OISD - STD - 119
Revision-1

FOR RESTRICTED CIRCULATION ONLY

INSPECTION OF PUMPS

OISD-standard-119
Revision - I
First Edition, February 1996

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas

OISD - STD - 119
Revision-1
February, 1996

FOR RESTRICTED CIRCULATION ONLY

INSPECTION OF PUMPS

Prepared by :
Committee on "Inspection of Pumps"

Oil Industry Safety Directorate
2nd Floor, "Kailash"
26, Kasturba Gandhi Marg
New Delhi - 110 001

NOTE

FOREWORD

The Oil Industry in India is over 100 years old. Because of collaboration agreements, a variety of international codes, standards and practices have been in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by the Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self-regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safe operation. Accordingly, OISD constituted a number of functional committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on 'Inspection of Pumps' has been prepared by the Functional Committee on 'Inspection of Rotary Equipment.' This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. This document is meant to be used as supplement and not as a replacement for existing codes and practices. It shall be borne in mind that no standard can be a substitute for the judgement of a responsible qualified Engineer. Suggestions are invited from the users after it is put into practice to improve the document further. This document will be reviewed periodically for improvements based on the new experiences and better understanding. Suggestions for amendments to this document should be addressed to the Coordinator, Committee on "Inspection of Rotary Equipment", Oil Industry Safety Directorate, 2nd Floor, "Kailash", 26, Kasturba Gandhi Marg, New Delhi - 110 001.

This standard in no way supercedes the statutory requirements of bodies like IBR, CCE, Factory Inspectorate or any other Government Body which must be followed as applicable.

COMMITTEE ON
“Inspection of pumps”
Revision - I

Name	Organisation
Leader	
Shri K. Gopalakrishnan	Cochin Refineries Limited
Members	
Shri C. Lal	Oil & Natural Gas Corpn. Ltd. (SRBC-Madras)
Shri R. Ragothaman	Hindustan Petroleum Corpn. Ltd. (Marketing-BRPL Operation)
Shri S. P. Ashokkumar	Cochin Refineries Ltd.
Shri R. P. Shriwas	Indian Oil Corporation Ltd. (R&P Division-Pipelines)
Shri M. Chakravarty	Gas Authority of India Ltd.
Shri D. Jagannadha Rao	Madras Refineries Ltd.
Shri R. Rehman	Hindustan Petroleum Corpn. Ltd. (Marketing - LPG)
Member coordinator	
Shri S. B. Shah	Oil Industry Safety Directorate

In addition to the above, several other experts from industry contributed in the preparation, review and finalisation of the document.

INSPECTION
OF
PUMPS

CONTENTS

INSPECTION OF PUMPS

1.0 INTRODUCTION

The rotary equipment play a vital role in hydrocarbon processing industry. Timely inspection and maintenance of rotary equipment will go a long way in ensuring safer operations of the installations in Oil Industry.

2.0 SCOPE

This standard covers the minimum requirements for inspection, maintenance, commissioning and testing procedures for the following Rotary Equipment used in the Oil Industry:

i) Centrifugal Pumps (Horizontal/Vertical, Both ends supported/overhanging type, Single/Multi stage and Submersible type)

ii) Positive Displacement Pumps (reciprocating Pumps, Gear Pumps, Screw Pumps and Dosing Pumps).

3.0 PREDICTIVE MAINTENANCE SCHEDULE FOR CENTRIFUGAL PUMPS

The condition of centrifugal pump can be assessed by measurement of vibration and shock pulse levels of antifriction bearings. The frequency of measurement shall depend on the criticality of the equipment. OISD RP 124 (Predictive Maintenance Practices) shall be referred for predictive maintenance of centrifugal pumps.

4.0 PREVENTIVE MAINTENANCE INSPECTION SCHEDULE FOR CENTRIFUGAL PUMPS

Centrifugal Pumps are classified in the following groups for preparation of preventive maintenance inspection schedule :

i) Horizontal Centrifugal Pumps (both ends supported)
ii) Horizontal Centrifugal Pumps (overhanging type)
iii) Vertical Centrifugal Pumps
iv) Submersible Pumps

Check list on Inspection items for each type of pumps shall be as per the schedule given below.

4.1 HORIZONTAL CENTRIFUGAL PUMPS (BOTH ENDS SUPPORTED)

All the following items shall be checked/recorded after the specified period :

4.1.1 After 1000 running hours or 3 months whichever earlier

i) Bearing lubricant (for water contamination and sediments)
ii) Oil ring for performance
iii) Deflector for looseness
iv) Constant level oiler for leakage
v) Mechanical seal for leakage
vi) Seal flushing/quenching system (of Mechanical Seal) for clogging and chocking.
vii) Gland for leakage (adjust as necessary)
viii) Cooling water flow in both the bearing housings
ix) Condition of bearing by sound and temperature (in running condition)
x) Performance of all measuring instruments (Pressure/Temperature gauges and Flow Meters)
xi) Coupling Guard
xii) Electric Motor load current
xiii) Axial position indicator (in case of multistage pump)
xiv) Dowel pins (in position or not; wherever provided)

4.1.2 After 4000 running hours or 1 year whichever earlier

i) Repeat all checks per 4.1.1.
ii) Flushing of bearing with lube oil and refilling of oil to required level, whether carried out or not
iii) Flushing of cooling water lines and strainers, whether carried out or not (to ensure proper flow of cooling water.
iv) Foundation, foundation bolts and supports
v) Replacement of old packing with new ones and condition of gland follower, lantern ring and sleeves (in case of gland packing)
vi) Condition of coupling, coupling bolts, nuts, spring washers and their confirmity to uniform size. Change grease in half coupling in case of gear type.

4.1.3 After 8000 hours or 2 years whichever earlier

i) Repeat all checks per 4.1.2.

ii) Condition of outboard bearing, lock nut and lock washer (in case lock washer found damaged and lock nut loose, shaft axial play shall be checked)

iii) Following items of Journal bearings :

a) Clearance of I/B and O/B bearings
b) High spot (High Spots shall be scrapped)
c) Condition of thrust bearing, lock nut and lock washer (in case lock washer found damaged and lock nut loose, shaft axial play shall be checked).

iv) OISD RP 123 shall be referred for inspection of bearings. (Replace the bearings if necessary)

v) Pump float (adjust if necessary)

vi) Oil filter for cleanliness if journal bearings are hydrodynamic

vii) Condition of mechanical seals (OISD RP 125, “Inspection and Maintenance of Mechanical seals” shall be referred)

viii) Alignment (Misalignment shall not be more than 0.05 mm)

ix) Painting of equipment, whether carried out or not

Notes:

i) After completing the checks listed above the pump shall be started and the following shall be checked during the trial run (the trial run duration shall be half to one hour for electric driven and 3 to 4 hours for diesel driven) :

a) Discharge pressure
b) Suction pressure
c) Liquid flow (if possible)
d) Condition of Mechanical Seal/Gland Packing
e) Electric Motor load current at discharge valve shutoff and open condition
f) Condition of bearing by sound and temperature
g) Any leakage
h) Vibration and shock pulse reading as per OISD 124

ii) Pumps in hot service shall not be rotated unless it is gradually heated up to a temperature close to that of the working fluid.

4.1.4 After 16000 hours or 4 years whichever earlier

Complete overhauling of the pump shall be carried out.

This shall include part-wise inspection as per item 4.5 and all checks specified for 8000 hours.

4.2 HORIZONTAL CENTRIFUGAL PUMPS (OVERHANGING TYPE)

All the following items shall be checked/recorded after the specified period :

4.2.1 After 1000 hours or 3 months whichever earlier

i) Oil in bearing housing for water contamination and sediment (Replace oil if necessary)
ii) Oil ring for proper working
iii) Constant level oiler for proper working
iv) Gland packing (for leakage)
v) Condition of Mechanical Seal (OISD RP 125, “Inspection and Maintenance of Mechanical Seals” shall be referred for replacement)
vi) Cooling water flow
vii) Condition of coupling guard
viii) Condition of bearing by sound and temperature
ix) Electric Motor load current (at discharge valve shutoff and open condition)
x) Performance of all measuring instruments (Pressure/Temperature gauges and flow meters)

4.2.2 After 4000 hours or 1 year whichever earlier

i) Repeat all checks per 4.2.1.
ii) Flushing of cooling water lines and cleaning of Strainers, whether carried out or not (to ensure proper flow of cooling water)
iii) Condition of coupling (in decoupled condition)
iv) Coupling end support for any abnormality
v) Foundation, foundation bolts and supports.
vi) Alignment (Realign, if necessary)

vii) Performance of all measuring instruments and recording of readings
viii) Suction line strainer for cleanliness

4.2.3 After 8000 hours or 2 years whichever earlier

Complete overhauling of the pump shall be carried out. This shall include part-wise inspection as per item 4.5 and all checks per item 4.2.2.

Notes:

i) After completing the checks listed above the pump shall be started and the following shall be checked during the trial run (the trial run duration shall be half to one hour for electric driven and 3 to 4 hours for diesel driven):
   a) Discharge pressure
   b) Suction pressure
   c) Liquid flow (if possible)
   d) Condition of Mechanical Seal/Gland Packing
   e) Electric Motor load current at discharge valve shutoff and open condition
   f) Condition of bearing by sound and temperature
   g) Any Leakage
   h) Vibration and shock pulse reading as per OISD 124
ii) Pumps in hot service shall not be rotated unless it is gradually heated up to a temperature close to that of the working fluid.

4.3 SUBMERSIBLE PUMPS (WET MOTOR TYPE AND DRY MOTOR TYPE)

The following items shall be checked/ recorded:

4.3.1 After every 250 hours or fortnightly whichever earlier

i) Ensure optimum liquid level to avoid dry run wherever auto cut in/cut out not provided
ii) Motor load current
iii) Pump discharge pressure
iv) Any abnormal sound and vibration of connected piping

4.3.2 After every 8000 hrs. or 2 years whichever earlier (For saline service, this interval may be reduced as required)

Complete overhauling of the pump shall be carried out. This shall include part-wise inspection as per item 4.5.

4.4 VERTICAL CENTRIFUGAL PUMPS

All the following items shall be checked/recorded after the specified period:

4.4.1 After 1000 hours or 3 months whichever earlier

i) Oil in bearing housing for water contamination and sediment (Replace oil if necessary)
ii) Constant level oiler for proper working
iii) Gland packing (for leakage)
iv) Condition of Mechanical Seal (OISD RP 125, “Inspection and Maintenance of Mechanical seals” shall be referred for replacement)
v) Cooling water flow
vi) Condition of coupling guard
vii) Condition of bearing by sound and temperature
viii) Electric Motor load current (at discharge valve shutoff and open condition)
ix) Performance of all measuring instruments (Pressure/Temperature gauges and flow meters)

4.4.2 After 4000 hours or 1 year whichever earlier:

i) Repeat all checks per 4.2.1.
ii) Flushing of cooling water lines and cleaning of Strainers, whether carried out or not (to proper flow of cooling water)
iii) Condition of coupling (in decoupled condition)
iv) Foundation, foundation bolts and supports
v) Alignment (Realign, if necessary)
vi) Performance of all measuring instruments and recording of readings
vii) Suction line strainer for cleanliness

4.4.3 After every 24000 hours or 4 years whichever earlier :

Complete overhauling shall be carried out.

During overhauling, part-wise, inspection as per item 4.5 and checks specified for 4000 hours shall be carried out.

4.5 PARTWISE INSPECTION DURING COMPLETE OVERHAUL OF CENTRIFUGAL PUMPS

Part-wise inspection shall be carried out during complete overhaul.

For the purpose of part-wise inspection the parts of centrifugal pump are classified into following two categories:

i) Stationary parts
ii) Rotating parts

4.5.1 STATIONARY PARTS

i) Casing, Volute and Stuffing Box

a) casing and volute shall be inspected for cavitation, erosion or corrosion.
b) Stuffing box walls shall be checked for corrosion, ovality and other damages including descaling in waterways.
c) Gasketing surface of Mechanical Seal flange shall be inspected for pitting and unevenness.
d) Casing wear ring seat shall be inspected. It should be complete round, smooth and free from corrosion/irregularities.
e) Volute, diffuser blades shall be inspected for wear/damage.

ii) Gland follower/Mechanical Seal flange

a) Flange face shall be inspected for wear due to corrosion and erosion
b) The following clearances shall be measured
   - Stuffing box inside dia and follower outside dia.
   - Shaft/sleeve outside dia and follower inside dia

iii) Bearing Housing

a) Bearing seats shall be inspected for trueness within prescribed limit.
b) Oil lifter rings shall be inspected for wear and ovality
c) Water jacket shall be descaled/cleaned and hydrotested.
d) Oil seal seat and deflector ring groove shall be inspected
e) Fittings of make up oil bottle shall be checked.
f) Constant level oiler shall be checked for performance.
g) Axial thrust bearing seat shall be inspected for ovality
h) Magnetic drain plug shall be inspected. Ordinary drain plug shall be replaced with magnetic drain plug.

iv) Casing wear ring/Case separating rings/Impeller separating rings

a) Rings shall be inspected for wear and damage and dimension shall be verified.
b) Locking arrangement shall be checked.

v) Throat bush, Balancing bush and Balancing sleeve

a) Bush sleeve shall be inspected for wear and damage.
b) OD and ID shall be measured
c) Locking arrangement shall be checked

vi) Lantern Ring

a) OD and ID shall be measured
b) Groove/hole for cooling media shall be checked
c) Lantern ring shall be inspected for wear, damage, corrosion and surface smoothness.

vii) Cooling system/Steam snuffing system/Gland sealing line

a) General condition of small bore lines and balancing lines (after sealing lines) shall be checked.
b) Condition of all pipe fittings shall be checked.
c) Piping shall be checked for proper flow.

viii) Bolt/Nut/Washer

All bolts/nuts/washers shall be inspected for wear, pitting and damage.

ix) Coupling Guard

a) Coupling guard shall be inspected for damage/corrosion
b) Coupling guard-locking system shall be checked.

x) Flow bypass system

Flow bypass arrangement system shall be checked.

xi) Protection devices

Protection devices for high casing temperature, high vibration, high bearing temperature etc. shall be checked. For overload relays, standard 137 “Inspection of Electrical Equipment” shall be followed.

4.5.2 Rotating Parts

i) Impeller

a) Impeller vanes shall be checked for clogging.
b) Impeller shall be checked for cracks in vanes, outer plates and hub
c) Impeller shall be inspected for pitting, corrosion, erosion and sign of cavitation
d) Overall diameter shall be measured.
e) Bore diameter and key groove shall be checked.
f) Impeller wearing seat shall be inspected and the diameter shall be measured.
g) Balancing holes shall be checked.
h) Impeller shall be balanced before assembly.
i) In case of new Impeller, direction of vanes and material of construction shall be checked.

ii) Shaft

a) Shaft shall be checked for burr, ridge and crack
b) Dimension at the following positions of the shaft shall be measured
   – at bearing seat
   – at impeller seat
   – at sleeve seat
   – at coupling seat
c) Groove tolerance and threads shall be checked
d) Shaft trueness shall be checked. The shaft run out shall not be more than 0.05 mm.

iii) Impeller Wear Ring

Checks of 4.5.1 iv) shall be done.

iv) Impeller Lock Nut

a) Threads shall be checked for damage.
b) Locking surface shall be checked for smoothness.
c) Hexagonal section of the nut shall be checked for any burr/deformation.

v) Key

a) Material of construction shall be checked for new
b) Dimensions shall be checked with respect to keyway groove dimensions

vi) Shaft Sleeve and Spacer Sleeve

a) Material of construction shall be verified in case of new/replacement
b) ID/OD shall be measured and checked with mating parts.
c) Gasketing seats shall be checked
d) ‘O’ ring groove (if provided) shall be checked.
e) Ensure tightness of sleeves

viii) **Balancing Drum**

a) Material of construction shall be verified in case of new/replacement
b) OD/ID shall be measured.
c) Gasketing seats shall be inspected.

ix) **Deflector**

a) Deflector shall be checked for crack, erosion and corrosion.
b) Bore dia and step dia (which fits in bearing housing) shall be measured.
c) Locking screw/threads in the deflector plate shall be checked.

ix) Oil Ring and other system of oil lifting.

The oil ring and other system of oil lifting shall be checked for wear/crack, ovality and squareness.

x) Rotor assembly

Dynamic balancing of the rotor assembly shall be checked provided in case.
– pump was running with high vibration prior to overhauling.
– components of the rotor have been replaced.
– wear observed on components of the rotor.

