7.2 CONTINUING SURVEILLANCE AND DAMAGE PREVENTION

There should be an on-going pipeline surveillance program. Information should be recorded and evaluated to determine the condition of the pipeline and to schedule needed repairs. Operators of gas pipelines must be aware of, and comply with, the rules for pipeline integrity.

For buried pipelines outside the physical confines of the producer's / consumer's facility, a damage prevention program should be maintained. Public education may be required regarding the same.

7.3 PATROL

The pipeline, pipeline right-of-way and underground trenches should be surveyed visually 24x7. The survey should be by pedestrian patrol, vehicular patrol, or aircraft patrol as best suited by the routing of the line. The inspector should look for leaks, vegetation kills, or impending excavation or construction or water accumulation in trenches that could damage the pipeline.

7.4 MONTHLY INSPECTION

The pipeline should be inspected for insulation, electric heat tracing, painting, cathodic protection, instrument calibration, leaks, damage, or serious external corrosion each month. On underground pipelines, the cathodic protection (voltage, protection rectifier, reverse current switches, and interference bonds) should be inspected and preventive maintenance performed every two months.

7.5 BI-MONTHLY INSPECTION

For underground pipeline shall be inspected for visibility of marker board, content on the board etc once in two months.

7.6 VALVE INSPECTION

Valves necessary for the safe operation of the system should be inspected and partially operated at intervals not exceeding 6 months

7.7 ANNUAL INSPECTION

An inspection should be conducted every calendar year that includes the following:

- Ultrasonic testing of wall thickness at pre-specified points. These points should be defined and maintained throughout the lifetime of the pipeline.
- Safety valve calibration
- Verification of calibration and operability of inspection equipment.

7.8 CONTINUOUS OVERLINE CATHODIC PROTECTION SURVEY

For underground lines with cathodic protection applied, a continuous over line cathodic protection survey should be conducted once every five years to determine the level of uniformity of cathodic protection.

8. MATERIALS OF CONSTRUCTION

All the materials used have to be compatible with Chlorine in the design conditions. The materials and equipment should be obtained from approved suppliers with a documented quality assurance procedure. Refer Attached Annexure II – Piping Specification.

8.1 PIPING

The carbon steel chosen for the construction of the pipe work should be of a certified quality, fine grain steel and readily wieldable. Seamless pipe is preferred.

The metal used in branches and other pieces welded to the pipe should be of a quality compatible with the base metal chosen for the pipe itself. It is advisable to choose a quality of carbon steel which avoids the need for stress relief after welding.

8.2 FLANGES, NUTS AND BOLTS

The metal used for flanges, nuts and bolts should possess the same characteristics as that of the piping.

8.3 GASKETS

The gasket used should be made of material compatible with Chlorine . No grease which is not compatible with Chlorine shall be used.

The mounting of the gaskets should be performed by well-trained people; only new gaskets should be used.

The stress relaxation resistance of some gaskets decreases with increasing thickness. It is therefore recommended that gaskets be fitted inside the bolt circle and should have thickness compatible with the flange rating. Under no circumstances should gasket contact surfaces be machined in a manner that leaves tool marks extending radially across the seating surface.

Where spirally wound gaskets using metal windings and a Chlorine compatible filler material are used, care should be taken to ensure that the flange faces are machined to the joint manufacturer's recommended standard and that the mating flanges are similar, i.e. of the same material and surface finish.

Jointing compounds are not recommended and paste should not be used with spiral wound, or PTFE gaskets under any circumstances. However, when paste is used for flanged joints which have to be broken and remade frequently for process or maintenance reasons, care should be taken to ensure that the paste is:

- Compatible with Chlorine
- Compatible with the gasket material
- Used sparingly and is not forced into the bore of the pipe.
- Spread evenly over the joint surface

9. SUPPORTS

The supports of the pipeline should permit the thermal expansion/contraction of the pipeline due to any likely variations in temperature, taking into account the maximum and minimum achievable temperatures. They should also deal with any possible earth movement. For above ground pipelines, it is preferable to use large radius expansion loops.

Expansion bellows should not be used because they may be weak points in the construction, unless a detailed study proves adequacy. For straight lines, where free expansion cannot take place, account must be taken of the longitudinal stresses which will result from the maximum variation in temperature. The support system should be designed to avoid any ingress of moisture under the thermal insulation, where fitted.

9.1.1 Buried Pipeline

If the terrain to be crossed is unstable or susceptible to movement, a pipeline should not be buried in the ground.

9.1.2 Pipelines Above-Ground or in Trenches

The supports should be fixed on foundations, which provide adequate rigidity. They should be insulated from the pipe with a mechanically robust material, which also provides adequate thermal insulation to avoid frosting on the support, leading to external corrosion.

10. EMERGENCY PLANNING

10.1 EMERGENCY CONTROL PLAN

Each pipeline operator will have written procedures to minimize the hazards resulting from a Chlorine pipeline emergency.

Pipeline operators must comply with requirements of The Chemical Accidents (Emergency, Planning, Preparedness and Response) Rules 1996 and participate in "Chlorine Emergency Response Network (Guide for Chlorine Consumers & Transporters)"

The emergency control plan must be able to reach all areas affected by any pipeline emergency. The pipeline operator should establish a continuing education program on emergency procedures to enable operators, customers, the public and appropriate organizations (police, fire) to recognize a pipeline emergency. It is also necessary to involve the State Disaster Response Force (SDRF) and integrate the emergency control plan into the SDRF module.

A Community Awareness and Emergency Response (CAER) system should be established at each plant location in cooperation with the Local Crises Group in that area for the purpose of alerting the public to a potential release of Chlorine. This system should provide for notification of all individuals within the predicted area of exposure to allow those persons to evacuate or to prepare to stay indoors until the danger has passed as per The Chemical Accidents (Emergency, Planning, Preparedness and Response) Rules 1996.

10.2 EMERGENCY PLAN IN CASE OF PIPELINE LEAK

Provision shall be kept to isolate the pipeline both at producer end and consumer end in case leak detected. It is also recommended to keep provision to isolate the pipeline by remote operated shut off valves during emergency. The pipeline after isolation can be evacuated by opening shut off valve to Chlorine absorption unit. It is recommended to have Chlorine absorption unit at producer end as well as at consumer end. Capacity of Chlorine absorption unit can be decide based on capacity of Chlorine inventory to be evacuated and time required to evacuate the inventory is based on risk modelling studies like QRA study etc. Isolation of pipeline and evacuation of pipeline shall be carried out from DCS or via dedicated SIL certified Emergency Shutdown System (ESD), manual operation is not recommended. In case of pipeline rupture or major leak communication to be established with SDRF for emergency plan implementation.

10.3 SECURITY

Needs for security should be developed with local, state and central agencies.

10.4 PERSONNEL QUALIFICATION

Each pipeline operator should have a written qualification program for individuals who perform operational, inspection and maintenance tasks on pipelines. This includes record keeping and

emergency response training. Operators should have qualification as required by local, state, and/or central regulations.