If imbalance is observed in rotor assembly, then dynamic balancing of individual component shall be checked.

xi) Bearing and Coupling

OISD RP 123 “Inspection and Bearing, Couplings and Belts” shall be referred.

xii) Mechanical Seal

OISD RP 125 "Inspection and Maintenance of Mechanical Seals" shall be referred.

4.6 COMMISSIONING AND TESTING PROCEDURES FOR CENTRIFUGAL PUMPS

The following procedures shall be followed for commissioning and testing of overhauled and newly installed pumps:

4.6.1 Overhauled Pumps

i) Pre Starting procedures

a) Pump and Prime mover alignment shall be checked in uncoupled condition
b) Suction/discharge pipings shall be checked to ensure no strain coming on the pump
c) Direction of rotation of prime mover shall be checked
d) All piping connections shall be checked
e) Ensure all instruments are calibrated
f) Foundation bolts shall be tightened and alignment rechecked.
g) Pump shall be coupled to the prime mover
h) Ensure replacement of lubricants/ lubricating oil (after flushing as necessary).
i) Coupling guard shall be fixed.
j) Suction strainer shall be checked for correct size.
k) Pump shall be primed by gradually opening the suction valve (In case of hot pump-cooling water, seal oil and steam quenching shall be kept open while heating the pump).
l) Leaks from joints/fittings (after the pump attaining suction pressure) shall be attended.
m) After completing all the above checks and the pump housing attaining temperature close to that of the fluid, the motor shall be rotated to ensure free rotation.
n) Alignment shall be rechecked after the pump has been heated up by the suction fluid.
o) Ensure that the discharge valve is fully closed and suction is fully opened.

ii) Start up Procedures

After completing the pre-starting procedure the pump is ready for start up. The start up procedures given below shall be followed.

a) Clearance for energising the Motor (in case of electrical drive) shall be obtained.
b) The pump shall be started & the discharge valve opened gradually.

iii) Post Start Checks

The following shall be checked/observed:

a) All instruments shall be checked and readings observed at regular intervals, and the performance of equipment compared with manufacturer's data.
b) Vibration readings shall be checked for abnormality (if any) and corrective action shall be taken as necessary. Signature for critical Pumps shall be checked.
c) Temperature rise, and abnormal sound (if any) for bearings shall be checked.

4.6.2 Newly Installed Pumps

i) Pre Starting Procedures

a) Equipment

Pump shall be thoroughly cleaned.

b) Piping

Assembly of all piping shall be checked to ensure that they are as per the design drawing. Piping shall be thoroughly flushed to remove rust preventive/foreign material.

c) Support

Relevant pipe supports shall be checked to ensure that they are as per design drawing.

d) Alignment

Alignment of pump and prime mover shall be carried out. OISD RP 126, "Specific Maintenance Practices" shall be referred.

e) Bearing

Bearings shall be lubricated with correct lubricant wherever applicable.

f) Prime Mover

The prime mover shall be prepared for operation as manufacturer's instruction. In case of Electric Drive correct direction of rotation shall be ensured in decoupled condition. Insulation value of motor and cable shall be checked and recorded.

g) Packing/Mechanical Seal

For gland packing and mechanical seal, cooling and flushing shall be ensured. Mechanical Seals (if applicable) shall be installed as per manufacturer's recommendations.

h) Heating up before Startup

Pumps on high temperature service shall be heated up gradually to an even temperature before putting on service.

i) Balancing drum leakage

For pumps equipped with balancing drums, any valve in the line shall be locked open for ensuring leakage return to pump suction or to the vessel.

j) High temperature pump operation

The following precautions shall be ensured:

- The required suction head.
- Sufficient flow to prevent flashing of liquid passing through the pump.
- Sudden change of temperature shall be avoided to prevent thermal shocks to the pump.
- The lubrication of bearings and stuffing box to prevent damage.

k) After the above checks, procedures per 4.6.1 shall be followed.

ii) Start up Procedures

The procedures as given below shall be followed for start up.

a) The free rotation of the pump shall be checked.
b) Ensure all instruments are installed as per P&I diagram.
c) Ensure that strainer is provided in the suction line.
d) Discharge valve shall be closed (if not already closed).
e) On pumps having externally sealed stuffing boxes, the injection line valves shall be opened and sealing fluid allowed to flow to the seal cages.
f) Pump shall be properly primed.
g) Prime mover shall be started as per prescribed recommendation.

iii) Post Start Checks

a) All instrument readings shall be checked and recorded periodically.
b) Vibration readings shall be checked and signature shall be taken as necessary.
c) Stuffing box packing shall be checked for overheating.
d) Temperature rise, vibration and any abnormal sound from bearings shall be checked.
e) Cooling water flow shall be checked frequently.
f) Suction and discharge pressure shall be monitored to ensure proper operating condition.
g) Alignment shall be rechecked within 100 hours of operation.

5.0 PREVENTIVE MAINTENANCE INSPECTION SCHEDULE FOR POSITIVE DISPLACEMENT PUMPS

Positive displacement pumps are classified in the following groups for preparation of preventive maintenance inspection schedule:

i) Reciprocating Pumps/plunger pump
ii) Gear Pumps/Screw Pumps

Checklist on inspection items for each type of pumps shall be as per the following schedules:

5.1 RECIPROCATING / PLUNGER / DIAPHRAGM PUMPS

All the following items shall be checked/recorded after the specified period.

5.1.1 After 1000 Hours

i) Crank case oil condition for contamination
ii) Gear Box oil condition for contamination
iii) Gland for leakage (shall be adjusted if necessary)
iv) Coupling guard condition (shall be rectified if necessary)
v) Motor and Gear box bearings by sound and temperature (in running condition)
vi) Relief valves for passing
vii) Lubricating oil pump and non return valve (for steam driven pump only)

5.1.2 After 4000 Hours

i) Crank case oil replacement (crankcase shall be flushed before oil replacement)
ii) Gear box oil replacement (gear box shall be flushed before oil replacement).
iii) Condition of piston/plunger and liner for wear
iv) Lubricating oil strainer and pipings
v) Bearing and Gear of Gear box for any damage
vi) Coupling guard condition
vii) Working of safety relief valve
viii) Ensure replacement of gland packing
ix) Alignment
x) Suction and discharge valve, valve seat etc.
xi) Stroke adjusting mechanism (shall be serviced if necessary)
xii) Lubrication for the steam driven side (in case of stream driven pump)
xiii) Foundation, foundation bolts and supports

Note : The pump shall be started after completing the checks listed i to xii above and the following shall be checked :

a) Vibration and temperature of bearing of Gearbox and Motor
b) Gland for leakage (shall be adjusted if necessary)
c) Pump performance

5.1.3 After 8000 Hours

Complete overhauling of the pump shall be carried out. This shall include part-wise inspection as per item 5.3 and all checks specified for 4000 Hours.

5.2 GEAR PUMPS/SCREW PUMPS

For Gear Pumps/Screw Pumps/ Dosing Pumps, the inspection schedule shall be fixed depending on the specific nature of application and manufacturer's recommendation.

5.2.1 Inspection items of Gear Pumps

The following shall be checked/ recorded:

i) Gear Casing

a) Clearance between gear and casing.
b) End clearance between gears and end covers
c) Backlash

ii) Bush/Bearing

a) Clearance between gear shaft and bush.
b) Bearing as per OISD 123

iii) Seal

a) Condition of Seal
b) Replacement of elastomer

5.2.2 Inspection Items of Screw Pumps

The following shall be checked/ recorded:

i) Screw/Casing

a) Clearance between screw and casing
b) Axial clearance between screw and end cover.

ii) Bearing

OISD RP 123, Inspection and Maintenance of Rotating Equipment 'Components' shall be referred.

iii) Seal

a) Condition of seal
b) Replacement of elastomer

5.3 PARTWISE INSPECTION DURING COMPLETE

OVERHAUL OF RECIPROCATING PUMPS

Part-wise inspection shall be carried out during complete overhaul.

For the purpose of part-wise inspection, reciprocating pump parts are divided into the following two groups :

i) Liquid end parts
ii) Power end parts

The liquid end performs the suction and discharge functions of the pump for the liquid handled whereas the power end provides the power for the pump.

5.3.1 Liquid end parts

i) Cylinder Liner

The cylinder liner shall be checked for wear, ovality and scratches. The base/ovality shall be measured, recorded and maintained within prescribed limits.

In case of replaceable liners, the liner wear plate and gasket shall be removed, checked and replaced if necessary. The gasket shall be replaced every time when it is removed.

ii) Piston/Plunger

Piston or plunger shall be checked for wear, ovality and scoring marks. In the case of piston with piston rings the wear on piston ring grooves shall be checked. The piston and piston ring grooves shall be brought back to acceptable tolerances.

iii) Plunger Packing Set

The packing shall be replaced. The lantern ring and spacer ring shall be checked for wear and corrosion.

iv) Gland Packing

Gland packing should be replaced.

v) Suction and Discharge Valve

The suction and discharge valve shall be inspected for :

a) Wear/Corrosion
b) Clearance of valve guide
c) Condition of seating face
d) Spring or dead weight for wear, crack and corrosion.

vi) Piston Rod

Piston rod shall be checked for straightness and wear.

vii) Throttle Bush

The clearance between throttle bush and the shaft shall be measured and the bush shall be replaced if the clearance is found more than prescribed.

5.3.2 Power End Parts (steam driven)

i) Cylinder

The cylinder shall be checked for wear, ovality and scoring. The bore & ovality shall be measured, recorded and maintained within prescribed limits.

ii) Piston

The piston shall be checked for wear, ovality and scoring. Piston ring grooves shall be checked for wear.

iii) Piston Ring

Piston ring shall be checked for wear, tension and gap. Piston ring width shall be checked.

iv) Piston Rod

Piston rod shall be checked for straightness and wear/scoring.

v) Throat Bush

The clearance between throttle bush and the shaft shall be measured.

vi) Slide Valves

These shall be checked for wear.

5.3.3 Power end parts (motor/engine driven)/Gearbox

The following shall be checked :

a) Warm shaft for trueness.

b) Backlash/gear clearances
c) Blue matching of gear teeth for uniform contact.
d) Condition of crankshaft with bearings.
e) Condition of connecting rod with bearings.
f) Cross head and cross head pin clearance.
g) Pinion shaft or sprocket shaft and bearing clearance
h) Condition of drive/driven sprocket and chain
i) Condition of pump sheave or coupling.

5.3.4 Diaphragm

a) shall be checked for condition and elongation
b) shall be replaced if dimensions don't match with original values.
c) lube oil sump shall be flushed and oil replaced.

5.4 COMMISSIONING AND TESTING PROCEDURES FOR RECIPROCATING PUMPS.

The following activities shall be performed when a new reciprocating pump or when a pump which is idle for a long period of time or a pump after overhauling is started.

i) Pre Starting Procedures

a) Pump and strainer shall be cleaned
b) Pump along with suction discharge line shall be flushed.
c) Ensure cross head, plunger are free of rust and clean.
d) Ensure freeness and direction of rotation of pump.
e) Ensure proper lubricant in crank case. In case of multiplex pump each crank case shall be checked.
f) Ensure installation of Relief Valve and Pressure Gauge in discharge line.
g) Ensure replacement of hardened any dry synthetic rubber packing.
h) For pump with stuffing box lubrication, the volume of oil in lubricating tank shall be checked. Lubricating pressure should not be raised higher than necessary.

ii) Starting Procedures

a) Suction valve shall be opened and the liquid is allowed to flow and no pressure is put on the discharge side. In case of liquid end with jacket, liquid shall be allowed to pass after the liquid end has reached a set temperature.
b) b) When starting for first time or after a long shutdown, stroke shall be set at 'O' before switching on the electric power source. Pump shall be run unloaded with stroke at 'O' for a few minutes.
c) Stroke length shall be raised gradually and pump is allowed to run for a while until 100% stroke length is attained. During this interval, check that no abnormal sound/abnormal vibrations have developed and the stroke adjusting handle is working smoothly.
d) Pressure shall be raised gradually until complete load is attained. In case the pressure cannot be applied on the process side, the back pressure valve can be used to load. The pressure should be raised by watching the pressure gauge but at first the set pressure of the back pressure valve should be at 0.
e) Ammeter shall be checked to ensure that there is no overload.
f) Gland shall be checked for leakage and overheating (shall be adjusted as necessary)
g) On ensuring mechanical soundness, volume check should be made under actual operating conditions.

6.0 DIFFERING SCHEDULES

The schedules given in this standard are very broad based on present experience and practices and may be modified from time to time. The schedules indicate the maximum interval of time between two inspections. Organisations having historical records and analysis of failures may alter the inspection interval accordingly. Records shall be maintained as per sample format of history cards and specification sheets provided in OISD STD 127, with respect to problems on equipment in different services. Based on the feedback obtained, the Committee shall upgrade inspection schedules and procedures.

7.0 DOCUMENTATION

Documentation and record keeping form an integral part of total Inspection Management System. The various inspection records on all areas shall be maintained in standard formats designed specifically for the individual requirements.

8.0 REFERENCES

a) *API 610 Centrifugal Pumps for General Refinery Services*

b) *API 674 Positive Displacement Pump- Reciprocating*

c) *OISD RP123 Inspection of Bearings, Couplings and Belts*

d) *OISD RP 124 Predictive Maintenance Practices*

e) *OISD RP 125 Inspection and Maintenance of Mechanical Seals*

f) *OISD RP 126 Specific Maintenance Practices (Rotating Equipment)*

g) *OISD 127 History Recording (Rotating Equipment)*

Notes

OISD-120
Amended edition
FOR RESTRICTED CIRCULATION

NO.

INSPECTION OF COMPRESSORS

OISD STANDARD-120

First Edition, January 1990
Amended edition, August, 1999

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum and Natural Gas

OISD STANDARD-120
First Edition, January, 1990
Amended edition, August, 1999

FOR RESTRICTED
CIRCULATION

No.

INSPECTION
OF
COMPRESSORS

Prepared by

COMMITTEE ON
INSPECTION OF ROTARY EQUIPMENT

OIL INDUSTRY SAFETY DIRECTORATE
2ND FLOOR, “KAILASH”
26, KASTURBA GANDHI MARG
NEW DELHI - 110 001

NOTE

This standard is intended to supplement rather than replace the prevailing statutory requirements.

Note 1 in superscript indicates the modification/changes/addition based on the amendments approved in the 17th Safety Council meeting held in July, 1999.

FOREWORD

The Oil Industry in India is 100 years old. As such a variety of practices are in vogue because of collaboration/association with different foreign companies and governments. Standardisation in design philosophies, operating and maintenance practices at a national level was hardly in existence. This, coupled with feed back from some serious accidents that occurred in the recent past in India and abroad, emphasised the need of the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by the Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly OISD constituted a number of functional committees comprising of experts nominated from industry to draw up standards and guidelines on various subjects.

The present standard on Inspection of Compressors was prepared by the Functional Committee on “Inspection of Rotary Equipment”. This standard is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. This standard is meant to be used as a supplement and not as a replacement for existing codes, standards and manufacturer’s recommendations. It is hoped that the provisions of this standard, if implemented objectively, may go a long way to improve the safety and reduce accidents in the Oil and Gas Industry. The users of this standard are cautioned that no standard can be substituted for responsible and experienced engineer. Suggestions are invited from the users after it is put into practice to improve the standard further. Suggestions for amendment to this standard should be addressed to:

The Coordinator,
Committee on “Inspection of
Rotary Equipment”
2nd Floor, “Kailash”
26, Kasturba Gandhi Marg
New Delhi - 110 001

COMMITTEE ON
INSPECTION OF ROTARY EQUIPMENT

List of Members

	Name	Designation & Organisation	Position in Committee
1.	Sh. K. Gopalakrishnan	Sr. Maint.MGR-CRL	Leader
2.	Sh. B.P. Sinha	Chief Proj.MGR-MRL	Member
3.	Sh. Chotey Lal	Ch.Engineer-ONGC	Member
4.	Sh. R.C. Chaudhary	Office Engg.MGR-BPCL	Member
5.	Sh. K.M. Bansal	Chief Maint.MGR-IOC	Member
6.	Sh. Ehsanuddin	Director-OISD	Member
7.	Sh. R.M.N. Marar	Joint Director-OISD	Member Coordinator

In addition to the above, several other experts from industry contributed in the preparation, review and finalisation of this document.

INSPECTION OF COMPRESSORS

CONTENTS

1.0 INTRODUCTION

The rotary equipment plays a vital role in hydrocarbon processing industry.