11. RECORDKEEPING

11.1 DESIGN AND INSTALLATION

Drawings, specifications, construction records, pressure test records, cathodic protection system details, maps, material verification, and modification records etc. should be kept up to date by the producer / consumer for the life of the pipeline. These should be kept where operation and maintenance activities are being conducted.

11.2 PIPELINE OPERATION

A manual of written procedures for operation of the pipeline must be prepared, made available and kept updated by the producer / consumer. For the operating life of the pipeline, training programs for the pipeline facility operating personnel should be maintained and updated, as necessary. At least once each calendar year, the performance of operating personnel should be reviewed and it should be verified that operating supervisors maintain a thorough knowledge of their responsibilities. Record of operating history must be maintained. An emergency control plan with written procedures should be established as detailed in section 7.

11.3 PIPELINE MAINTENANCE

A manual of written procedures for operation of the pipeline must be prepared, made available and kept up to date. For the life of the pipeline maintain records of inspections, tests, investigation, repairs and modifications of the pipeline. These records should also include information on line patrols, leak surveys, actual leaks and instances of maintenance line breaks.

11.4 RECORD RETENTION PERIOD

All records pertaining to pipeline operation and maintenance should be kept for minimum 10 years,

12. ACCIDENT REPORTING AND ANALYSIS

- Accidents of Gas Pipeline facilities have to be reported as per Codes of Practices for Emergency Response and Disaster Management Plan
- All accidents have to be reported to respective State Director of Factories, local authorities and State Pollution Control Boards.
- A Root Cause Analysis is to be done for all accidents and learning from incidents shared with all operating and maintenance personnel

13. ANNEXURES

- Annexure I Chlorine vapour pressure curve
- Annexure II Piping Specification
- Annexure III Typical aboveground pipeline section
- Annexure IV Typical underground pipeline section
- Annexure V Emergency Control Plan

14. APPLICABLE RULES

Transportation of Chlorine is governed by following rules:

- The Chemical Accidents (Emergency, Planning, Preparedness and Response) Rules, 1996
- Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989
- Factories Act, 1984
- The Public Liability Insurance Act, 1991
- The Environment (Protection) Act, 1986
- Static and Mobile Pressure Vessel (SMPV) Rules, 1981

15. BIS STANDARDS

- IS 646 - Liquid Chlorine purity
- IS 2379-1963 - Color code for identification for pipelines
- IS 4263-1967 - Code of Safety for Chlorine
- IS 8867 - Hydraulic Stretch Test – test pressure
- IS 5844 - Hydrostatic stretch test – Procedure (welded cylinder)

16. REFERENCES

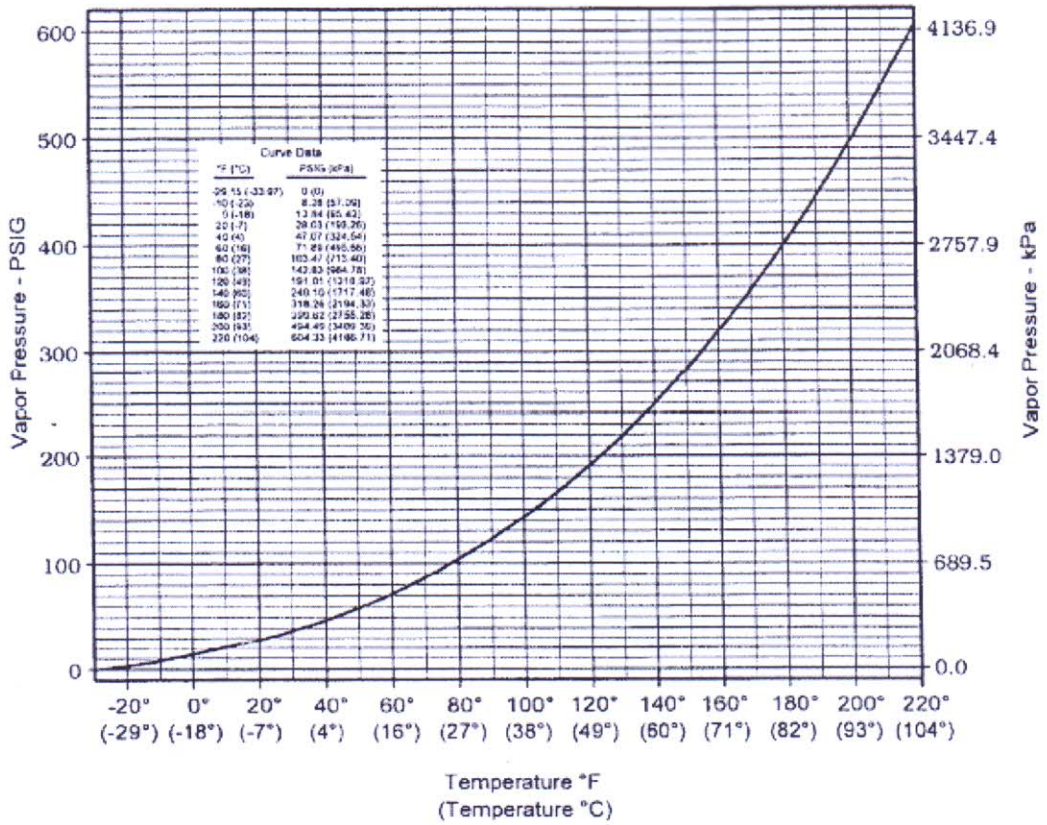
A. The Chlorine Institute Documents

Pamphlet	Title
1	Chlorine Basic Edition 7 Pamphlet 1; The Chlorine Institute: Arlington, VA, 2008
6	Piping System for Dry Chlorine, Edition 16 Pamphlet 6; The Chlorine Institute: Arlington, VA, 2013
60	Chlorine Pipelines; The Chlorine Institute: Arlington, VA, 2013
64	Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite and Hydrogen Chloride Facilities, Edition 6 Rev. 1 Pamphlet 64; The Chlorine Institute : Arlington, VA, 2008
95	Gaskets for Chlorine Service, Edition 4 Pamphlet 95; The Chlorine Institute: Arlington, VA, 2008
100	Dry Chlorine Behaviors of Moisture in Chlorine and Analytical Issues, Edition 4 Pamphlet 100; The Chlorine Institute: Arlington, VA, 2011
164	Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials, Edition 2 Pamphlet 164; The Chlorine Institute: Arlington, VA, 2007

B. Euro Chlor Documents

Standard	Title
GEST 10/362	Corrosion Behaviour of Carbon Steel in Wet and Dry Chlorine, 2nd Edition, 2013
GEST 73/25	Transport of Chlorine by Pipeline Outside site boundaries, 10th Edition, 2009
GEST 79/82	Materials of Construction for Use in Contact with Chlorine, 11th Edition, 2013
GEST 80/84	Commissioning and Decommissioning of Installations for Dry Chlorine Gas and Liquid, 6th Edition, 2013
GEST 87/133	Overpressure Relief of Chlorine Installations, 5th Edition, 2012
GEST 92/176	Chlorine Emergency Equipment, 2nd Edition, 2004
GEST 93/179	Emergency Intervention in case of Chlorine Leak, 8th Edition, 2003
GEST 94/216	Experience of Gaskets in Liquid Chlorine and Dry or Wet Chlorine Gas Service, 4th Edition, 2013

Annexure I – Chlorine vapour pressure curve

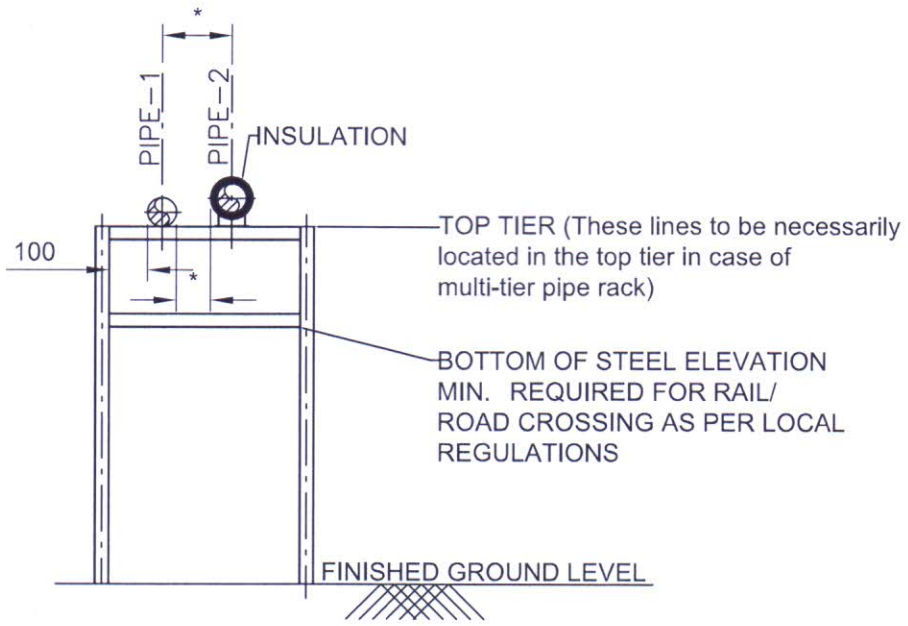


Annexure II – Piping Specification

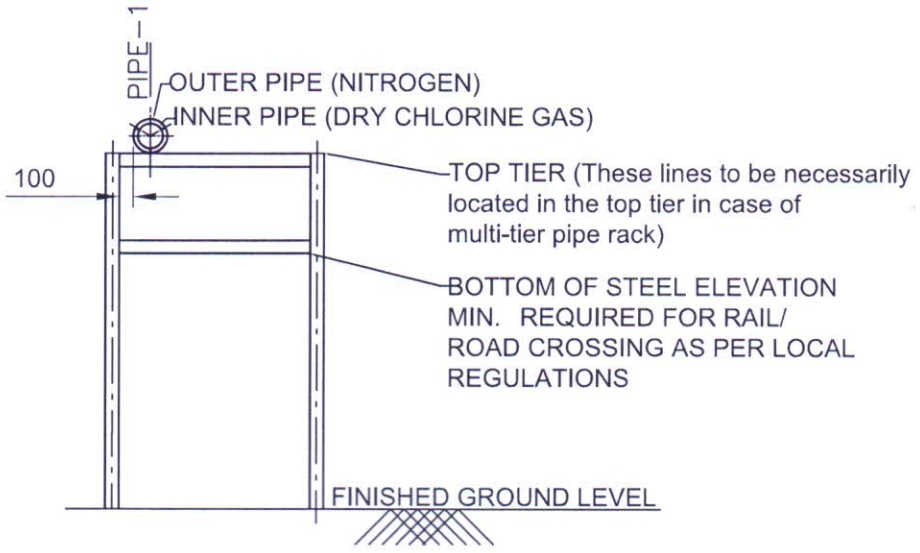
Rating Class	: ANSI Class 300
Piping Size	: Minimum size: 25 DN
Pipeline Size	: Minimum size: 80 DN
Piping Material	: A 333 GR.6, Seamless, Standard ASME B36 .10M, Butt Weld Ends connections / Optional: API Specification 5L with Charpy Test at (-) 45°C
Pipe fittings	: A420 Gr.WPL6W, Standard: ASME B16.9, Butt Weld Ends connections
Pipe Flanges	: A350 Gr.LF2, Standard: B16.5, Butt Weld Ends connections, Raised Face
Pipe Bolts	: A320 Gr.L7/A194 Gr.4
Gaskets	: Spiral Wound, Monel + PTFE, B16.20/B16.5
Valves Type	: Bellow Sealed Globe Valves, Euro Chlor Design and Euro Chlor certified valves
Valves material	:

Body Material	: A352 Gr.LCB, Stellated seat,
Bellow material	: Hatalloy C-276
Bonner Gasket	: Spiral wound Monel + PTFE
Packing	: PTFE V-RING
Standard	: ASME B16.34, Flanged B16.5, Raised Face

Annexure III - Typical above ground Pipeline Section



ABOVE GROUND BARE / INSULATED PIPE



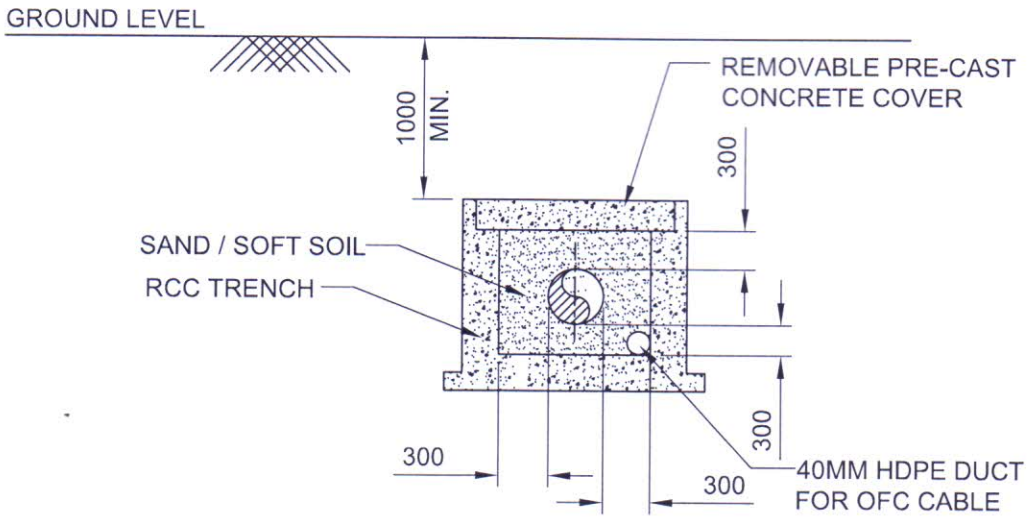
ABOVE GROUND PIPE IN PIPE

NOTES:

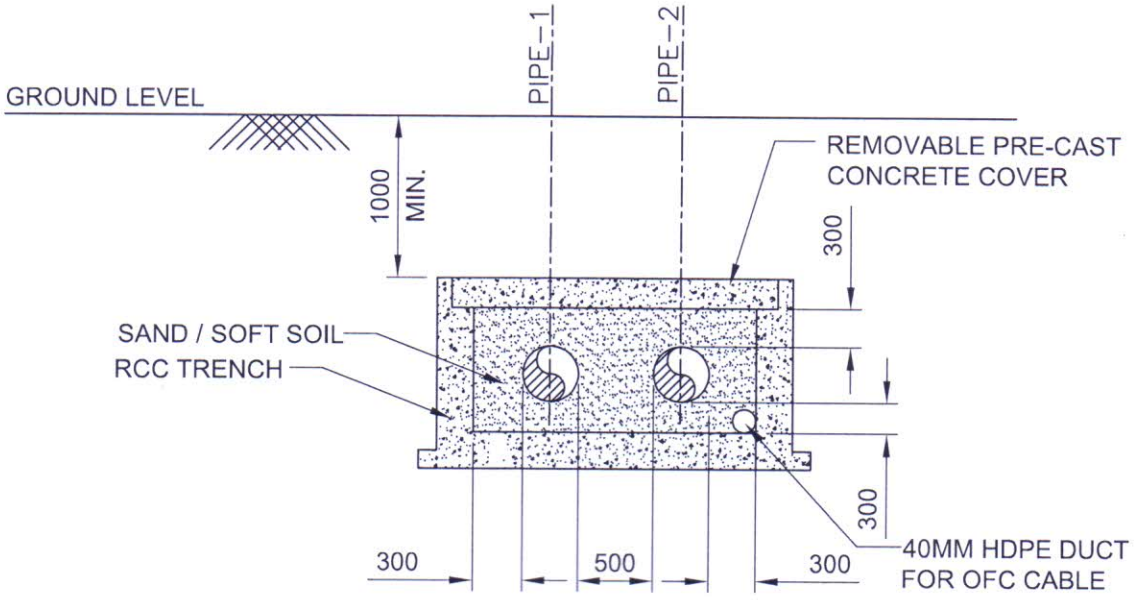
1. All dimensions are in MM.

* As per good Engineering Practice

Annexure IV - Typical Underground Pipeline Section



SINGLE BURIED PIPE



TWIN BURIED PIPES IN COMMON TRENCH

NOTES:

1. All dimensions are in MM.
2. Concrete trench / cover is to be designed for the loads.
3. Trench fill shall be sand / soft soil free from rocks or other such materials and shall be suitably compacted.

I/3001672/2018

Minutes of the meeting held on 27/04/2018 under the Chairmanship of Secretary (C&PC) regarding formulation of regulations/guidelines for transfer of chlorine through pipelines

The list of participants is attached.

The Secretary (C&PC) welcomed all the participants. JS (Chemical) briefed about the purpose of the meeting and the requirement of regulations for chlorine transfer through pipelines.

Dr. S. K. Singh, Controller of Explosives, PESO explained about the current regulations under the Manufacture, Storage and Import Of Hazardous Chemicals (MSIHC) Rules, 1989 which specifies that a pipeline having inventory equal to 10 tonnes or more requires approval. However, no specific standards are available as a statutory guideline in India for the transfer of Chlorine through pipelines.

Shri Dinesh Runiwal, Joint Director, MOEF&CC said that under the MSIHC Rules 1989, PESO will be the executing authority and Chief Controller of Explosives will be authorized to issue permission.

During the discussion, it was felt that to prepare guidelines for transfer of chlorine through pipelines, standards/norms for the same are required. Dr. Singh further added that the best practices in the world may be analyzed before finalizing the guidelines.

After detailed discussions, it was decided to constitute an Expert Committee under the chairmanship of the Chief Controller of Explosives, PESO. The Expert Committee will study global best practices for chlorine transfer through pipelines. The expert committee shall submit its report within three months. The draft report of the Expert Committee will be reviewed in the month of July.

The composition of the Committee will be as under:

1. Chief Controller of Explosives, PESO : Chairman
2. Representative of MOEF&CC : Member
3. Representative of CPCB : Member
4. Shri K. Srinivasan, AMAI : Member
5. Shri. S. M. Pathak, Reliance Industries : Member
6. Shri. D. B. Jain, GACL : Member
7. Shri Sunil Kumar Sharma, Director, C&PC : Member Secretary

The Committee will also identify chemicals/petrochemicals for which regulations have not yet been notified and propose suitable standards/guidelines for them. The terms of reference of the Committee will be finalized by the Department in consultation with the Chairman and Members.

The meeting ended with vote of thanks to the chair and all the participants.

4437/2018/SECRETARY CPC

Minutes of the meeting with stakeholders in the office of CCE, Nagpur on 28/05/2018 in connection with formulation of regulations/guidelines for transfer of Chlorine through pipelines

The details of the participants attended the meeting is enclosed as annexure.

At the outset, Chief Controller of Explosives welcomed all the participants and thanked them for attending the meeting within a short notice. He intimated that a meeting on the subject matter was held under the Chairmanship of Secretary (C&PC) on 27/04/2018 at New Delhi wherein it was decided to constitute an Expert Committee under the Chairmanship of the Chief Controller of Explosives to study global best practices for Chlorine transfer through pipelines.

The Chairman expressed his concerned with respect to absence of the Expert Committee members i.e. Representative of MOEF&CC, Shri Sunil Kumar Sharma, Director, C&PC including Member Secretary representing CPCB defeating the very purpose of this meeting. However, he requested the participants to express their views with respect to transportation of Chlorine through cross-country pipeline.

The representing of GACL intimated that as on date 2000 MT per day of chlorine is transported through tonners in Dahej Industrial Area. M/s. GACL is filling 700 MT per day of chlorine in tonners. To avoid the filling and transportation of tonners, it is proposed that chlorine shall be transported through pipelines. At present, the transportation of chlorine is through CCE approved tonners.

The Chairman intimated that as per MSIHC Rules, 1989, the threshold quantity of chlorine is 10 tonnes. Therefore, if the entire volume of the cross-country pipeline is less than 10 tonnes, such pipeline will not be covered under the MSIHC Rules, 1989. He also stated that in case of release of Chlorine through pipeline, depending upon the size of the leakage, an approximately area of 7-8 KM will be affected thereby jeopardizing the public safety. Therefore, enough care is to be taken for introduction of cross-country pipeline in the country. Further, the pros and cons as well as benefits of transporting chlorine through pipeline is required to be assessed by the stakeholders.