Timely inspection and maintenance of rotary equipment will go a long way in ensuring safer operations of the installations in Oil Industry.

2.0 SCOPE

This standard covers the minimum requirements for inspection, maintenance, commissioning and testing procedures for the following Rotary Equipment used in the Oil Industry:

i) Centrifugal Compressors (excluding rotary equipment classified as fans or blowers that develop pressure less than 0.34 bar or packaged integrally geared centrifugal air compressors).

ii) Reciprocating Compressors (excluding portable air compressors).

3.0 PREDICTIVE MAINTENANCE SCHEDULE FOR CENTRIFUGAL COMPRESSORS

The following measurements shall be taken weekly:

i) Vibration of bearings
ii) Axial displacement of compressor
iii) Shock pulse values for compressor fitted with antifriction bearings.

4.0 PREVENTIVE MAINTENANCE INSPECTION PROCEDURES

Preventive Maintenance Inspection Procedures should be tailored to individual equipment application with references of manufacturer's operating and maintenance manual.

For Centrifugal Compressors the first complete overhaul should be taken up after 8000 hours of operation. This will enable to have an inspection of the internals and will become a guide for future inspection schedules. The subsequent complete overhaul should be carried out based on monitored data or 24000 hours of operation (whichever is earlier).

All inspection data shall be carefully taken and compared with manufacturer's data to ascertain if any changes have occurred during operation.

If any part/component is found damaged or the amount of wear is more than the limit specified by the manufacturer, the component shall be either replaced or repaired using sound engineering practices.

Prior to complete overhaul, an operational test run of the machine shall be made for reference operating parameters which shall serve as a means of comparison with identical test that shall be made immediately after the complete overhaul.

4.1 PREVENTIVE MAINTENANCE INSPECTION SCHEDULE FOR CENTRIFUGAL COMPRESSORS

All the following items shall be checked/recorded after the specified running hours:

4.1.1 Once in 3 month or After 1000 Hours of operation whichever occurs earlier [Note 1]

i) Lube oil for the following:
Flash point
Water content
Impurities and wear particles
Viscosity and Viscosity index
Maximum total acidity

(Note: The oil sample shall be collected from the running machine).

ii) Filters in Gas/Air/Seal oil/Lube oil circuits(Replace if necessary)

iii) Drain system for proper functioning

iv) All switches such as low lube oil pressure, high discharge temperature, low suction pressure, cooling low etc. and control circuits are to be checked for proper functioning. [Note 1]

4.1.2 After 8000 Hours

i) Filters in gas/air circuits (whether cleaned or not)

ii) Condition of bearings (Axial float shall be measured)

iii) Gas Seals (in case the inner seal drain quantity is more during run)

iv) Lube oil cooler and gas cooler (whether cleaned or not)

v) Instruments (whether calibrated or not)

vi) Auto changeover system of pumps for proper functioning

vii) All safety protections for proper functioning

viii) Settings of safety valves

ix) Coupling (whether cleaned or not, in decoupled condition)

x) Alignment

xi) Foundation bolts for tightness

xii) Gas traps in the seal oil circuit for gas compressor (whether cleaned or not)

(**Note**: Operating parameters shall be checked and recorded before and after 8000 hours inspection).

4.1.3 After 24000 Hours

Complete overhauling of the compressor shall be carried out.

(**Note**: During complete overhauling, partwise inspection as per item 4.2 shall be carried out).

4.2 PARTWISE INSPECTION DURING COMPLETE OVERHAUL OF CENTRIFUGAL COMPRESSORS

i) ROTOR

a) Critical impeller dimensions (such as bore, eye seal and outside diameter) shall be measured.

b) Each impeller shall be examined by magnetic particle or dye penetrant methods.

c) Each impeller shall be inspected for erosion and/or corrosion and abrasion.

d) Impeller vane thickness and clearances/tolerances shall be measured.

e) Rotor shall be tested to determine the run out/shaft bow.

f) Shaft shall be subjected to non destructive examination.

g) Inter stage sleeves shall be checked for cracks and wear.

h) Rotor assembly should be dynamically balanced in case of corrosion, erosion and unbalance indicated by vibration analysis before shutdown.

i) Thrust collar and journal shall be examined for wear and scoring.

ii) COMPRESSOR CASING

a) Casing shall be inspected for cracks, corrosion and deposits. Suspected cracks shall be checked by dye penetrant test.

b) Diaphragms labyrinth or other packings shall be removed, cleaned and inspected for wear and replaced wherever required.

c) Diaphragms shall be removed, cleaned and inspected by magnetic particle inspection or DP test.

iii) JOURNAL AND THRUST BEARING

a) Housing outer diameter and inner diameter shall be measured to make sure it is even.

b) Bore, face and plates shall be checked for nicked edges, scratches or scoring.

c) Parting line surfaces shall be inspected for full contact.

d) Pivoting surfaces of shoe and house ring shall be examined for scratches, scoring or erosion.

iv) TILT PAD BEARING

a) Tilting- pad bearing shall be checked for contact area and position. The contacting surface shall be in center only and at the bottom portion of the pivot bore in the retainer.

b) Checks shall be done to ensure that pins do not bottom-out in pads.

v) SEAL

a) Shaft Seal

- Clearances between the bushing and the shaft shall be measured.
- Bushing shall be inspected for wear, scores, wipe and crack. 'O' rings in the seal housing shall be replaced.

b) Internal seal

- The internal seals are normal wearing parts and shall be replaced.
- Clearances between rotating and stationary parts shall be measured.
- Rotating parts shall be inspected for wear, scores, wipe and cracks.

vi) LUBE AND SEAL OIL SYSTEM

a) Physical/Chemical properties of the oil shall be checked.

b) Piping shall be inspected for clogging and corrosion.

c) Oil reservoir, run-down tank and overhead tank shall be inspected and cleaned.

d) Oil coolers shall be inspected, cleaned and hydrotested.

e) Oil strainers shall be inspected.

f) Lube oil and seal oil lines shall be air blown prior to fitment. **Note 1**

vii) COUPLING AND ALIGNMENT

a) Gear couplings shall be inspected for tooth breakage, scoring and pitting.

b) Disc couplings shall be checked for cracks in the discs.

c) Alignment between the driver shaft and the compressor shaft shall be checked.

4.3 COMMISSIONING AND TESTING PROCEDURES FOR CENTRIFUGAL COMPRESSORS

The following procedures shall be followed for commissioning and testing of overhauled compressors, compressors started up after long period of non-operation/newly installed compressors.

4.3.1 Overhauled Compressors and Compressors started after long period of Non Operation

i) INITIAL PREPARATION

a) Assembly of all the piping shall be checked to ensure that they are in accordance with the 'Flow diagram' and the 'Piping Assembly Drawings'.

b) Tightness of all the nuts, bolts, screws etc. shall be checked.

c) Thorough cleaning (acid cleaning if necessary) and flushing of all piping shall be done to prevent any foreign particles from entering the compressor.

d) Interior of the suction gas filter and suction gas pipes shall be checked to ensure that these are free from any foreign materials.

e) The lubrication and seal oil system shall be flushed and cleaned to remove dirts and foreign particles.

f) Blowing out and thorough cleaning of all the gas lines shall be carried out.

g) All check valves in the system shall be checked for its correct direction.

h) Check valves (NRV) for lube and seal oil system shall be checked for correct direction.

i) Assembly of couplings shall be in accordance to match marks.

j) Couplings and other naked rotating parts shall be protected by the coupling guards or suitable cover.

k) Cold alignment data shall be compared with manufacturer's limits.

l) All pressure and temperature gauges shall be calibrated.

m) Thermocouple or similar alarm/shutdown devices shall be calibrated.

n) All pressure switches shall be tested/calibrated.

o) All controllers, transmitters and control valves shall be adjusted and set.

p) All interlock relays should be completed on sequence circuit and in correct functions.

q) All lines shall be checked for proper supports.

r) Lube oil/seal used should be of proper quality as recommended by manufacturer.

ii) PRE-START OPERTION

a) The compressor house shall be made gas free.

b) All utilities shall be established.

c) All safety devices shall be checked for their normal working.

d) All compressor drains shall be opened to drain off the liquid and then all valves shall be closed.

e) Lube oil and seal oil system shall be put in operation.

f) All main oil line valves shall be opened and oil flow to the bearings, gears and seals shall be ensured.

g) Block valves for pressure and temperature sensing devices shall be opened.

h) Bypass valves of pressure regulator or differential pressure regulator and level control valves shall be opened.

i) Level of oil reservoir and degassing drum shall be checked.

j) The valves in cooling water supply line shall be fully opened and the adjustment of water flow rate shall be made by the valve in the return line.

k) System using accumulator shall be charged with inert gas.

l) Main oil pump shall be started.

m) Filling and pressurising of oil system with lube and seal oil shall be done by slowly closing the by pass valve of pressure regulator/differential pressure regulator.

n) Oil cooler and oil filter venting shall be done.

o) Overhead tank level shall be checked.

p) Auto-starting of standby lube oil and seal oil pump shall be checked.

q) Fine wire mesh may be put in lube oil inlet header and oil circulation shall be carried out for at least 4 hours after which the wire mesh shall be checked for rust/dirt particles, based on which further circulation may be continued. [Note 1]

iii) START UP OPERATION

a) Proper lubrication shall be ensured.

b) The system shall be purged with inert gas and sample shall be taken for analysis.

c) Each suction and discharge valve shall be checked for correct positioning.

d) The compressor shall be manually rotated to ensure free rotation.

e) Prime mover shall be started as per manufacturer's instructions.

f) The direction of rotation shall be checked.

iv) POST START OPERATIONS/ CHECKS

a) The mechanical running test shall be conducted to assess the performance of the compressor (as per API 617 after every major overhaul).

b) Oil pressures and temperatures shall be monitored to ensure that they are within the range recommended by manufacturer.

c) For compressors with oil seals, the amount of inward oil leakage (contaminated oil) from each seal, with approximate design differential pressure shall be measured. Seal leakage rate per seal shall not exceed the recommended rate as per manufacturer.

d) Compressor drains should be inspected before and after the test to ensure that oil has not entered the compressor casing.

e) All warning, protective and control devices shall be checked.

f) During the running test, unfiltered vibration reading shall be checked for any abnormality. The allowable limit shall be as under:

Allowable test level (unfiltered) = Double amplitude including run out (mills)

= Vibration + Run out

$$= \frac{12000}{NMC} + 0.25\ \frac{12000}{NMC}$$

Where NMC = Maximum Continuous Speed in revolutions per minute

g) Satisfactory performance at all specified operating ranges and horse power at the normal operating point shall be established.

h) Bearing metal temperatures shall be checked for confirming normal operation as specified by manufacturer.

i) Vibration measurements on all bearings shall be recorded while the compressor is operating.

4.3.2 Newly Installed Compressors

In addition to the procedures as per item 4.3.1 above, the following procedures shall be followed for commissioning of newly installed compressors. This procedure is for compressors having the seal oil system.

i) PREPARING THE OIL SYSTEM

a) Oil tank
- Oil level in the tank shall be checked.
- The oil shall be heated upto 40 deg C and the oil temperature should not be less than 25 deg C.

b) Lube Oil pumps
- The pumps shall be checked for free rotation.

c) Coolers
- Ensure cooling water flow in the coolers.
- Ensure that the cooling water pressure in the system is always less than the delivery pressure of the pumps.

d) Filters
- The filter cartridges shall be cleaned.

e) Valves
- Suction and discharge valves of the pumps shall be kept open.
- Bypass valves PCVs and LCVs shall be closed.

- Isolation valves upstream and downstream of control valves shall be kept open.
- Gas vent valves of the drain traps shall be kept open.
- Valves between the seal oil degassing drums and the oil tank shall be closed.
- Isolation valves for the pressure switches, pressure gauges and level gauges shall be kept open.
- Drain valves near the oil coolers, filters and pressure control valves shall be kept closed.
- Bypass valves across three-way transverse valves for oil coolers & filters shall be kept open.
- Vent valves of oil coolers and filters shall be kept open initially and then closed.

ii) PREPARING THE LUBE OIL SYSTEM

a) The main oil pump shall be started.

b) Oil pressure at various points shall be ensured.

c) The oil flow to the bearings shall be ensured.

d) Ensure pressure drop across the filter is within limit.

e) Overhead oil tank shall be filled. The by-pass valves of the calibrated orifice shall be closed when oil starts to overflow into the oil tank.

f) Oil temperature in the lube oil header shall be maintained around 40 deg. C.

g) The standby pump shall be put on auto start.

h) Automatic start up of standby and emergency oil pumps shall be ensured.

i) The lube oil header pressure and main oil pump functioning shall be checked with standby pump in auto position.

iii) PREPARING THE SEAL OIL SYSTEM

a) Main seal oil pump shall be started.

b) Ensure automatic starting of standby pump.

c) Normal oil flow from LP seals shall be ensured.

d) Nitrogen flow to the degassing tank shall be maintained.

e) Oil temperature in the degassing tank shall be maintained within 60 deg C to 80 deg C.

f) Oil from degassing tank shall be analysed (for original properties) prior to putting back to oil tank.

iv) PREPARING THE GAS SYSTEM

a) Compressor shall be isolated from upstream and downstream systems.

b) Gas system shall be purged with nitrogen at pressure of 5 atm (g) till the oxygen content in the gas loop becomes 0.05% or less.

c) Nitrogen supply shall be maintained to the main tank and compressor bearing housing around a pressure of 100 mm of water column.

d) Nitrogen inlet valve and compressor blowdown vent valve shall be closed after purging.

e) The gas loop filled with nitrogen shall be maintained at 3 Kg/CM2 pressure to avoid atmospheric air entering the compressor loop after purging.

f) The compressor gas loop shall be charged with active gas by opening the bypass valve of the suction pressure control valves.

g) The gas pressure shall be raised slowly to normal suction pressure and the seal system shall be checked (if applicable).

h) The suction control valve shall be opened and bypass valve closed when upstream and down stream pressure across the suction control valve equalises.

i) The gas system shall be purged with active gas till nitrogen percentage is within the acceptable limit.

j) The compressor gas interlocking and trip system shall be kept in normal start up position.

5.0 PREVENTIVE MAINTENANCE INSPECTION SCHEDULE FOR RECIPROCATING COMPRESSORS

Preventive Maintenance Inspection Schedule for Reciprocating Compressors are sub-divided into the following two groups:

i) Inspection Schedule for first 1000 hours from commissioning of the compressor.

ii) Inspection Schedule for normal operating condition.

5.1 PREVENTIVE MAINTENANCE INSPECTION SCHEDULE FOR THE FIRST 1000 HOURS FROM COMMISSIONING

All the following items shall be checked/recorded after the specified running hours:

5.1.1 After 60 Hours

i) Cross headnuts for tightness (Nuts shall be tightened, if necessary).

5.1.2 After 500 Hours

i) The following for tightness:

a) Cross head pin plate screws

b) Piston lock nuts

c) Connecting bolts - slide bodies to frame

d) Correcting bolts - Cylinders to slide bodies

e) Tie bolts of big and connecting rod

f) Stud bolts of main bearing cap.

g) Foundation bolts of main bearing cap.

h) Connecting bolts - cylinder supports.

ii) Wear of non metallic shoes for piston (by feeling clearance between lowest point of piston and the sliding surface of cylinder liner).

iii) The following of non-metallic piston rings

a) Radial wear

b) Clearance between side of rings and grooves

c) Ring end clearance

iv) The following of stuffing box with non-metallic seal rings

a) Radial clearance

b) Clearance between side of rings and grooves.

5.1.3 After 1000 Hours

i) Condition of suction and discharge valve seats, plates and springs

ii) Crank case oil replacement (whether carried out or not)

iii) Oil filter, (whether cleaned or not)

5.2 PREVENTIVE MAINTENANCE INSPECTION SCHDULE AFTER FIRST 1000 HOURS OF COMMISSIONING

The following items shall be checked/recorded after the specified running hours:

5.2.1 After 2000 Hours

i) Condition of compressor suction and discharge valve

ii) Oil filters (whether cleaned or not).

5.2.2 After 4000 Hours

i) All checks of 2000 hours Schedule.

ii) Crank case oil replacement, whether carried out or not.

iii) Nuts connecting piston to cross-head for tightness.

iv) Piston ring end gap and side clearance of teflon and graphite piston rings (shall be replaced if necessary)

v) Piston shoes for wear (for piston shoes of teflon or graphite).

vi) Stuffing box seal ring radial wear, clearance between rings and grooves (in case of stuffing box packing made of teflon/graphite).

vii) Foundation bolts for tightness

viii) All traps, whether serviced or not.

ix) Safety interlocking of compressor for proper functioning.

5.2.3 After 8000 Hours

i) All checks of 4000 Hours Schedule.

ii) The following for tightness:

a) Connecting bolts - cylinder to slide bodies

b) Connecting bolts - cylinder supports

c) Tie bolts of big end connecting rod

d) Stud bolts of main bearing caps.

e) Connecting bolts - slide bodies to frame.

iii) Cylinder or cylinder liner for wear.

iv) Piston ring grooves and piston shoes of white metal for wear (adjust or replace if necessary)

v) Piston rod for wear, smoothness and deflection

(Note: Piston rod run out shall be as per appendix C of API 618).

vi) Metal piston ring for breakage or crack, end and side clearance (Deeply scored piston rings shall be replaced).

vii) Wear of seal rings of stuffing box provided with metal seal rings (replace if necessary)

viii) Suction valve unloader for proper operation.

ix) Condition of non return valve in the discharge lines of the compressor (Non return valve shall be dismantled for inspection).

x) Safety valves, whether recalibrated or not.

xi) Tubes of intercooler and aftercooler, whether cleaned and pressure tested or not.

xii) Lube oil pump and lubricator, whether serviced or not.

xiii) All instruments, whether calibrated or not.

xiv) Piston end clearance with cylinder.

5.2.4 After 16000 Hours

Complete overhauling of the compressor shall be carried out.

(Note: During complete overhauling, all checks specified for 8000 hours schedule and partwise inspection as per item 5.3 shall be carried out).

5.3 PARTWISE INSPECTION DURING COMPLETE OVERHAUL OF RECIPROCATING COMPRESSORS

i) SUCTION AND DISCHARGE VALVE

a) Suction and discharge valves shall be inspected for accumulation of foreign material, damage of plate, springs and channel.

b) Unloader yoke tip shall be inspected for wear.

Free movement of spring in channel is to be checked in fitted condition. **Note 1**

ii) PISTON ASSEMBLY

a) Piston ring, rider ring and piston rod packing shall be inspected for wear.

b) Piston rod sliding surface shall be checked for streaks and wear.

c) Piston rod shall be inspected by using magnetic and ultrasonic flaw detector.

d) Deflection of piston rod shall be measured.

e) Piston shall be examined for cracks by dye penetrant test.

f) Rod end thread is to be checked for damages, wear & tear. Note 1

iii) CYLINDER ASSEMBLY

a) Cylinder liner surface shall be checked for streaks and wear (shall be bored if necessary)

b) Cylinder interior shall be inspected for corrosion.

c) Cylinder air tight surface shall be checked for scratches.

d) Cylinder bore dimension shall be measured and recorded.

e) Cylinder cooling jacket is to be inspected for scaling etc. Note 1

iv) CRANK SHAFT

a) Journals shall be checked for wear. Main bearing clearance shall be checked for wear.

b) Magnetic flaw inspection shall be carried out.

c) Crank arm deflection shall be measured.

d) Crank shaft shall be dynamically balanced for compressors running at 800 or more revolution per minute.

V) CROSSHEAD ASSEMBLY

a) The sliding section shall be checked for wear.

b) Magnetic flaw inspection of big end bolt shall be carried out (if recommended by manufacturer).

c) Crank pin and crosshead pin bearings shall be inspected for wear.

d) Crosshead pin shall be checked for wear. Flaw inspection shall also be carried out.

e) Crosshead shall be inspected by magnetic flaw detector.

f) Connecting rod shall be inspected by magnetic flaw detector.

g) Horizontality of through centre of cylinder and crosshead guide shall be checked by level gauge.

vi) LUBE OIL SYSTEM

a) Oil filters shall be checked for clogging condition.

b) Crank case oil tank and cylinder lube oil tank shall be cleaned.

c) Physical/chemical properties of the lube oil shall be tested.

d) Piping shall be inspected for clogging and corrosion.

e) Oil coolers shall be inspected, cleaned and hydrotested.

f) Lubricator casing shall be inspected/cleaned.

g) Lubricator plunger surface shall be inspected for wear/scratches.

h) The lubricator element shall be inspected (shall be replaced if necessary)

vii) GAS COOLER

a) Tube sheet, tubes and channel section shall be inspected.

b) Thickness of shell and internal diameter of tubes shall be measured for ten per cent of tubes at random.

c) The cooler shall be cleaned and hydrotested at one-and-half times the working pressure.

viii) CRANK SHAFT BEARING

a) Bearings shall be checked for wear. The clearances shall be measured and compared with manufacturer's data to assess the condition.

ix) COUPLING AND ALIGNMENT

a) Coupling shall be inspected for cracks and damage.

b) Alignment between the driver shaft and the compressor crank shaft shall be checked to ensure the alignment is within the limits.

5.4 COMMISSIONING AND TESTING PROCEDURES FOR RECIPROCATING COMPRESSORS

The following procedures shall be followed for commissioning and testing of overhauled compressors or compressors started up after long period of non-operation or newly installed compressors.

5.4.1 Overhauled Compressors and Compressors started after long period of Non Operation

i) INITIAL PREPARATION

a) Assembly of all the piping shall be in accordance with the 'Flow diagrams' and the 'Piping Assembly Drawings'.

b) Tightness of all nuts, bolts and screws shall be checked.

c) Thorough cleaning and flushing of all process piping shall be done to prevent any foreign particles from entering the compressor cylinder (if necessary acid cleaning shall be done).

d) Interior of the suction gas filter and suction gas piping shall be checked to ensure that these are free from any foreign particles.

e) Blowing out and thorough cleaning of all the gas lines shall be carried out.

f) The lubricating oil lines shall be flushed.

g) Coupling and other naked rotating parts shall be protected by proper coupling guards or suitable covers.

h) Alignment readings shall be ensured within manufacturer's recommended limits.

i) All pressure and temperature gauges shall be calibrated.

j) Alarm/trip devices shall be calibrated.

k) All controllers, transmitters and control devices shall be adjusted and set to required settings.

l) Adjustment of all interlocks shall be completed.

ii) PRE START OPERATIONS

a) Oil level in the oil tank shall be checked.

b) Lubrication unit shall be started and proper lubrication ensured at all points.

c) Block valves of pressure and temperature sensing devices of lubrication system shall be opened.

d) When the lubrication unit is driven by the crankshaft, it shall be turned by hand and piping upto cylinder and piston rod packing lubricating points shall be filled with oil.

e) Purging of the compressor system with an inert gas (in the case of combustible gas) shall be carried out.

f) The compressor shall be rotated to form an oil film on the sliding sections. Attention shall be given to any abnormal resistance during the turning of the compressor.

g) Piston of each valve (open or close) shall be checked.

h) Instrument air pressure for the unloader shall be checked/ confirmed.

i) The compressor shall be charged with active gas and the system shall be made free of liquid.

j) Normal suction pressures shall be established.

k) Steam tracing shall be provided on suction vessels/dampeners.

l) Main inlet and outlet valves of cooling water shall be opened and water flow shall be checked/confirmed.

m) Electric power source for the local panel shall be switched on.

n) Air purge valve for the pressurised explosion panel shall be opened and ensure internal pressure of the panel is at required pressure.

o) Suction side of crank-shaft driven gear pump shall be filled with oil for priming.

p) To prevent any load to the compressor from being applied at the time of starting the load shall be at ‘Zero’ per cent.

iii) START UP OPERATION

a) The changeover switch of each stage capacity control shall be set to ‘Manual’.

b) Prime mover shall be started as per manufacturer’s instructions.

c) In the case of a gas, which contains condensing components, hot water to the cylinder jacket shall be supplied.

d) Noise/vibration in the frame, cylinder shall be measured and various sections shall be checked for abnormal vibration.

e) Oil pressure and proper lubrication shall be confirmed.

f) Sliding sections shall be checked for abnormal temperature rise.

g) Main gas pressure in the system shall be gradually raised in the suction side.

h) During the pressure rise, the pressure and temperature of each section shall be checked and ensured that they are within normal range.

i) Ensure that there is no gas leak in any system.

j) In case of gas containing condensing components, temperature of the cooling water outlet of the cylinder jacket, shall be higher than the suction gas temperature.

k) All operating parameters (such as pressure and temperature) shall be as specified by the manufacturer.

l) Drive load or horse power shall be established at different capacities.

iv) POST START CHECK

a) Bearing temperature shall be checked for confirming normal operation.

b) Ensure no abnormal noise/vibration in the cylinder.

c) Colour of drained oil from piston (for lubricated type compressor) shall be checked for confirming normal operation.

d) Inlet and outlet temperature of cooling water shall be checked.

e) Noise in suction and discharge valves shall be checked to ensure normal operation.

f) Ensure that valves are not overheated.

g) Outlet gas temperature of gas coolers shall be checked.

5.4.2 Newly Installed Compressors

In addition to the procedures as per item 5.4.1 above, the following checks shall be carried out for commissioning a newly installed compressors.

i) Ensure correct sizing of discharge piping.

ii) Ensure appropriate positioning and sizing of safety relief valve.

iii) Ensure installation of proper pipe supports.

iv) Ensure installation of temporary suction filter in the suction line (in case permanent suction filter is not provided).

6.0 DIFFERING SCHEDULES

In case of differences between this standard and the manufacturer's recommendations, the instruction given by the manufacturer shall govern. The schedule given in this standard are very broad based on present experience and practices may be modified from time to time. The schedules indicate the maximum interval of time between two inspections. Since data with respect to frequency of problems occurring on equipment handling corrosive products, hot products, dirty products etc. was not readily available, inspection schedule with respect to product handled could not be drawn up. Organisations having historical records and analysis of failures may alter the inspection interval accordingly. Records shall be maintained as per sample format of history cards and specification sheets provided in OISD STD 127 with respect to problems on equipment in different services. Based on the feedback obtained, the Committee will attempt to further sophisticate inspection schedules and procedures.

7.0 DOCUMENTATION

Documentation and Record keeping form an integral part of total Inspection Management System. The various inspection records on all areas shall be maintained in standard formats designed specifically for the individual requirements.

8.0 REFERENCES

i) API 550 - API Recommended Practice

ii) API 614 - Lubrication, Shaft sealing and control oil systems for special purpose application.

iii) API 615 - Sound control of mechanical equipment for Refinery services.

iv) API 617 - Centrifugal compressors for general refinery services.

v) API 618 - Reciprocating compressors for general refinery services.

vi) API 670 - Non-Contacting vibration and axial position monitoring system.

vii) Compressor handbook for the Hydrocarbon Process Industries, Gulf Publishing Co. Huston, Texas.

viii) Gas Turbine Engineering handbook; Meherwan P. Boyce, Publishing Co. Huston, Texas.

ix) OISD 124 - Predictive Maintenance Practices

x) OISD 125 - Inspection and Maintenance of Mechanical Seals.

xi) OISD 126 - Specific Maintenance Practices (Rotating Equipment.

xii) *OISD 127* - History Recording (Rotating Equipment).

OISD-122
Amended edition

FOR RESTRICTED CIRCULATION

No.

INSPECTION OF
FANS, BLOWERS, GEAR BOXES & AGITATORS

OISD STANDARD-122
First Edition, January 1990
Amended edition, August, 1999

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum and Natural Gas

OISD- STANDARD-122

First Edition, January, 1990
Amended edition, August, 1999

FOR RESTRICTED CIRCULATION

No.

INSPECTION OF FANS, BLOWERS, GEAR BOXES & AGITATORS

Prepared by

COMMITTEE ON INSPECTION OF ROTARY EQUIPMENT

OIL INDUSTRY SAFETY DIRECTORATE
2ND FLOOR, “KAILASH”
26, KASTURBA GANDHI MARG
NEW DELHI-110 001.

NOTE

These documents are intended to supplement rather than replace the prevailing statutory requirements.

Note 1 in superscript indicates the modification/changes/ addition based on the amendments approved in the 17th Safety Council meeting held in July, 1999.

FOREWARD

The Oil Industry in India is 100 years old. As such a variety of practices are in vogue because of collaboration/ association with different foreign companies and governments. Standardisation in design philosophies operating and maintenance practices at a national level were hardly in existence. This, coupled with feed back from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the then Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a serious of self-regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly OISD constituted a number of functional committees comprising of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present standard on Inspection of Fans Blowers, Gear Boxes and Agitators was prepared by the Functional Committee on Inspection of Rotary Equipment". This document based on the accumulated knowledge and experience of industry members and the various national and international codes and practices, is meant to be used as a supplement and not as a replacement for existing codes standards and manufacture's recommendations. It is hoped that the provision of this standard, if implemented objectively, may go a long way to improve the safety and reduce accidents in the Oil and Gas Industry. The users of this document are cautioned that no standard can be a substitute for a responsible and experienced engineer. Suggestions are invited from the users after it is put into practice to improve the standard further. Suggestions for amendment, if any, should be addressed to:

The Coordinator
Committee on
“Inspection of Rotary Equipment"
Oil Industry Safety Directorate
2nd Floor, “Kailash”
26, Kasturba Gandhi Marg
New Delhi-110 001.

This standard in no way supercedes the statutory regulations of CCE, Factory Inspectorate or any other Statutory body which must be followed as applicable.

COMMITTEE ON
INSPECTION OF ROTARY EQUIPMENT

List of Members

	Name	Designation & Organisation	Status
1.	Sh.K. Gopalakrishanan	Sr.Maint.MGR-CRL	Leader
2.	Sh.B.P. Sinha	Chief Project, MGR-MRL	Member
3.	Sh.Chotey Lal	Chief Engineer - ONGC	Member
4.	Sh.R.C. Chaudhary	Office Engg. MGR-BPCL	Member.
5.	Sh.K.M. Bansal	Chief Maint. MGR-IOC	Member.
6.	Sh.Ehsanuddin	Director-OISD	Member
7.	Sh.R.M.N. Marar	Joint Director-OISD	Member Co-Ordinator.

In addition to the above, several other experts from industry contributed in the preparation, review and finalisation of this document.

INSPECTION OF FANS, BLOWERS, GEAR BOXES & AGITATORS

CONTENTS

SECTION

INSPECTION OF FANS, BLOWERS, GEAR BOXES & AGITATORS

1.0 INTRODUCTION

The Rotary Equipment plays a vital role in hydrocarbon processing industry.

Timely inspection and maintenance of Rotary Equipment will go a long way in ensuring safer operations of the installations in Oil Industry.

2.0 SCOPE

This standard covers the minimum requirements for inspection and maintenance of installed fans, blowers, mechanical agitators and gear boxes of rotary equipment. It does not intend to supercede API and other applicable standards, technical specifications and manufacturer's recommendations.

3.0 DEFINITIONS

i) FAN: The word 'fan' is used to describe a machine with pressure rise upto 1 psig.

ii) BLOWER: The word 'Blower' is used to designate a machine, which raises pressure from 1 psig to 5 psig.

4.0 FANS AND BLOWERS

4.1 PREVENTIVE MAINTENANCE SCHEDULE

Bearing Temperature, Bearing cooling water flow & cooling water temperature and motor amperage should be checked daily. Note 1

The following checks shall be carried out for fans and blowers, after specified hours of operation as given below:

4.1.1 After every 200 hours

i) Bearing oil for contamination and level

ii) Bearing temperature

iii) Bearing cooling water flow and cooling water temperature

Clause (I), (ii), (iii) are deleted. Note 1

iv) Motor amperage

v) Grease lubrication of bearings.

vi) Bearing vibration

vii) Grease lubrication for damper shaft bearings.

4.1.2 After every 1000 hours

i) Repeat the checks given at 4.1.1

ii) Foundation bolts for tightness

iii) Freeness of dampers

4.1.3 After every 2000 hours

i) Repeat the checks at 4.1.1 and 4.1.2

ii) Condition and cleanliness of bearing cooling water system

iii) Condition of bearing oil

iv) Condition of lube oil filters

v) Cleanliness of suction strainers

vi) Suction/discharge damper bearings for proper grease lubrication.

4.1.4 After every 4000 hours

i) Repeat the checks at 4.1.3

ii) Alignment

iii) Bearing condition

iv) Lube oil filters (replaced or not)

v) Condition of vane control damper (rollers to be checked and repaired, as necessary).