After lot of discussions and deliberations, it was decided that a technical presentation may be made by Chlor-alkali Industry detailing the following :-

1. The material of construction of pipeline, standard/code, design details of the pipeline, diameter of pipeline, length of pipeline, life of pipeline, measures taken to prevent corrosion along with data available on operating and maintenance practices being adopted globally.

2. Chlorine in gas/vapour form is hygroscopic in nature. Traces of water in the pipeline can lead to severe corrosion of the walls and fittings of the pipeline which may cause leakage of chlorine through the pipeline.

3. The underground pipelines are prone to corrosion and erosion due to soil conditions.

4. Traces of Nitrogen tri chloride are formed during compression of gaseous chlorine to form liquid chlorine. The concentration of nitrogen tri chloride in tonners is negligible. However when the chlorine will be transported through pipelines, the concentration cannot be ascertained and may cause bursting of pipeline in case not taken care of leading to major accident.

5. The climatic condition, soil conditions, human behavioral aspects of European countries and India is completely different. Therefore the data obtained from operation of pipeline in European countries are required to be compared with respect to the tropical conditions prevailing in the country.

37/2018/SECRETARY CPC

6. One volume of liquid chlorine expands into 450 volume of gaseous chlorine. Therefore a pin hole in the pipeline can lead to major catastrophic accident affecting a huge surrounding area, contamination of ground water, health hazards to living being. The said property should be considered from public safety point of view.

7. Interlocking arrangements, neutralization techniques, leakage detection, online monitoring, remedy for prevention of accident and hazard, patrolling of pipelines.

8. A detailed HAZOP study and QRA through reputed and well established agencies such as EIL, PDIL, etc shall be conducted for arriving at various design aspects and mitigating measures.

9. He also suggested the participants to find out the existence of Chlorine cross-country pipeline elsewhere in the world. If required, a ~~visit~~ to other countries can be made where such Chlorine cross-country pipelines are already operating since long time to gain first hand knowledge on the subject.

The meeting ended with vote of thanks to the Chair.

*****

Minutes of the Meeting of the Expert Committee constituted for development of guidelines/regulations for transportation of chlorine through pipelines held on Monday, 16 th July 2018 at 05.00 pm in Shastri Bhawan.

In the Chair: Shri N T Shahu, Chairman of the Expert Committee.

List of participants in the meeting is attached.

A presentation covering the logistics involved in transportation of chlorine through tonners at present, the advantages a pipeline system offers and the suggested system for pipeline (cross country) transportation of chlorine was made by Mr. K Srinivasan and Mr. SM Pathak.

The Chairman mentioned that regulations for transportation of chlorine through pipelines are already in place as these will be covered under the MANUFACTURE, STORAGE AND IMPORT OF HAZARDOUS CHEMICAL RULES, 1989. This Committee will develop Guidelines to supplement the Rules, for transportation of Chlorine.

The Committee decided on the following:

1. Guidelines will cover transportation of chlorine in gaseous form only. Guidelines for transportation of liquid chlorine will be taken up later based on experience and confidence achieved in handling gaseous chlorine
2. Pipeline transportation will be initially limited to a distance not exceeding 15 kms and to be laid in notified industrial areas/zones or PCPIRs.
3. Pipelines will be laid below ground.
4. Pipeline transportation for non-notified areas or passing through public land will be taken up at a later stage after gaining the experience.
5. Pipelines (confined in inside factory area) in successful existing operation and where no major incident has occurred will not be covered under the proposed guidelines. However, supervision and mitigation measures will be aligned with the new guidelines.
6. The proposal contained in the presentation by AMAI for implementation SCADA and PIDS is acceptable in principle.
7. As extreme cold conditions do not prevail in States such as Gujarat or Maharashtra where initial chlorine pipeline projects are likely to come up, the Committee decided on not having Heat Tracing and Thermal Insulation system. However, wherever extreme cold conditions are likely, these will have to be included.
8. The following key components of the pipeline system are acceptable. However, more details will be needed before a final decision is taken as per the standard/code.
    a. Pipelines laid below ground will be in a concrete lined trench filled with sand. The trench will have provision for outflow of water that enters the trench
    b. The trench will be covered with concrete slabs. The top of these slabs will be at a depth of minimum 6 inches below the ground

c. An optic fiber cable will be laid along the chlorine pipe for connecting to sensing/monitoring equipment for detection of leakages

d. There will be appropriate cautionary markings above the ground along the entire length of the pipeline

e. Continuous Patrolling of the corridor

9. The Committee sought the following information in order to prepare an Interim Report to be submitted to the Department of Chemicals & Petrochemicals:

a. Specification of pipelines – size, material, casing, etc.

b. Model for detection of leakage

c. HAZOP, QRA to estimate the likelihood of occurrence and consequence of hazardous events. This will be based on some hypothetical model assuming a certain volume over a distance of up to 15 km as proposed

d. Detailed drawing of trench for laying of pipeline, including specifications of material

e. Distances from road, ROW, public areas, utilities such as water pipes/drains, electric poles, etc.

10. The committee also desired to have whatever information can be gathered on existing pipelines in operation within complexes in India

11. The Committee proposed to visit a facility in India to study the pipeline system between chlor-alkali plant and PVC plant

12. The Committee also decided on visiting a chlorine pipeline facility in Europe / the US to study the transportation system and gain practical knowledge. The Committee advised Member Secretary of the Expert Committee & Director, DCPC to finalise the tour programme with support from AMAI who will coordinate with Euro Chlor and the Chlorine Institute, USA.

The meeting concluded with a vote of thanks to the Chair.

7413/2018/TECH-CPC

List of Participants

1. Shri N T Shahu, Chief Controller of Explosives, PESO: Chairman
2. Shri D. Praveen, Director, DCPC
3. Dr. Sanjay Kumar Singh, Controller of Explosives, PESO
4. Dr. Narender Sharma, Additional Director, Central Pollution Control Board (CPCB)
5. Shri Dinesh Runiwal, Joint Director, Ministry of Environment Forest and Climate Change(MoEFCC)
6. Dr. Rohit Misra, Asst. Industrial Advisor, DCPC
7. Shri Malkit Singh Vilkhoo DGM(INST), SIEL Chemical Complex, Rajpura,
8. Shri Dinesh Chaubey, Grasim Industries
9. Shri Shashank Gupta AGM, Siel Chemical Complex, Rajpura,
10. Shri Navin Jaiswal, Asst.V.P., DCM SHRIRAM, BHARUCH
11. Shri Shirish Pathak, Vice President, Reliance Industries Limited,
12. Shri D.B. Jain, Advisor to MD, GACL
13. Shri M.A Hania, Vice President, MFL
14. Shri H.S Das, Joint Director(SHE), Alkali Manufacturers Association of India(AMAI)
15. Shri K. Srinivasan, Secretary General, AMAI

89024/2018/TECH-CPC

Minutes of the 3rd Meeting of the Expert Committee constituted for development of guidelines/regulations for transfer of chlorine through pipelines held on 17th August, 2018 at 1200 hrs in IPFT, Gurgaon.