4.1.5 After every 8000 hours

i) Repeat the checks at 4.1.4

ii) Condition of bearings (change, if needed)

iii) Alignment (repair coupling, if needed, pins-bushes, toothed hub-cover/hubs shall be changed, if needed)

iv) Condition of bearings of damper-shafts (change if needed)

v) Condition of turbine bearings in case of steam turbine and change, if needed

vi) Condition of shaft seals.

vii) Check coupling guard & rectify if necessary. Note 1

viii) Check Belt guard and rectify, if necessary. Note 1

4.1.6 After every 16000 hours

i) Repeat all checks at 4.1.5

ii) Replacement of bearings

iii) Condition of shafts, impeller and casing

iv) Condition of suction and discharge dampers

v) Alignment

vi) Lubrication system

Complete overhauling shall be carried out, which includes partwise inspection as detailed in 4.2

4.2 PARTWISE INSPECTION

Partwise inspection shall be carried out during complete overhaul and the following items shall be checked/inspected:

4.2.1 Vane Control System

i) Vane control/variable inlet control should be checked for proper functioning.

ii) Rollers shall be checked for proper grease lubrication.

iii) Levers and other parts shall be checked for proper movement.

iv) The ring shall be checked for ovality/distortion of pins, (in case the arms are operated by a ring).

Note:

The necessary repair of arm (levers), actuating pneumatic cylinders, control valves and flappers, should be carried out.

4.2.2 Shafts

i) The bearing portion, lock nut threading, key portion and coupling portion shall be checked for wearing out, corrosion/pitting (If the worn out part is beyond fitment limit, repair/ change the shaft.

ii) The shaft shall be checked for trueness before fitting with impeller (Trueness limit is to be maintained as per manufacturer's recommendation. However, run-out should not exceed 0.02 mm.)

4.2.3 Impellers

i) The impellers shall be cleaned by compressed air/water blasts or can be wire brushed and repaired.

ii) Blade thickness and casing cover thickness should be checked for assessment of corrosion. Critical zones for examination are:

a) Leading edge of the blade
b) Trailing edge of blade
c) Cone sheet/flange/shround ring

Note:

If the thickness reduction is more than 10%, necessary repair shall be done. Wherever possible, protective coating like painting, epoxy coating, FRP lining, etc. should be done. The impeller, after major repair, should be balanced along with shaft coupling.

4.2.4 Casing

i) The casing shall be checked for wear and tear (Repair wherever necessary).

ii) The casing shall be cleaned and if made of mild steel, remove old paint and renew painting of internals. (If the casing is split, renew packing at the joints, If it is lined, renew/repair lining).

4.2.5 Bearing

i) The bearings shall be checked for clearances and rectified as recommended by manufacturer.

ii) The bearing housing internal diameter shall be checked for possibility of looseness of bearings. (Change, if clearances have gone high. In case of ball/roller bearings, it is a good practice to change bearings.)

iii) Check for looseness of bearing over the shaft sealing. (Rectify if required by metal spraying or any other suitable method to attain proper fit of the bearing over the shaft as per the bearing fitting standards).

4.2.6 Seals

Renew/repair the seals. (If it is a felt type seal, renew the felt while checking bearings, etc. If it is a labyrinth type, the worn out strips should be changed or if wear is excessive the set of seals shall be changed.)

4.2.7 Foundation

i) Check for tightness of bolts of casing supports, bearing pedestals, motor and base plate.

ii) Check alignment before start up after tightening the motor and fan casing foundation bolts.

4.2.8 Lubrication System

i) Check the system of lubrication for proper functioning, (where lubricating oil is used, same shall be changed.)

ii) Check oil pump with piping (in the case of forcefeed lubrication system).

4.2.9 Suction and discharge dampers

i) Condition of damper plates, shaft, bearings, pointer (indicator), ducting, and ducting joints shall be checked.

ii) In case where the damper ducting is having inside refractory lining, the lining shall be checked and repaired as necessary.

iii) Arms, main shaft bearings, pins, bushed rollers and individual flappers shall be checked and repaired as required.

4.2.10 Instruments

All instruments (like pressure gauges, temperature gauges, flow meters, vibration monitors etc.) shall be calibrated.

5.0 GEAR BOXES:

5.1 PREVENTIVE MAINTENANCE SCHEDULE

The following schedule shall be complied with after specified hours of operation as noted below:

5.1.1 After every 2000 hours

Inspection (through window and end covers) for:

i) Condition of the gear and bearings
ii) Coupling and alignment
iii) Oil level

5.1.2 After every 16000 hours

Complete overhauling of the Gear Box shall be carried out.

Note: During overhaul, Partwise Inspection as detailed in 5.2 and all the checks covered in 5.1.1 shall be carried out.

5.2 PARTWISE INSPECTION

Partwise inspection as given below shall be carried out during complete overhaul.

5.2.1 Pinions & Gears

a) Pinions and gears shall be inspected for wear and cracks of teeth. (Cracks should be inspected with the help of magnifying glass on all teeth faces. In cases of critical services, dye penetrant test on all teeth should be conducted. In case of cracked tooth, the gear/pinion should be replaced.)

b) Tooth faces should be checked for the wear on the tooth faces and determining the backlash. (Double ended gear shaft permit reversal of the gear to reduce the backlash. Excessive backlash requires replacement of the gear).

c) Meshing of the teeth shall be checked by Blue matching to ensure 70% meshing. (While dismantling the gear match marks are put on the face of the gear to ensure that after assembly, the meshing of the teeth does not get disturbed).

5.2.2 Bearings

i) Anti friction bearings-Refer-OISD-RP-123 (Inspection of Rotating Equipment Components)

ii) Babbited bearings-The following shall be checked:

a) Signs of wear, damage such as spalling etc.

b) Clearances (restore if necessary)

c) Bearing seals (Ensure no leakage can take place)

5.3 INSPECTION OF SPARES

Spares supplied by equipment manufacturers shall be used. However, where spares other than from original supplier are required to be used due to equipment being obsolete, it shall be ensured that:

i) Heat treatment and hardening are done prior to gear cutting and finishing.

ii) Heat treatment and hardening are carried out to an AGMA material hardening factor of 1.97 or less.

iii) Gear material is selected equivalent to original material used.

iv) Blue matching of gear meshing is carried out to ensure 70% matching.

6.0 MECHANICAL AGITATORS

6.1 GENERAL

Mechanical agitators consist of speed reduction unit and agitators of various designs. These agitators are mounted on the top, side or at the bottom of the vessel. Agitation is achieved by using impellers, marine propeller, paddle, gate, turbine anchor or saw cutter depending on specification of fluid to be agitated.

In the case of side entry or bottom entry agitators the shafts are sealed by using stuffing box or mechanical seals. In the case of long shafts steady bearings may be used. Therefore, agitators can be subdivided for the purpose of preventive maintenance schedule into Gear boxes and sealing arrangements.

6.2 GEAR BOXES

The maintenance schedule mentioned for gear boxes in 5.0 will be applicable to mechanical agitators also.

6.3 SEALING

The maintenance schedule mentioned for mechanical seals will be applicable to sealing of shafts of mechanical agitators also.

7.0 DIFFERING SCHEDULES

In case of differences between this standard and the manufacturers' recommendations, the instructions given by the manufacturers shall govern. The maintenance schedules given in this standard are very broad based on present experience and practices and may be modified from time to time. The schedule indicates the maximum interval of time between two inspections. Organisations, on the basis of historical records and analysis of failures may alter the inspection interval accordingly. All organisations shall maintain records of history cards and specification sheets, with respect to problems on equipment in different services. Based on the feed back so obtained, the committee will attempt to further sophisticate inspection schedules and producers.

8.0 REFERENCES

The following codes, standards and publications have either been referred to or *used in the preparation of this standard, and the same shall be read in conjunction with this standard:*

i) API standard 512 High Speed special purpose gear units for refinery service.

ii) American Gear Manufacturers Association (AGMA) standard 420 Helical & Herringbone gear speed reducers.

iii) Fan Engineering-An Engineer's Handbook edited by Robers Jorgensen, Buffalo Farge Co. USA.

iv) Balancing of fans- A Schenek publication No. AB 1094, Germany.

v) 'Fans and Blowers' by Robert Pollak, Chemical Engineering, January 22, 1973.

vi) Fans and Fan Systems by John E. Thompson, C.J. Trickler, Chemical Engineering-March 21, 1981.

vii) 'Fans' a special report power, March 1968.

viii) 'Fans' and Blowers' - An Engineering reference from "The Oil and Gas Journal".

NOTES

NOTES

OISD STANDARD - 127
First Edition, October 2010

FOR RESTRICTED CIRCULATION

SELECTION, OPERATION, INSPECTION & MAINTENANCE OF DIESEL ENGINES

OISD-STD-127

First Edition, October, 2010

Prepared by

FUNCTIONAL COMMITTEE FOR REVISION OF STANDARDS ON ROTARY EQUIPMENT

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
7th Floor , New Delhi House
27, Barakhamba Road
New Delhi - 110001
www.oisd.gov.in

<< Back Home Next >>

NOTE

OISD publications are prepared for use in the oil and gas industry under Ministry of Petroleum and Natural Gas. These are the property of Ministry of Petroleum and Natural Gas and shall not be reproduced or copied and loaned or exhibited to others without written consent from OISD.

Through every effort has been made to assure the accuracy and reliability of the data contained in these documents, OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use.

These documents are intended only to supplement and not to replace the prevailing statutory requirements.

FOREWORD

The Oil Industry in India is more than 100 years old. As such a variety of practices are in vogue because of collaboration/ association with different foreign companies and governments. Earlier, standardisation in design philosophies, selection, operating and maintenance practices at a national level were hardly in existence. This, coupled with feed back from some serious accidents that occurred in India and abroad, emphasised the need for the industry to review the existing state of art in designing, selecting, operating and maintaining oil and gas installations.

With this in view, the then Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a serious of self-regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly OISD constituted a number of functional committees comprising of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present standard on “Selection, Operation, and Inspection & Maintenance of Diesel Engines” has been prepared by the “Functional Committee on Revision of Standards for Rotary Equipment". This committee felt that the existing OISD-STD-121 titled “Inspection of Turbines and Diesel Engines” should be bifurcated into two standards namely “Selection, Operation, Inspection and Maintenance of Steam & Gas Turbines” and “Selection, Operation, Inspection & Maintenance of Diesel Engines”. Present document is one of them titled “Selection, Operation, and Inspection & Maintenance of Diesel Engines.”

This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices, is meant to be used as a supplement and not as a replacement for existing codes standards and manufacture's recommendations. It is hoped that the provision of this standard, if implemented objectively, may go a long way to improve the safety and reduce accidents in the Oil and Gas Industry. The users of this document are cautioned that no standard can be a substitute for a responsible and experienced engineer. Suggestions are invited from the users after it is put into practice to improve the standard further. Suggestions for amendment, if any, should be addressed to:

The Coordinator
Committee for Revision of Standards On Rotary Equipment
Oil Industry Safety Directorate
7th Floor, “New Delhi House”
27, Barakhamba Road
New Delhi-110 001.

Website www.oisd.gov.in

This standard in no way supersedes the statutory regulations of CCE, Factory Inspectorate or any other statutory body which must be followed as applicable.

Functional Committee for Revision of Standards on Rotary Equipment

List of Members

	Name	Organisation	Status
1.	Sh. D.K.Puri	Reliance Industries Ltd.	Leader
2.	Sh. S.K.Chatterjee	Hindustan Petroleum Corporation Ltd.	Member
3.	Sh. Deepak Prabhakar	Mangalore Refinery & Petrochemicals Ltd.	Member
4.	Sh. R.C. Agrawal	Bharat Petroleum Corporation Ltd.	Member
5.	Sh. A.K.Dash	Indian Oil Corporation Ltd.	Member
6.	Sh. K. Ravi	Kochi Refineries Ltd.	Member
7.	Sh. Shamsher Singh	Oil Industry Safety Directorate	Member
8.	Sh. S.K.Sharma	Oil Industry Safety Directorate	Member Coordinator

CONTENTS

SELECTION, OPERATION, INSPECTION & MAINTENANCE OF DIESEL ENGINES

1.0 INTRODUCTION

A diesel engine is an internal combustion engine which operates using the diesel cycle, named after Dr. Rudolph Diesel. The defining feature of the diesel engine is the use of compression ignition to burn the fuel, which is injected into the combustion chamber during the final stage of compression. This is in contrast to a petrol engine, which uses the Otto cycle, in which a fuel/air mixture is ignited by a spark plug. The diesel engines are used in vast majority as prime movers for fire water pumps, air compressors, power and emergency generators in Hydrocarbon Industry.

Hence the proper selection, safe operation, inspection and maintenance of diesel engine is very critical. This document has been prepared, considering the importance of this equipment in the overall safety of the industry.

2.0 SCOPE

This standard specifies the minimum requirements in selection, installation, commissioning, operation, inspection & maintenance of diesel engines in hydrocarbon industry, both offshore & onshore.

3.0 DEFINITIONS

3.1 **Governor :** It provides the engine with the feedback mechanism to change speed as needed and to maintain a speed once reached. A governor is essentially a speed-sensitive device, designed to maintain a constant engine speed regardless of load variation

3.2 **Fuel Injectors:** Each cylinder has a fuel injector designed to meter and inject fuel into the cylinder at the proper instant.

3.3 **Shall :** Indicates mandatory requirement

3.4 **Should :** Indicates recommendatory requirement.

For Diesel Engine operational terminology, please refer Annexure - 4 & major components of diesel engine are detailed in Annexure -5.

4.0 SELECTION OF DIESEL ENGINES

The selected engine shall conform to international standard like ISO 3046 / proven vendor standards. In addition, the following factors shall be considered for selection of diesel engines:

4.1 Selection criterion for Diesel Engines shall include:-

a) Focus on the parameters that can result in unsafe condition.
b) Fire Hazard.
c) Health and environmental concerns.
d) Provision in the basic design that shall prevent occurrence of unsafe conditions.

4.2 Equipment shall be selected from the manufacturer's standard range of products. Prototype equipment shall not be considered.

4.3 The following safety and environment factors shall be given consideration while selecting the diesel engines:-

a) Emission Controls

Emission control of nitrogen and carbon oxides and un-burnt hydrocarbons in the engine exhaust shall meet the applicable statutory requirements.

All other fugitive emissions such as from crankcase breather shall be suitably controlled.

b) Temperature

Engine surfaces with temperature in excess of 70’C shall be screened to avoid personnel contact and burn.

The screening shall ensure that the discharge from a crankcase breather and any other leak from the lubrication or fuel systems do not reach any hot surface with a temperature greater than the auto ignition temperature of lubricating oil or fuel.

c) Noise Control

The selected engine shall have noise control equipment to meet the maximum allowable sound level as per applicable legislation / statutes.

d) Corrosion Protection

All carbon steel piping, silencer etc subject to exhaust temperatures and exposed to the atmosphere shall be properly protected against corrosion.

e) Fuel Quality

The diesel engine manufacturer shall advise the maximum allowable quantity and size of solids and water in the fuel for safe engine operation. Proper filters/ separators/ coalescer shall be used for achieving the fuel quality.

f) Engine Cooling

The water cooled engine shall have provision for addition of scale and corrosion inhibitors. The cooling system shall be provided with an expansion tank, level indicator and pressure relief valve. Low coolant level and high coolant temperature shall generate alarm and shall not allow diesel engine start up.

g) Over speed Protection

The engine shall be fitted with an over speed protection device. The device shall give alarm /high high alarm / trip the engine depending upon the engine application. Engine used for emergency services like fire water pump operation shall have alarm. The over speed tripping device shall be manual reset type only.

h) Vibration

Proper care shall be taken to limit the engine vibrations transmitted to the foundation or surroundings. Suitable anti –vibration pad may be used if required between base plate and supporting structure.

i) Coupling Guard

All moving parts shall be protected from human contact by suitable guards. All such guard shall be non sparking type.

j) Crankcase Explosion Relief

Engine having a crank case volume of over 0.6 m3 shall be provided with crankcase explosion relief devices. Dipstick and / or caps shall be effectively secured against ejection following crankcase explosion. The crankcase breather shall be as small as possible and located to minimize air inrush into crankcase following an explosion.

k) Instrumentation and Controls

The engine shall be supplied with monitoring and protection instruments. The monitoring and protection functions shall include the following as minimum:-

i) Low lubricating oil pressure
ii) High cooling water temperature
iii) Low cooling water level
iv) Engine over speed.

Detailed instrumentation and controls shall be as per Annexure-1. For Diesel Engine protections, please refer Annexure -3.

5.0 COMMISSIONING, OPERATION & MONITORING of DIESEL ENGINES

Procedures shall be in place to ensure that diesel engines are commissioned, operated and monitored so as to prevent failures, resulting in unsafe conditions.

5.1 Commissioning

This shall include the first time commissioning of the diesel engine system as well as the re-commissioning after repairs. Detailed check lists shall be prepared to cover:-

a. Installation checks
b. Pre start up checks
c. Start up checks

Typical check list for start up is as per Annexure-2.

5.2 Operation & Monitoring

The operation and monitoring procedures shall include the following:-

a. Ensuring proper operation of equipment as recommended by the OEM/ relevant standards..
b. Engine exhaust shall be routed to a safe location.
c. Engine RPM monitoring.
d. Ensuring proper functioning of the auxiliary systems by noting suitable parameters like:-
   i) Cooling water level
   ii) Cooling water temperature
   iii) Fuel tank level
   iv) Air inlet filter DP
   v) Lubrication oil level
   vi) Oil pressure
   vii) Exhaust temperature etc.
e. Visual inspection for any leakage from engine fuel system, lubrication oil system and cooling water system. Notice for any abnormal sound.
f. Proper display boards detailing the precautions to be observed in handling the equipment including its safe start-up and shut down procedure shall be displayed prominently near the equipment.

6.0 INSPECTION SCHEDULES FOR MAINTENANCE

System should be in place for periodic inspection. Schedules shall be finalized based on OEM recommendation .The inspection schedules shall mainly include:

6.1 Weekly Inspection

The following checks shall be done weekly:-

i) Walk around inspection for any leakages
ii) Check for fuel level in fuel tank and fuel valve position
iii) Check service meter and note
iv) Drain water from water separator
v) Check for coolant level in coolant tank
vi) Check lube oil level in crank case
vii) Check battery electrolyte level in batteries
viii) Check for belt tension
ix) Check hoses and clamp condition
x) Check engine mounts for any damages

6.2 250 running hours inspections

The following checks shall be carried out after every 250 hours:-

i) Check condition of oil and change if required
ii) Check the fuel filter elements for metal particles clean it or replace if required.
iii) Check for lubrication oil filter element for holes and tears, gaskets and 'O' rings for damage and replace if required.
iv) Coolant PH value. Change corrosion resistor element if PH value is below normal range of 8.5- 10.5.
v) Belts; New belts will stretch within one hour of use. These shall be readjusted.
vi) Fan hub and drives.
vii) Throttle linkage

6.3 1500 running hours / 2 years (which-ever is earlier) inspection

The following checks shall be done after 1500 hours/ 2 years whichever is earlier:-

i) All maintenance checks mentioned in the 250 hours maintenance schedule shall be repeated.
ii) Thermostat operation. It should start opening and closing fully within the range prescribed by the manufacturer.
iii) Fan hub and drive. Mounting bolts and bearing endplay shall be checked.
iv) Water pump, i.e. check the impeller and bearings.
v) Turbocharger oil leaks.
vi) Exhaust and inlet manifold nuts and cap screws.
vii) Vibration damper for eccentricity

6.4 4000 running hours / 3 years (which-ever is earlier) inspection

The following checks shall be done :-

i) All the checks mentioned in 1500 hours maintenance schedule shall be repeated.
ii) Turbocharger bearings, impeller and diffuser check and float.
iii) Crankshaft end float. If in excess of recommended limit take corrective action.

6.5 8000 running hours / 5 years (which-ever is earlier) inspection

i) Repeat all the checks mentioned in the 4000 hours schedule.
ii) Carry out complete overhauling of the engine carrying out the following checks:
  a) Check crank shaft-main bearing journals, bearings, big end bearing journals and big end bearings Check connecting rod, piston and piston rings
  b) Check all valves
  c) Check cam shaft and drive gears
  d) Overhaul lube oil pump.
iii) Calibrate fuel injectors & timing device

7.0 PART WISE INSPECTION

7.1 Cylinder head valves

The following shall be checked:

i) Valves seats and, if required, carry out grinding.
ii) Valve guides, if required, replace it.
iii) Valve rocker shafts and bushes; if worn out or distorted replace the same.
iv) Check valve spring stiffness.

7.2 Cylinder block

Cylinder liner bores be checked for wear. Measure the ovality of the cylinder liner. If it is not within the manufacturer's recommendation, replace the same. Check piston and piston rings. While replacing liners, replace piston and piston rings also.

7.3 Connecting rods

Check connecting rods for distortion. Gudgeon pin bushes are to be renewed along with the pistons during major overhaul.

7.4 Crankshaft / Crank case

Main and connecting rod journals shall be measured and grinding to be done to the next under size if found necessary. After grinding, use new under-size bearings. Check end-float. Check bearing clearance, replace if necessary. Check bedding and locking arrangement.

Explosion relief devices shall be checked and calibrated. Set pressure of relief devices shall be checked inline with OEM guidelines.

7.5 Fuel injection system

The fuel pump shall be inspected and overhauled.

7.6 Cam Shafts

The following shall be checked:

i) Cam wear and tear.
ii) Journals and bushings
iii) Cam shafts shall be checked for straightness.

7.7 Cooling systems

The following inspection shall be carried out:

i) Inspect radiators for leaks.
ii) Inspect radiator hoses.
iii) Open heat exchangers, clean the tubes and pressure test the same.
iv) In case of tube leakages beyond 10 per cent of the number of tubes, the tube bundle shall be replaced.

7.8 Chassis overhaul

i) The chassis shall be checked for distortion.
ii) All spring hanger brackets shall be checked for wear.
iii) It shall be ensured that spring check cambering are done as recommended by the manufacturer.

8.0 FAILURE ANALYSIS

i) Failure of diesel engine shall be analyzed thoroughly.
ii) Root cause shall be established for each premature failure and necessary corrective action shall be implemented to improve the engine reliability.
iii) Root cause analysis shall be carried out as per the OISD-RP 126.

9.0 CHANGE MANAGEMENT

a) Change management systems shall be in place as per OISD-RP- 126.

b) Changes in the Process and Equipment related parameters or any related System shall be properly reviewed by all concerned and approved by designated authority and suitably documented.

10.0 DOCUMENTATION

Following documents shall be maintained:-

a) Installation & Test Plan
b) Standard Maintenance Procedure
c) Equipment Failure History
d) Failure Analysis Report

11.0 REFERENCES

This Standard shall be read in conjunction with the following standards, codes & publications:-

i) OISD-RP-126 (Specific maintenance practices for rotating equipment)
ii) ISO 3046 (Reciprocating internal combustion engines – Performance)
iii) EEMUA 107 (Recommendations for the protection of Diesel engines for use in Zone 2 hazardous areas issued by The Engineering Equipment & Materials User Association London U.K.)
iv) Troubleshooting and repairing of diesel engines by Paul.K.Dempsey.

Annexure-1

ENGINE MONITORING AND PROTECTION INSTRUMENTATION

This is a comprehensive list of instrumentation & protections and is intended to cover all types of installation. It requisite instrumentation, alarms and shutdowns shall be selected depending upon specific site requirements. The minimum essential instruments are indicated with an asterisk. Whether an indicator is local or on the control panel will be dictated by the site specific requirements.

MONITORING AND PROTECTION INSTRUMENTATION			
Function	Indication	Alarm	Shutdown
GENERAL			
Engine speed	X*	H L	HH* LL
Hours run	X*		
Turbocharger speed	X	H L	HH LL
Engine vibration	X		HH
Cylinder head vibration(1)	X		
Turbocharger vibration	X	H	HH
Fan vibration	X	H	HH
Start sequence	X		
Start sequence fail	X	X	X
Controls fail	X	X	X
Mode of operation (4.1)	X		
Crankshaft keyphaser	X		
TEMPERATURE			
Lube oil to engine	X*	H L(3)	HH
Lube oil to cooler	X	H	HH
Lube oil from cooler	X	H L	HH
Coolant to engine	X	H L	HH
Coolant from engine (2)	X*	H	HH*
Air inlet manifold	X		
Exhaust - each cylinder	X	XH XL	
Exhaust - turbocharger inlet	X		
Exhaust - turbocharger outlet	X		
Main bearings	X		HH
Big end bearings	X		HH
Turbocharger bearings	X		HH

Function	Indication	Alarm	Shutdown
PRESSURE			
Lube oil	X*	L	LL*
Coolant	X	L	LL
Air inlet manifold	X		
Exhaust to turbocharger	X		
Starting air	X*	L	
Hydraulic start accumulator	X*	L	
DIFFERENTIAL PRESSURE			
Lube oil filter	X*	H	HH
Air filter	X*	H	HH
LEVEL			
Lube oil sump	X*	L	LL
Coolant	X*	L	LL
Air filter oil bath	X*		
Fuel day tank	X*	H L	
ELECTRICAL/INSTRUMENTS			
Mains power	X*		
Battery voltage	X*	L	
Battery charger on	X*	L	
Instrument power	X*	L	
Instrument pneumatic pressure	X*	L	

* Indicates essential indication and ESD functions.
(1) One per cylinder head for combustion diagnostics.
(2) Sensing points on each cylinder block.
(3) Start permissive.
X Indicates a requirement.
H Indicates alarm on high warning.
L Indicates alarm on low warning.
HH Indicates shutdown on high overshoot.
LL Indicates shutdown on low undershoot.

Annexure 2

DIESEL ENGINE START-UP CHECK LIST

This checklist should be used to validate the completion of diesel engine start-up procedure. A check-list should be completed for each diesel engine.

Diesel Engine environment and services

Pre commissioning work & checklist complete ☐
Surroundings clean & clear from obstruction ☐
Lighting / heating, etc., systems operational ☐

Observations…………………………………………………....

Safety Checks

Ensure starting is inhibited until start-up is required ☐
Set clean and fully assembled ☐
No loose materials near set ☐
Air ducts clear and clean ☐
Access & egress routes unobstructed & labeled ☐
Control & maintenance positions unobstructed ☐
Room secure – no unauthorized access ☐
Personnel warned of start-up process ☐

Cooling System

Cooling water pipe work checked for leaks ☐
Cooling water pump belts & guards checked for security / slipping ☐
Coolant heater operational if provided ☐
Cooling water is with added scale and corrosion inhibitors check ☐
Cooling water level & valves open ☐
Fans, pumps and controls checked ☐
Secondary cooling system checked ☐
Record dosing chemical & concentration............................

Diesel Fuel System

Bulk storage facility ☐
Isolating valves correctly positioned ☐
Transfer pump & controls operational ☐
Pipeline / tank heating system operational ☐
Fill point alarm operational ☐
Leaks check ☐
Storage facility secure ☐
Day tank Isolating and solenoid valves checked ☐

Tank filled ☐
Spillage containment & alarms operational ☐
Transfer pump operational ☐
Leak check ☐
Fire valves & release tested and operational ☐

Fire alarm / suppression system

Fire alarm / suppression system operational ☐
Suppression system lock-off operational ☐
Operator instructed in fire system operation ☐

Lubrication system

Engine oil pan filled to correct level ☐
Oil make up system operational ☐

Starting system

Battery starting ☐
Batteries installed, filled and connected ☐
Battery charger commissioned ☐
Isolating valves correctly positioned ☐
Condensate drained ☐

Exhaust system

Check security of pipe work & muffler ☐
Check cowl and/or rain cap are operational ☐
Check water drain pipe work and valves correct ☐
Leak check ☐
Check for exhaust gas recirculation ☐

Ventilation & attenuation

Check louvers are clear and operational ☐
Forced ventilation system operational if applicable ☐
Check for hot air recirculation ☐

Initial start-up

Manual start-up, idle & full speed checks complete ☐
Local stop / emergency stop control checked ☐
Remote start / stop / emergency stop checked ☐

Checklist completed by ……………………………………….

Date………………………………………………………………..

Annexure-3

DIESEL ENGINE PROTECTIONS

A diesel engine is designed with protection systems to alert the operators of abnormal conditions and to prevent the engine from destroying itself.

Over-speed Device -Because a diesel Engine is not self-speed-limiting, a failure in the governor, injection system, or sudden loss of load could cause the diesel Engine to over speed. An over speed condition is extremely dangerous because engine failure is usually catastrophic and can possibly cause the engine to fly apart.

An over speed device, usually some type of mechanical flyweight, will act to cut off fuel to the engine and alarm at a certain preset rpm. This is usually accomplished by isolating the governor from its oil supply, causing it to travel to the no-fuel position, or it can override the governor and directly trip the fuel rack to the no-fuel position.

Water Jacket -Water-cooled engines can overheat if the cooling water system fails to remove excess heat. Removal of the excess heat prevents the engine from seizing due to excessive expansion of the components under a high temperature condition. The cooling water jacket is commonly where the sensor for the cooling water system is located.

The water jacket temperature sensors provide early warning of abnormal engine temperature, usually an alarm function only. The set point is set such that if the condition is corrected in a timely manner, significant engine damage will be avoided. But continued engine operation at the alarm temperature or higher temperatures will lead to engine damage.

Exhaust In a diesel engine, exhaust temperatures are very important and can temperatures -provide a vast amount of information regarding the operation of the engine. High exhaust temperature can indicate an overloading of the engine or possible poor performance due to inadequate scavenging (the cooling effect) in the engine. Extended operation with high exhaust temperatures can result in damage to the exhaust valves, piston, and cylinders. The exhaust temperature usually provides only an alarm function.

Low lube oil: Low oil pressure or loss of oil pressure can destroy an engine in short pressure -order. Therefore, most medium to larger engines will stop upon low or loss of oil pressure. Loss of oil pressure can result in the engine seizing due to lack of lubrication. Engines with mechanical-hydraulic governors will also stop due to the lack of oil to the governor.

The oil pressure sensor usually stops the engine. The oil pressure sensors on larger engines usually have two low pressure set points. One set point provides early warning of abnormal oil pressure, an alarm function only. The second set point can be set to shutdown the engine before permanent damage is done.

High Crankcase: High Crankcase pressure is usually caused by excessive blow-by (gas pressure -pressure in the cylinder blowing by the piston rings and into the crankcase). The high pressure condition indicates the engine is in poor condition. The high crankcase pressure is usually used only as an alarm function.

Annexure-4

DIESEL ENGINE OPERATIONAL TERMINOLOGY

The following are some of the most commonly used terms in operation of a diesel engine.

Bore and Stroke

Bore and stroke are terms used to define the size of an engine. As previously stated, bore refers to the diameter of the engine's cylinder, and stroke refers to the distance the piston travels from the top of the cylinder to the bottom. The highest point of travel by the piston is called top dead center (TDC), and the lowest point of travel is called bottom dead center (BDC). There are 180o of travel between TDC and BDC, or one stroke.

Engine Displacement

Engine displacement is one of the terms used to compare one engine to another. Displacement refers to the total volume displaced by all the pistons during one stroke. The displacement is usually given in cubic inches or liters. To calculate the displacement of an engine, the volume of one cylinder must be determined (volume of a cylinder = (phi*r^2)*h where h = the stroke). The volume of one cylinder is multiplied by the number of cylinders to obtain the total engine displacement.

Degree of Crankshaft Rotation

All events that occur in an engine are related to the location of the piston. Because the piston is connected to the crankshaft, any location of the piston corresponds directly to a specific number of degrees of crankshaft rotation. Location of the crank can then be stated as XX degrees before or XX degrees after top or bottom dead center.

Firing Order

Firing order refers to the order in which each of the cylinders in a multicylinder engine fires (power stroke). For example, a four cylinder engine's firing order could be 1-4-3-2. This means that the number 1 cylinder fires, then the number 4 cylinder fires, then the number 3 cylinder fires, and so on. Engines are designed so that the power strokes are as uniform as possible, that is, as the crankshaft rotates a certain number of degrees, one of the cylinders will go through a power stroke. This reduces vibration and allows the power generated by the engine to be applied to the load in a smoother fashion than if they were all to fire at once or in odd multiples.

Annexure-5

MAJOR COMPONENTS OF A DIESEL ENGINE

Figure 1 shows a typical cross section of a medium-sized, four-stroke, supercharged, diesel engine with inlet ports and exhaust valves. Figure 2 provides a cross section of a similarly sized V-type diesel engine.