In the Chair: Shri S.K. Shukla, Chairman of the Expert Committee.

List of participants in the meeting is appended.

The Committee condoled the demise of Bharat Ratna Shri Atal Bihari Vajpayee, the ex-Prime Minister.

At the outset, the Chairman welcomed the participants and briefed about the purpose of the meeting. Thereafter, Chairman mentioned that as per the minutes of second meeting of Expert Committee, several information was required to be prepared and Interim Report to be submitted to the Department of Chemicals & Petrochemicals by industry representatives who are members of the Committee and also by AMAI. The information so required includes:

1. Specification of pipelines – size, material, casing, etc.
2. Model for detection of leakage
3. HAZOP, QRA to estimate the likelihood of occurrence and consequence of hazardous events. This will be based on some hypothetical model assuming a certain volume over a distance of up to 15 km as proposed
4. Detailed drawing of trench for laying of pipeline, including specifications of material
5. Distances from road, ROW, public areas, utilities such as water pipes/drains, electric poles, etc.
6. information on existing pipelines in operation within complexes in India
7. Information on chlorine transportation practised over long distances and cross fences pipelines in other countries

Shri Shirish Pathak, Vice President, Reliance Industries Limited stated that in order to provide these information, a consultant is required. He also informed that the above components are critical to finalize the guidelines.

After discussion, the following has been decided in the meeting:

- A Consultant has to be engaged to draft the guidelines and submit to the Committee. The Consultant should have sufficient experience in execution of such projects. The Consultant may be hired by the industry and the details of the Consultant so hired may be informed to the Committee.

- At present, there are no guidelines for transfer of chlorine through pipelines in India. However, pipelines do exist in the country for transfer of chlorine, but they are restricted to the same individual industrial complex. The Committee therefore, decided to study some of these pipelines. Accordingly, the domestic study of these guidelines will be completed by first week of September, 2018. AMAI will finalize the modality of the visit and the cost regarding travel expenditure etc will be borne by the respective organization of the participant.
- The Committee noted that cross country pipeline network for transfer of chlorine are in existence in European countries and USA. The Committee therefore, decided that in order to draft and adopt guidelines for cross country transfer of chlorine through pipelines in India, it is essential that the best practices followed in developed countries need to be studied. Therefore, the Committee proposed to undertake a study tour to Europe / US, in the last week of September, 2018. The Committee advised Member Secretary of the Expert Committee & Director, DCPC to finalize the tour programme in consultation with AMAI, who will coordinate with Euro-Chlor and / or the Chlorine Institute, USA. The expenditure on travel etc would be borne by the respective organization of the participants.

The meeting ended with Vote of Thanks to the Chair.

List of Participants

1. Shri Shri S.K. Shukla, Chief Controller of Explosives, PESO: Chairman
2. Shri D. Praveen, Director, DCPC and Member Secretary
3. Shri. D.K. Gupta, Dy. Chief Controller of Explosives, PESO
4. Dr. Sanjay Kumar Singh, Controller of Explosives, PESO
5. Dr. Rohit Misra, Asst. Industrial Advisor, DCPC
6. Shri Shirish Pathak, Vice President, Reliance Industries Limited
7. Shri D.B. Jain, Advisor to MD, GACL

Draft

Annexure I D

Minutes of the 4th Meeting of the Expert Committee in connection with Formulation of Guidelines for Transfer of Chlorine through Pipelines, held at 3.00 pm on 9th January 2019 in Shastri Bhawan, New Delhi

In the Chair: Shri M K Jhala, Chairman of the Expert Committee

List of participants in the meeting is given in the Annexure.

The Chairman welcomed the Members and gave a brief on the visit of the Committee to the chlorine pipeline site in Germany during 22-25 October 2018. The team visited the chlorine pipeline site of AkzoNobel at Bitterfeld near Leipzig. The visit was facilitated by Euro Chlor and AMAI. The team also visited thyssenkrupp Head Quarters in Dortmund where they had discussions with tk experts. The Chairman and the Members who visited expressed satisfaction from the visit.

Shri D Praveen, Member Secretary, informed Members that thyssenkrupp Industrial Solutions (India) Ltd. (tkIS) who were engaged as consultant had submitted a Draft Guideline Document which was circulated to all Members for their comments. Shri Praveen further mentioned that considering the importance of the exercise and the need to finalise the guidelines at an early date, this meeting will discuss the Draft Guideline in detail and any changes required will be finalised before the Final Draft is presented. He further stated that there will be one more meeting of the Committee for a final review of the Guideline document before it is presented to the Secretary, DCPC.

The Chairman then requested the representative from tkIS, Shri Ranga Rao to make a presentation based on the Draft Guideline document for detailed comments/ discussions by Members.

The Committee deliberated on the contents of the Draft Guideline document and advised the following changes to be incorporated in the Draft Guideline document:

1) Pipeline shall be installed/laid in the notified industrial area
2) Pipeline can be laid below ground in the Industrial area with proper Right of Use (ROU).
3) Maximum operating pressure:
    a. For above ground pipeline: 3 Bar g
    b. For underground pipeline: 5 Bar g
4) Insulation and heat tracing is not required for underground pipeline
5) Requirement of Intermediate Isolation Valves to be decided based on risk modelling studies such as QRA study, etc.
6) Risk modelling / QRA should also include prescription of evacuation time for pipeline during emergencies
7) For fluid/gas velocity required at less than 20m/sec, appropriate reference /authority to be quoted
8) Pipeline should not be laid in populated areas

9) Pipeline life to be specified at not exceeding 20 years
10) Design considerations must include
    a. Seismic factor
    b. Recommendations on distances from HT wires/ requirement of sacrificial protection
11) GI cladding to be mentioned in place of aluminium cladding
12) There will be continuous daily monitoring of the pipeline in operation
13) All records, including monitoring/observation records and calibration records to be retained for minimum ten years
14) The guidelines may be reviewed and modified, if required, as often as may be necessary but not exceeding a gap of two years.

The Guideline may be titled "Guidelines for Transportation of Dry Chlorine Gas through Pipelines".

Shri Praveen proposed that the revised document, incorporating the above changes be submitted by the Consultant for circulation latest by 23rd January 2019. Shri Praveen further proposed that a meeting will be convened in mid-February 2019 for a final review of the guideline document and its approval by Members for submission to DCPC.

It was proposed that the document will be presented as "Recommendation of the Expert Committee" to the Secretary, DCPC. The document may thereafter be presented by DCPC to PESO to be adopted and published for implementation.

The meeting ended with Vote of Thanks to the Chair.