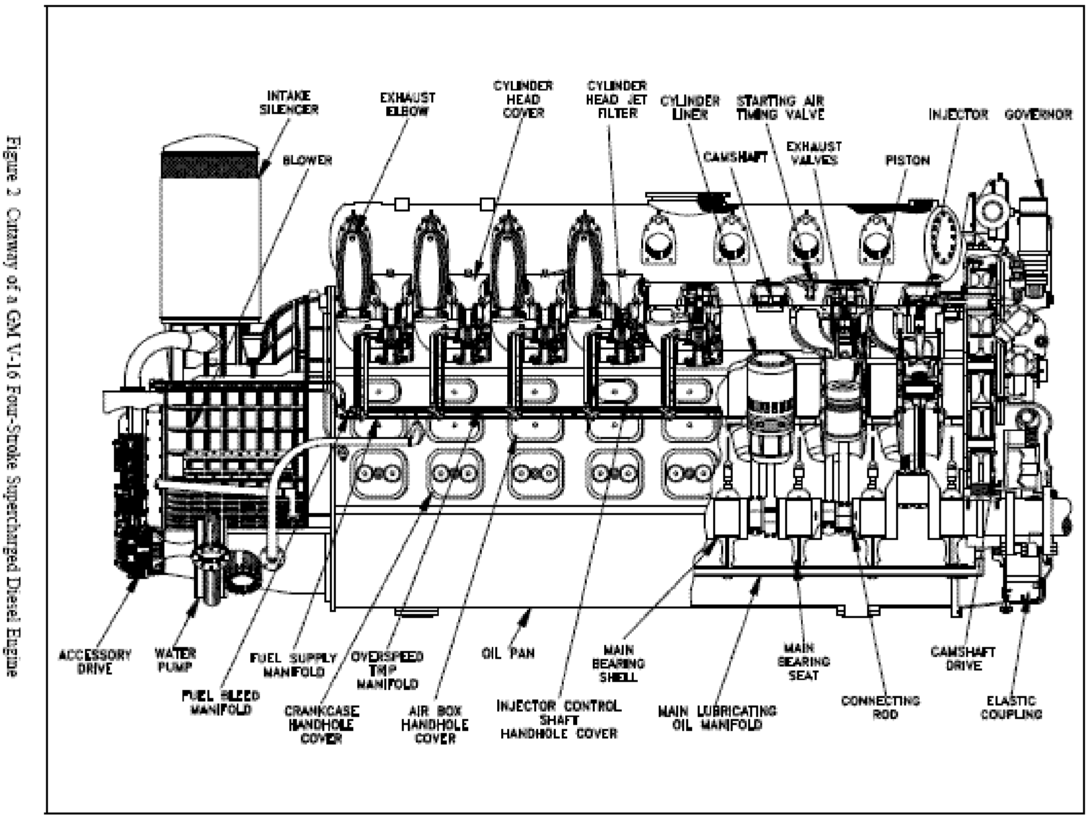


Figure-1

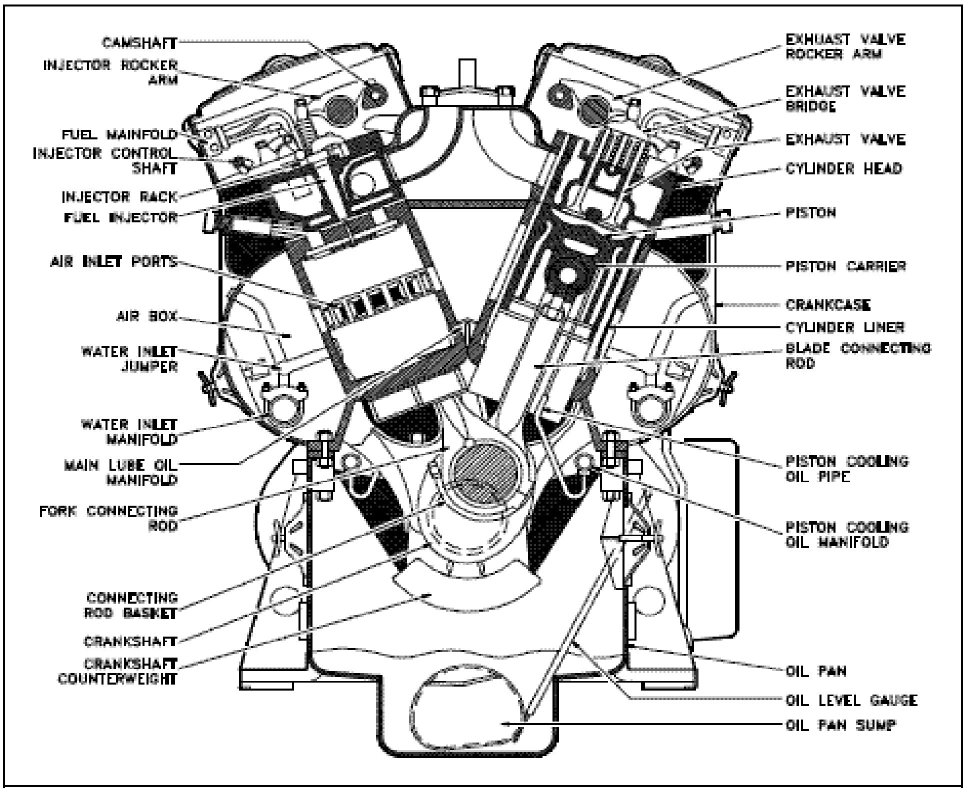


	Figure-2	

<< Back Home Next >>

OISD STANDARD - 137

FOR RESTRICTED CIRCULATION ONLY

STANDARD FOR INSPECTION OF ELECTRICAL EQUIPMENT

OISD STANDARD - 137

First Edition, January 1990
Reaffirmed, August, 1999
Amended Edition, October, 2010
Revised Edition, April, 2016

Oil Industry Safety Directorate

Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Website: www.oisd.gov.in

Tele: 0120-2593800, Fax: 0120-2593802

OISD STANDARD - 137
First Edition, January 1990
Reaffirmed, August, 1999
Amended Edition, October, 2010
Revised Edition, April, 2016

**FOR RESTRICTED
CIRCULATION ONLY**

STANDARD
FOR
INSPECTION OF ELECTRICAL EQUIPMENT

Prepared by

**FUNCTIONAL COMMITTEE ON
INSPECTION OF ELECTRICAL EQUIPMENT**

OIL INDUSTRY SAFETY DIRECTORATE
Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 by Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director

Oil Industry Safety Directorate

FOREWORD

The Oil Industry in India is 100 years old. As such variety of practices has been in vogue because of collaboration / association with different foreign companies and governments. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasized the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum & Natural Gas, in 1986, constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD), staffed from within the industry, in formulating and implementing a series of self-regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safe operations. Accordingly, OISD constituted a number of Functional Committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on “Inspection of Electrical Equipment” was prepared by the Functional Committee on “Inspection of Electrical Equipment. This document is based on the accumulated knowledge and experience of Industry members and the various national and international codes and practices. It is hoped that provisions of this standard if implemented objectively, may go a long way to improve the safety and reduce accidents in Oil and Gas Industry. Users of this document are cautioned that no standard can be a substitute for the judgement of responsible and experienced engineer.

Suggestions for amendments, if any, to this standard should be addressed to:

The Co-ordinator,
Committee on
“Inspection of Electrical Equipment”

Oil Industry Safety Directorate

Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Website: www.oisd.gov.in

Tele: 0120-2593800, Fax: 0120-2593802

.

NOTES

OISD publications are prepared for use in the Oil and Gas Industry under Ministry of Petroleum and Natural Gas. These are the property of Ministry of Petroleum and Natural Gas and shall not be reproduced or copied and loaned or exhibited to others without written consent from OISD.

Though every effort has been made to assure the accuracy and reliability of data contained in these documents, OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use.

These documents are intended only to supplement and not replace the prevailing statutory requirements.

COMMITTEE

ON

INSPECTION OF ELECTRICAL EQUIPMENT

2016

NAME	ORGANISATION
LEADER	
Shri C.K. Tiwari	Indian Oil Corporation Limited
MEMBERS	
Shri Satyajit Sanyal	Reliance Industries Limited
Shri Mahesh Kotasthane	Reliance Industries Limited
Shri Rajeev Kumar	Essar Oil Limited
Smt. Meenaxee P Medhi	GAIL (India) Limited
Shri F.R. Siddiqui	Bharat Petroleum Corporation Limited
Shri B.K. Basu	Bharat Petroleum Corporation Limited
Shri Jaikishen C Nath	Bharat Petroleum Corporation Limited
Shri S Dasgupta	Hindustan Petroleum Corporation Limited
Shri V. Thanasekar	Cairn India Limited
MEMBER CO-ORDINATOR	
Shri Parmod Kumar	Oil Industry Safety Directorate

In addition to the above several experts from industry contributed in the preparation, review and finalisation of the document.

COMMITTEE
ON
INSPECTION OF ELECTRICAL EQUIPMENT

NAME	DESIGNATION/ ORGANISATION
LEADER	
Shri R.K. Ghosh	Chief Power and Utility Manager - IOC (R &P)
MEMBERS	
Shri G.A. Patrachari	Chief Tech. Services Manager, HPC(R)
Shri B.M. Jayaraman	Chief Engineer (Safety), OIL
Shri A.P. Kant	Maint. Manager (Elect.), BRPL
Shri G.P. Paret	Manager (Project - Electrical),CRL
MEMBER CO-ORDINATOR	
Shri N.V. Mani	Joint Director (OISD)

In addition to the above several experts from industry contributed in the preparation, review and finalisation of the document.

INSPECTION OF ELECTRICAL EQUIPMENT

CONTENTS

ANNEXURES

INSPECTION OF ELECTRICAL EQUIPMENT

1.0 INTRODUCTION

Electricity constitutes one of the major sources of ignition for fire accidents and explosions in petroleum installations where hazardous atmosphere is normally encountered. In so far fire losses due to electricity are concerned, it is estimated to account for approximately 30% of all fire losses. Besides equipment damage and property loss, electrical hazards also results in injuries and fatalities to personnel due to electric shock.

Timely inspection, condition monitoring and preventive maintenance of electrical equipment and its connected systems will go a long way in ensuring safer operations, for a longer period of time, of the electrical installations in the Oil Industry.

2.0 SCOPE

This standard specifies the minimum inspection requirements for the installed electrical systems in the Oil Industry, during their operation and maintenance with special reference to the safety aspects. Also included are:

i) Permit-to-work (Electrical) or Electrical Line Clearances covering special safety requirements for jobs requiring Electrical Isolation/ Lockout.

ii) Pre-commissioning check items for new installations as well as for repaired equipment.

This standard in no way supersedes the statutory regulations of the Chief Electrical Inspectorate, Factory Inspectorate, Petroleum and Explosives Safety Organisation, Directorate General of Mines Safety, or other government bodies, which shall be followed, as applicable.

3.0 DEFINITIONS

i) DESIGNATED ELECTRICAL PERSON

Designated Electrical Person (s) is / are the responsible person (s) of the Electrical Section in the owner organisation, designated by the organisation to carry out Electrical Isolation / Energisation. He is also designated under the provisions of CEA Regulation 19(3), 37 (i), 44 (1)(i), 44(2)(vii), 44(2)(viii x, xi), 94(2), 105 (1)(2), 105(5), 108 and 109(8).

Note:
1. Owner organisation shall maintain a list of such Designated Electrical person as per CEA regulations clause 3(2)

2. Suggestive format for details of designated personnel available in Annexure-III.

ii) ENGINEER-IN-CHARGE (EIC)

EIC is competent person of the owner organisation, in charge of the work, to whom work permit shall be issued by Unit-in-charge. In case the work involves electrical jobs, EIC shall be an electrical engineer.

EIC shall be responsible for continuous supervision of the work and for arranging safe Isolation/Energisation of the electrical equipment through designated Person as detailed in Section 4.0 to ensure safety while working on the equipment and associated systems. He shall also ensure the implementation of effective safety measures by personnel/ agencies working under his supervision, throughout the duration of work.

iii) UNIT-IN-CHARGE (UIC)

UIC is Owner-in-charge as defined in OISD-STD-105 (Work Permit System) authorised to issue Work Permit to work in the respective Unit under his jurisdiction (e.g. Chief Chemist shall be UIC for Laboratory).

iv) ELECTRICAL-IN-CHARGE (ELIC)

Electrical-in-charge is a competent person in charge of the Electrical Department/Section of the owner organisation responsible for safe operation and maintenance of all electrical systems. The system of issuing Electrical Line Clearances as detailed in Section 4.0 and conformity of installations with statutory requirements from time to time, shall also be ensured by him.

v) ELECTRICAL SAFETY OFFICER

Electrical Safety Officer is a competent person in the Electrical discipline of the owner organisation who shall ensure observance of safety measures specified under CEA Safety Regulation 2010 in their organisation for construction, operation and maintenance of power stations, sub-stations, transmission and distribution lines. He shall possess the competence required for Electrical Safety Officer as per CEA Regulation 5.

vi) PERMIT-ISSUING AUTHORITY (ELECTRICAL)

Permit-Issuing Authority (Electrical) is a competent person in the Electrical Department/Section of the Owner organisation, designated by Electrical in-charge to issue Permits (Electrical Line Clearances) and related safety instructions. He shall issue Permit only after ensuring that required competent electrical staff, depending upon the specific nature of work, are actually engaged in the work.

vii) ELECTRICAL LINE CLEARANCES:

These Clearances are electrical safety requirements related to jobs covered under Permit-to work(Electrical) as described in Section 4.0

Both the terms “Permit-to work (Electrical)” and “Electrical Line Clearance” (briefly “Permit” or “Clearance”) referred in this Standard covey the same meaning and are interchangeable.

viii) LOCKOUT/TAGOUT (LOTO):

The placement of a lockout and tagout devices on an energy isolating device, in accordance with an established procedure, to ensure and indicate that the energy isolating device and the equipment being controlled cannot be operated until the lockout and tagout devices are removed.

ix) ENERGISED

Energised or ‘live’ means electrically charged.

x) ISOLATED

Isolated or ‘dead’ means at or about earth potential and disconnected from any live system. It is used only with reference to current carrying parts when these parts are not live.

4.0 PERMIT-TO-WORK (ELECTRICAL) OR ELECTRICAL LINE CLEARANCES

4.1 SCOPE

This section shall be read in conjunction with the OISD STD-105 (Work Permit System). The scope in this section covers the special requirements for any job on electrical system where Electrical Isolation-Lockout/Energisation or Earth Excavation Clearances are also needed.

For definitions of terms and responsibilities of various categories of staff involved in Permit System, Section 3.0 shall be referred.

4.2 APPLICATION

For any construction, repair, testing, maintenance or inspection jobs on an electrical system or for any work in close proximity to energised electrical circuits, or for that matter any job in general where an Electrical Isolation is needed, the requirements detailed in this section shall apply.

Compliance to these requirements is necessary to prevent:

i) The equipment/line becoming accidentally or inadvertently electrically charged when persons are working on them (as cautioned in CEA Regulation 19).

ii) Induction effect from the nearby energised electrical systems.

iii) Accidental contact by the personnel with any live part of electrical circuit.

The requirements detailed in Section 4.6 shall apply for obtaining clearances during earth excavation.

4.3 TYPES OF CLEARANCES

Following Electrical Line Clearances, through a written Permit-to-work system, shall be obtained by EIC from Permit-Issuing Authority (Electrical), for any work covered under Permit system as detailed in this Section, in addition to Work Permit from UIC.

i) Electrical Isolation-Lockout Line Clearance (before commencement of work) and Electrical Energisation Line Clearance before energisation of isolated equipment and circuit (after completion of work).

ii) Earth Excavation Clearance.

iii) In special cases, when Checking/ Testing/ maintenance job (like control circuit checking, measurement, interlock checking etc.) are to be carried out on equipment/ circuit which are energized (live), specific safety related work practices, in consistent with the nature & extent of the associated electrical hazards, shall be employed :
   1) All Work Permits (except Work Permit issued to EIC for job on energized equipment/ circuit), pertaining to that particular equipment and associated facilities, shall be withdrawn by UIC during such checking.
   2) Safe working procedure, suitable for the conditions under which work is to be performed, shall be determined.
   3) Time period for the job to be clearly specified.
   4) Job list / checklist for the jobs to be kept ready.
   5) Job Safety analysis for the job to be carried out by UIC and EIC.
   6) Rough sketch, if necessary, should be attached depending upon hazard.

4.4 PROCEDURE FOR ELECTRICAL ISOLATION - LOCKOUT / ENERGISATION LINE CLEARANCES

Whenever the jobs covered under Permit system fall into any of the following four categories, the procedure detailed below (applicable to the respective category) and Special Instructions as per section 4.5 shall be followed. Electrical Isolation and Energisation shall be carried out only by Designated Person.