Annexure

List of Participants

1. Shri M. K. Jhala, Chief Controller of Explosives, PESO – Chairman of the Expert Committee
2. Shri D. Praveen, Director, DCPC and Member Secretary
3. Shri Shirish Pathak, Vice President, Reliance Industries Limited
4. Shri D.B. Jain, Advisor to MD, GACL
5. Shri K. Srinivasan, Secretary General, AMAI
6. Dr. Sanjay Kumar Singh, Controller of Explosives, PESO
7. Dr. Rohit Misra, Asst. Industrial Advisor, DCPC
8. Shri Ranga Rao N, General Manager – Process Technology, thyssenkrupp Industrial Solutions (India) Ltd.
9. Shri S N Sastry, Vice President – Central Tech. Services & Trg. – CA Business, Grasim Industries Ltd.

Annexure 2

Government of India
Ministry of Chemicals and Petrochemicals
Department of Chemicals & Fertilizers

Tour Report of the Expert Committee to study Chlorine Pipe Line in Germany from 22nd October 2018 to 25th October 2018

Meeting Dates : From 22nd October to 25th October 2018

Committee members

(i) Mr. Mukesh Kumar Jhala, Jt. Chief Controller of explosives, Petroleum and Explosives Safety Organization (PESO) – Representing Chief Controller of Explosives and Chairman of the Committee.

(ii) Mr. D. Praveen D, Director, Department of Chemical and Petrochemical- Member Secretary

(iii) Dr. Sanjay Kumar Singh, Controller of Explosives, Petroleum and Explosives Safety Organization – Associated member from PESO

(iv) Mr. Pathak S.M, Vice President, Reliance Industries Ltd. - Member

(v) Mr. Sastry S.N, Head-Technical Services, Grasim Industries Ltd. – Representative of AMAI

(vi) Mr. N. Ranga Rao N, GM-Process, thyssenkrupp Industrial Solution Pvt. Ltd. – Representing the Consultant engaged by AMAI.

Company and Persons met during visit

EuroChlor	Mr. Ton Manders, Technical & safety Director, European Chemical Industry Council – Cefic aisbl
AkzoNobel Industrial Chemicals GmbH	Mr. Stefan Kauerauf, Site Manager Mr. Harald Jennert, Maintenance Engineer
ChemiePark Bitterfeld-Wolfen GmbH	Dr. Michael Polk, Executive Director Mr. Max Fuhr, Dept. investment management
thyssenkrupp Uhde Chlorine Engineers, GmbH	Mr. Denis Krude, CEO Dr. Dmitri Donst, Head of Global Service Mr. Michael Rohlmann, Chief Engineer Mr. Albert Schadt, Senior Process Engineer

Meetings have been conducted at the following places

(i) SeaPark Hotel, Leipzig, Germany
(ii) AkzoNobel Industrial Chemicals GmbH, Bitterfeild Site office
(iii) ChemiePark Bitterfeld-Wolfen GmbH, Bitterfeild office
(iv) thyssenkrupp Uhde Chlorine Engineers, GmbH, Dortmund Office

Note on Discussions and Observations

Following points were discussed in various meetings. Observations and the outcome of meetings are noted below:

1. EuroChlor gives guidelines of process safety for Chlorine Pipe Lines along with other process guidelines for pipes like Caustic Soda etc. Engineering guidelines has to be followed as per local regulations.
2. Design pressure and Design Temperature to be arrived based on local design codes. In case of Germany, DIN (Deutches Institut) standards are fallowed. Design pressure is approx.. 25 barg and Design temperature is approx. 120°C.
3. The pipe lines used for Dry Chlorine service is Carbon Steel (CS) of DIN standard in Germany for Chlorine gas; and Low temperature Carbon Steel (LTCS) of DIN standard in Germany for Liquid Chlorine service.
4. AkzoNobel Plant has around 8 kM of Dry Chlorine Gas line to supply Chlorine gas to adjacent plants and crossing the public roads and also a hotel.
5. Chlorine gas pipe line in AkzoNobel is above ground on common pipe rack / bridge, where other pipe lines like HCl gas etc. are laid.
6. EuroChlor informed that the following pipe lines are in operation through public access places, other than Germany:

    a. Rotterdam, Netherlands – Liquid Chlorine Pipe line is in operation for about 12 k.m, which is partly above ground and partly underground along the railway track.
    b. Brussels, Belgium – Liquid Chlorine Pipe line is in operation for about 5 k.m, partly underground.
    c. Cologne, Germany – Liquid Chlorine Pipe line is in operation and crossing Rhine river and it is underground.
    d. Switzerland - Liquid Chlorine line is in operation and placed underground.
    e. Great Brittan- Liquid Chlorine line is in operation and placed underground.

f. Underground (buried) pipe lines are majorly supplying Liquid Chlorine and above ground pipe lines are majorly supplying Chlorine gas.

g. The Dryness of Chlorine pipe line is more important, no condensation is allowed and temperature of Carbon Steel pipe line should not cross more than 120°C at any point of time to avoid Iron-Chlorine fire.

h. No Chlorine gas pipe lines are laid underground in Europe due to the fact that the possibility of condensation is more due to low temperature weather conditions in Europe.

i. Maximum distance of single Chlorine gas pipe line available in Europe is approx. 3.5 km and approx. 12km for Liquid Chlorine pipe line.

j. Maximum pipe diameter in use in Europe is 200mm (8") Carbon Steel.

7. Europe has following types of public crossing Chlorine pipe lines, there are total approx. 8 such locations are available, for example

   a. Road crossing (above ground as well as underground pipe line), Germany
   b. Rail way crossing (underground pipe lines) Rotterdam
   c. Highway road crossing (underground pipe lines), Rotterdam
   d. Cannel/River crossing (underground pipe lines), Cologne
   e. Harbour crossing (underground pipe lines), Rotterdam

8. EuroChlor recommended no sectional isolation of Chlorine pipe line and it should be with only two isolation, one at the producer end and one at the receiver end. EuroClor recommended to avoid flange joints and any unnecessary tapings.

9. Europe has good Liquid Chlorine Pump supply vendors to build pressure upto 35barg. EuroChlor recommended to use simple centrifugal hermetically sealed pumps for Liquid Chlorine Service.

10. Europe has more than 60 years of experience for cross country pipe lines for Chlorine Service and no single incident has been reported so far, except the one happened in France in the year 2005. As per the information gathered during the meeting with EuroChlor that the incident was due to accumulation explosive mixture like hydrogen and chlorine in 8" (200 mm) pipeline, which ignited and detonated the pipeline. However, no casualty was reported.

11. There is no special safety measuring equipment in use in Europe like SCADA, Optical fibre, earth excavation monitoring instrument for underground and above ground pipe lines. For above ground pipe lines only Chlorine monitors are located at 60 to 100m intervals in AzkoNobel plant.

12. If two parallel chlorine pipe lines need to run then the gap between the two pipe lines to be maintained as per good engineering practise or as per maintenance requirement, applicable for both underground and above ground pipe lines.
13. AkzoNobel plant started Caustic Soda Plant in Year 1894 and now they upgraded the plant to latest technology of Uhde. Present plant capacity of AkzoNobel is 90,000 mtpa Chlorine. Highlights of AkzoNobel are:
    a. The product Chlorine is supplied to three plants. Evaporated Chlorine gas product to two adjacent plants, total Chlorine pipe length is 6 k.m and maximum single pipeline length is about 3.5 k.m. Third product is Liquid Chlorine, transporting through Rail wagons. Liquid Chlorine is running for about 800 m.
    b. 30 Nos. of Chlorine detectors are placed throughout the length of Chlorine gas lines, each Chlorine detector is located around 60-100m away and connected to DCS system.
    c. Fried Brigade department patrols and inspect the pipe line once in every 4 weeks.
    d. No isolation valves throughout the length of the Chlorine gas and Liquid Chlorine pipeline between AkzoNobel Chlorine producing plant and consumer plant(s), except isolation valve at AkzoNobel plant and receiver's plant(s).
    e. Only one Chlorine gas scrubber for the entire pipeline and it is at AkzoNobel plant.
    f. All valves used for Chlorine service are EuroChlor designed valves.
    g. Operating pressure of AkzoNobel Chlorine gas pipe line is 2 bar.g and Design pressure of the pipe line is approx. 26 bar.g During winter the operating pressure and temperature are adjusted in such a way that no condensation is accrued due to low temperature of the Bitterfeld location.
    h. Good corrosion protection painting is adopted on outside.
    i. Pipeline is crossing roads where public access is possible and close to a hotel. Pipeline near hotel is "pipe in pipe design" and the annular space is maintained by Nitrogen gas, which is around 800 m.
    j. At AkzoNobel plant, a "Moisture in Chlorine" analyser is installed to check moisture content in Chlorine gas.
    k. AkzoNobel Plant also supplies Hydrogen gas to adjacent plant by pipe rack, which in turns purifies and supplies to around 250 km in Germany.

l. AkzoNobel also supplies Anhydrous HCl gas to adjacent plant.
m. No pigging facilities are available for inspection and maintenance.
n. Plant shuts down 8-10 days every year for repairs and maintenance.
o. AkzoNobel informed that upto 150mm (6"), a detailed report is required based on local regulations in Germany like EIA study, Dispersion study and number of habitat affecting, in case of eventualities etc.
p. For Leak detection system mass flow meters are provided at the entry of pipeline (supplier side) & exit (customer side).

14. ChemiePark is taking care the entire industry needs between Berlin and Leipzig, which is open Chemical park accessible for public as well and covering about 1200 hectares. Following information provided by ChemiePark:
    a. This park is established in year 1893.
    b. ChemiePark is taking care the Industry requirements/needs like allocating land and supplying Power, Water, Nitrogen gas and steam.
    c. Open chemical park water requirement is taken care by ground water pumping.
    d. ChemiePark also built roads and the pipe bridges between chemical industries and takes care of them.
    e. ChemiePark also take care the Effluent treatment plant of capacity 85,000m^3/day, this is combined treatment of industrial and communal sewage.
    f. There are around 70 plants in this open Chemical Park in Bitterfeld and Wolfen area, producing various products and internal feedstock interconnection system of the companies at this location.
    g. In this area, there are around 120 different service bodies in operation to serve the industry.
    h. ChemiePark was once coal mining area. It has converted mined area into a water pond by pumping the treated effluent water.
    i. First PVC plant started in Europe in year 1936 in this open chemical park.
    j. 1/3rd of world glass is manufactures are located in this chemical park.
    k. Around 12,000 employees are working In this chemical park.

15. thyssenkrupp Uhde Chlorine Engineers has presented the following latest technologies:
    a. Water Electrolysis to produce clean energy renewable fuels and chemicals and also carbon recycling to produce clan methane etc.

b. HCl-ODC (Oxygen Depolarized Cathode) technology to produce Chlorine from HCl as feed stock and also HCl-Diaphragm technology to produce Chlorine and Hydrogen, a well proven technology.
c. NaCl-ODC (Oxygen Depolarized Cathode) technology, to produce Chlorine using ODC technology, which consumes 25% power lower than conventional Chlorine producing plant.
d. tkUCEG had shown the example of liquid Chlorine transfer pipe line for about 500 m long in Rafnes site. This pipe line is within the plant having both above ground and below ground pipeline crossing a road.
e. tkUCEG has shared its experience regarding Chlorine pipeline and indicated that each case has to be treated appropriately and suitable studies to be conducted on case by case basis.

16. Decision regarding permission for Chlorine pipe line, above ground pipe line or underground (buried) pipeline is totally depending on dispersion study and EIA Study, effect on Environmental, Habitat and Number of personnel effecting. A Case to case study is required and the following key points to be taken into consideration:
    a. Minimise the public access as much as possible.
    b. No condensation of Chlorine gas pipe line in all weather conditions, if Chlorine gas pipe line transfer is considered.
    c. Temperature of the Chlorine pipe line should not exceed more than 120°C internally and externally (due to fire or fire causing pipe lines adjacent to Chlorine Pipe line like Hydrocarbon pipe lines in a pipe rack/pipe corridor etc.). External Temperature protection by fire protection insulation to be considered.
    d. For underground pipe lines, clear visual mark-up throughout the length of pipe line is required.
    e. If underground pipe line to be adopted, pipe should be installed in a dedicated concrete casing with sand fill.
    f. Daily patrolling of cross country pipe lines is recommended.
    g. Periodic inspection, one in a year.
    h. If tracing is required, then it should be electric tracing only and avoid temperature of pipe line to cross 120°C at any point of time.
    i. If above ground pipe line is selected, required number of Chlorine detectors to be considered at particular intervals.

j. No sectional isolation is required.

k. Two separate Chlorine Scrubber Systems to be implemented at Chlorine producer's plant and receiver's plant to address the emergency evacuation of Chlorine gas in pipe line.

l. Two separate flow measuring and monitoring instrumentation system to be implemented at both Chlorine producer's plant and receiver's plant.

m. If above ground pipe line is selected, where public access is substantial, then a "pipe in pipe" construction to be adopted and the annular space to be padded with inert gas like Nitrogen gas and continuous monitoring of the annual space pressure to be integrated with the Chlorine producing and receiver's DCS control systems.

n. Carbon Steel Pipe line wall thickness should be calculated as per following minimum conditions:

"Maximum Operating Pressure + margin for design pressure as per pipe design code + Corrosion allowance (for Europe is 1.5mm), calculate the thickness and select the pipe schedule on the top of calculated thickness."

Conclusion:

The visit was fruitful and the Committee gained lot of knowledge and insight in operation of cross country chlorine pipelines. The Committee would take forward the learnings to finalise the guidelines for chlorine transport through pipelines in India.

31/10/18

(D.Praveen)
Director, DCPC
& Member Secretary of the Committee.