4.4.1 UIC requiring an electrical system to get checked through Electrical-in-charge (e.g. An electric motor trips repeatedly interrupting plant operation).

i) UIC issues Job Request along with Work Permit to Electrical in charge to carry out the work

ii) Designated person after receiving Work Permit does the positive Electrical Isolation (If required), completes all the work, makes the circuits ready for energisation, reports to Electrical-in-charge, and returns Work Permit.

iii) Electrical-in-charge verifies the completion of all work, and returns Work Permit to UIC, after ensuring that the circuits are kept ready for safe re-energisation.

iv) UIC decides when to start the equipment for operation.

4.4..2 Electrical-in-charge requiring to complete departmental job of checks/repair/test on an electrical system.

i) EIC raises job request specifying the job requirement to UIC

ii) UIC issues Work Permit duly authorised along with Electrical Isolation Line clearance to EIC for carrying out the specific work, after getting clearance from production-in-charge.

iii) EIC on completion of the work returns Work Permit and Clearance to UIC, after ensuring that the circuits are kept ready for safe re-energisation

iv) UIC decides when to start the equipment for operation and arranges for safe charging of the equipment, after getting clearance from production-in-charge.

4.4.3 Another Department requiring execution of a job on an electrical system (e.g. Revamping work or a design improvement etc.)

i) Job Request by concerned Department Engineer in charge (who proposes to carry out the specific work) is raised to UIC with details of work. Rough sketch, if necessary, should be included depending upon hazard.

ii) UIC requests Electrical-in-charge in writing for positive Electrical Isolation.

iii) Designated person does electrical isolation, and submit the electrical isolation line clearance to UIC.

iv) UIC issues Work Permit duly authorised to EIC for carrying out the specific work.

v) EIC on completion of the work returns Work Permit to UIC along with the document showing the modification being carried out, after ensuring that the circuits are kept ready for safe re-energisation.

vi) UIC decides when to start the equipment for operation and arranges for safe charging of the equipment.

4.4.4 Another Department requiring execution of a job on a non-electrical equipment (e.g. Pump, compressor, fan, etc.) having electric drive.

Procedure identical to section 4.4.3 shall be followed.

4.5 SPECIAL INSTRUCTIONS

i) The system of issuing Work Request, Electrical Line clearances (for Isolation-Lockout/Energisation) and Work Permit, shall be implemented through a written Permit-work, system in the prescribed format which shall be developed by individual organisation depending on the type of installation and administrative set up, taking care that the provisions of CEA Regulations 3, 5, 12, 19; IS:5216 and the Owner-in-charge concept, as defined in OISD-STD-105 (Work Permit System) are incorporated in this format.

ii) Authorised Person while carrying out the work covered under Permit system shall physically possess Permit duly authorised by Permit-Issuing Authority (Electrical).

iii) In case of different agencies having taken work permit for the same equipment e.g. Air Fin Cooler – motor by Electrical Maintenance, and Fan Blades by Mechanical Maintenance; UIC shall ensure that work permits from all the agencies involved are returned back, before energising the equipment.

Each such agency shall be issued separate work permit along with lock out and tag out (LOTO) on respective equipment. Unless all the work permits are returned back to UIC, locks & tags are removed, the equipment shall not be energised.

iv) Before issuing any permit for single equipment having more than the one source of electric supply, UIC shall arrange through Electrical-in-charge for:

a. Positive Electrical Isolation (by disconnection of all sources of electric power supply) and obtaining Electrical Isolation Line Clearance. All the respective outgoings at the source panel themselves are locked and tagged properly.

b. Effective earthing of line/ equipment (Isolated section).

v) After completion of the work, EIC shall arrange to deenergise and remove all temporary installations, construction materials, debris and withdraw personnel from site, and returns Work Permit/Clearances to UIC. UIC shall arrange for safe charging of the equipment after obtaining Electrical Energisation Line Clearances.

vi) Throughout the work, designated person shall ensure that the switches and circuit breakers controlling the supply to the equipment or line, shall be kept tagged with caution boards stating **MEN WORKING ON EQUIPMENT** to caution against anyone inadvertently closing them. The control switches/ breakers, wherever possible, should be locked and in racked out position. The area of work shall be strictly cordoned off from unauthorised entry.

vii) While carrying out Electrical Isolation/ Energisation work, the persons connected with the work shall use only approved and tested protective equipment (such as Rubber gloves, rubber shoes, safety belts, ladders, earthing devices, helmets, etc.,) for protection against mechanical and electrical injury, taking all the safety precautions described in IS:5216. Such Tools and devices shall always be maintained in sound and efficient working condition. Provision of the Insulating Floor or mats conforming to IS-15652:2006 is to be adhered.

viii) Electrical Line Clearances shall be taken even while working in proximity of bare energized electrical conductor.

ix) Each line clearance Energisation permit Certificate shall be used for one equipment only.

x) For non-routine jobs, Job safety Analysis (JSA) should be carried out. JSA should involve all the working personnel including non-electrical persons (but who requires electrical isolation for their job), Designated Electrical Person, UIC, Electrical In Charge and EIC. The program, sequence, steps & tasks of the job, various hazards involved in each task and their mitigation measures shall be discussed and recorded. This record can be attached to the work permit. The same shall be followed strictly during the execution of the job, considering the scenario changes at site at that time of execution.

xi) Where ever the source of supply is fed from long distance and it is practically not possible to get the Electrical Line clearance / Energising Certificate in person, then telephonic clearance/ recording Electrical Lockout/ Message No. at both ends can be adopted. Owner organisation shall document and establish such a procedure and are to be followed as per IS 5216.

xii) Overriding of any safety related interlocks for the purpose of testing even under isolated condition shall be carried out under the special written permission from appropriate authorities. The owner organisation shall have documented and established procedure, approved by competent authority. A record shall be maintained to track such overrides. Once the testing job is over, safety interlocks shall be normalised immediately.

4.6 PROCEDURE FOR EARTH EXCAVATION CLEARANCE

This Clearance shall be taken by EIC from concerned departments like electrical, communication, civil, process, fire & safety etc.), wherever earth excavation is to be carried out. Without such clearance, if excavation is carried out, especially over underground facilities (Cables, Pipelines etc.) it may cause fatal accidents to the personnel, besides adversely affecting the plant operation due to possible damage of such underground facilities (e.g. piercing the insulation of live cable through sharp tool like pickaxe/ heavy excavation equipment).

i) Based on clearances from the concerned departments, UIC will issue the work permit to EIC in an approved format to be developed by individual organisations depending on the type of installations and administrative set up. While designing the format, the need of owner-in-charge concept shall also be taken care of, as defined in OISD-STD-105 (Work Permit System).

ii) UIC/ Respective departments shall clearly spell out the precautions to be taken, while carrying out such earth excavation, in the Clearance certificate itself. Prior to issue of Clearance certificate, he shall ensure that the proposed excavation does not interfere with existing underground facilities such as power (H.T & L.T), telephone, fire alarm, lighting, and control cables, earthing, and cathodic protection installations, OFCs, process pipelines, etc.

iii) EIC shall ensure compliance of all the safety measures including those stipulated in the Clearance and provide supervision throughout the work for safe excavation and protection of the underground facilities from any damage due to excavation. He shall promptly report to UIC/ concerned departments for any damage to underground facilities even if it be of minor nature, and shall proceed with the excavation work only after complying with further instructions, as endorsed in Permit, if any.

iv) UIC shall ensure that all the clearances obtained by EIC have been returned and facilities are normalised before closing the Work Permit.

5.0 BASIS AND TYPES OF INSPECTION

5.1 BASIS OF INSPECTION

5.1A Failures of electrical equipment gives rise to any or all the following hazards:

i) Fatal accidents due to electric shock.

ii) Fire accidents and burn injuries due to electric arcs/sparks/hot surfaces

iii) Abrupt interruption in plant operation.

iv) Environmental hazards such as leakage of insulating oil / SF6 gas etc.

v) Burn injuries due to leakage of hot lube oil/ transformer oil.

vi) Injuries to the personnel due to due to improper handling of charged springs of various circuit breakers.

vii) Fire/ spark/ burn/ explosions due to wrong operations of battery bank and capacitor bank.

viii) Flashover due to failure of shrouds between phases in a cubicle.

5.1B The failures of electrical equipment can be attributed to:

i) Imposed external conditions such as deterioration of enclosure, insulation and operating mechanism by environment conditions like heat, moisture, dust, chemical attack, dirt, drop object, cable damage due to vehicle/ crane entry etc.

ii) Quality of power supply (like undervoltage, overvoltage, frequency variation, asynchronous operation, improper wave form e.g. main supply to inverter supply, overheating, power dips, unbalanced voltage, frequently failures of power supply etc.)

iii) Overloading due to any reason.

iv) Internal faults in the equipment itself mainly due to manufacturing defects, or those crept in during installation, maintenance and repairs.

v) Inferior quality of work due to factors like poor workmanship by unqualified/unskilled and untrained workers, inadequate or incompetent supervision, non-compliance of safety and statutory requirements, adoption of incorrect procedures, and usage of poor quality of tools and tackles.

vi) Usage of substandard materials and equipment not in conformity with original design specifications.

vii) Design deficiencies in the technical specifications, improper sizing and layout of installations and lack of total system concept.

viii) Bypassing of protective and interlocking devices/circuits during operation though originally designed for the system.

ix) Inability for carrying out shutdown inspection/tests on the equipment in time, as required by maintenance inspection schedules, due to difficulties in taking the equipment out of service.

Inspection programmed on electrical equipment and associated circuits shall be devised on the basis that the inspection results will be able to pinpoint the trouble spots in the installations, well in advance, allowing ample time for the maintenance personnel to take remedial measures, so as to prevent failure of equipment leading to unsafe conditions and hazards as mentioned above. No equipment shall be operated beyond its safe life period assessed on the basis of inspections from time to time and optimum replacement schedule shall be followed. Manufacturer's recommendation should also be reviewed, wherever available, before replacement decisions are made.

5.2 TYPES OF INSPECTION

The field inspection of electrical equipment in an operating unit is classified into following three types:

i) ONSTREAM INSPECTION

This covers audio visual inspection items (instrument aided or otherwise) for checking of general equipment conditions, while the equipment is in operation. (e.g. an abnormal noise or vibration of motor, leakage of transformer oil or overheating of equipment etc., can be assessed through such inspections).

ii) SHUTDOWN INSPECTION

This covers those inspection items for checking conditions of equipment and systems which cannot be revealed through onstream Inspection (such as internal condition of equipment). This inspection shall be carried out after taking the shutdown of the related equipment after obtaining the Electrical Line Clearance, and Work Permit, requirements of which are detailed in Section 4.0 and in OISD-STD-105 (Work Permit System)

iii) INSPECTION OF STANDBY EQUIPMENT AND SPARE PARTS

The standby electrical equipment shall be inspected periodically. A scheduled change over concept from running equipment to standby equipment shall be in place to ensure the equipment's technical and process integrity. Preferably standby rotory electrical equipment should not remain idle for more than 2 months. The standby rotary equipment remaining idle for more than 6 months, should additionally be checked for-

a) Free rotation of shaft
b) Proper functioning of space heater circuit
c) Weather protection.
d) Insulation resistance of motor with cable.

If, however, standby equipment was not energised earlier, all applicable Precommissioning checks, as detailed in Section 9.0 shall be carried out before taking it into service.

The spare parts shall be inspected to ensure compliance with original specifications as per manufacturers' catalogue number.

6.0 FREQUENCY OF INSPECTION

The inspection scheme given in the following tabular format shall be followed as minimum requirement for the items to be inspected. Frequencies of inspection in this format have been arrived at, considering a typical installation and therefore shall be treated as guidelines. Depending on specific requirements of the installation, considering severity of usage, criticality of equipment, environmental conditions and such other factors, individual organisations shall review and develop own inspection frequency standards which shall be strictly followed.

The frequency of inspection for new or special equipment, where previous experience is not available, shall be reviewed by the concerned organisation, after one or two inspections and reconsidered whether the interval could be lengthened safely or should be shortened. Care shall be taken against the bad effects of over maintenance especially for flameproof and such critical installations. No attempt should be made to replace or repair a glass in a flameproof enclosure (e.g. in lighting fixture or the parts) except with the complete assembly or part obtainable from the manufacturer for which the flameproof certificate from the competent authority shall be obtained to confirm its flame proofness.

For inspection procedures, Section 7.0 shall be referred. The safety Electrical Line Clearances as required in Section 4.0 shall be obtained for work where Electrical Isolation is needed or when any work is to be carried out in close proximity to bare energised electrical circuits.

Insulation resistance, earth resistance and continuity tests, when required to be carried out in a hazardous area, shall be carried out only with certified intrinsically safe insulation/earth tester suitable for use in classified hazardous area, after taking the shutdown of the related equipment through permit system.

However, if such hazardous area is rendered non hazardous and certified by competent authority to be a safe area, usage of standard testing equipment shall be permissible till such time the area continues to remain non-hazardous.

Additionally, the applicable provisions in the API Guide Chapter XIV (electrical systems) Table 5 to 13 (methods of Inspection) and the recommendations of the manufacturer shall be followed, while devising inspection schedules.

LEGEND:

D : Daily
W : Weekly
F : Fortnightly
M : Monthly
Q: Quarterly
HY : Half yearly
nY : Once in n years
TA : Turn around
ASCO: After specified cycles of operation
BU: Before use

Wherever, the monitoring of the system is through SCADA, it should be ensured that monitoring of critical data is maximised through on-line data acquisition system.

6.1 ROTATING MACHINERY

Items to be inspected	Frequency

6.1.1 Generator (including Exciter)

6.1.1A The following shall be Onstream Inspection items:

i)	Condition of commutator (for sparking), brushes, and collector ring). Due care to be taken for hydrocarbon gas presence, hot spot, and inspection of spark on commutator with naked eye.	W
ii)	Bearing condition (lubrication, noise, and temperature)	W
iii)	Cooling system condition.	W
iv)	Housekeeping	W
v)	External damages	W
vi)	Leakage of Oil/Water	F
vii)	Surface overheating	F
viii)	Ventilation	F
ix)	Abnormal noise	F
x)	Functioning of local meters & gauges	F
xi)	Corrosion effects (external)	HY
xii)	Provision of Guards to moving parts	M
xiii)	any other inspection recommended by the manufacturer	

Note:
For critical generators such as for Captive power plants, the frequency of inspection shall be Daily (D) basis for all items, except for items (XIII).

6.1.1B The following shall be Shutdown Inspection items (during scheduled maintenance):

i)	Insulation resistance
ii)	Earthing connections (checks shall include earth resistance measurements, tightness of connections, and continuity of conductors)
iii)	DC resistance of stator/ rotor / exciter**
iv)	Air gap between stator and rotor**
v)	Manual and automatic synchronising and change-over systems.
vi)	Alignment of coupled machine
vii)	Operation of circuits especially related to space heater, temperature detector, tripping devices, annunciators and interlocks.
viii)	Availability of all protective devices, and circuits in line as per design, and all in operating condition
ix)	Moisture absorption (Die-electric Absorption Test)*
x)	Insulation deterioration (Polarisation Index Test)*
xi)	Internal damages, discolouration, open or short circuits, and loose connections**
xiv)	Condition of commutators, brushes, and collector rings
xv)	Condition of foundation and tightness of foundation bolts
xvi)	Any other inspection recommended by the manufacturer

Note :
* Items (ix) and (x) are needed for critical high voltage equipment only.
** items to be checked during major overhauling

6.1.2 Motor (H.T and L.T)

6.1.2 A The following shall be Onstream Inspection items:

i)	General Cleanliness	M
ii)	Corrosion effect (external)	HY
iii)	Surface Overheating/sparking	M
iv)	Ventilation	M
v)	Vibration	M
vi)	Abnormal noise	M
vii)	External damages	M
viii)	Load (Amperes)	M
ix)	Lubrication	Q
x)	Cooling System	Y
xi)	Provision of Guards to moving parts	M
xii)	Condition of commutator, brushes, and collector rings for slipring and synchronous motors	M
xiii)	Healthiness of purging system for Ex 'p'	M
xiv)	Effect of supply system disturbances such as voltage drop, power dip etc. (as given in the log entries at substation)	
xv)	any other inspection recommended by the manufacturer	

Note:

For critical motors, the frequency of inspection shall be weekly (W) basis in case of all items (i) to (xv).

6.1.2B The following shall be Shutdown Inspection items (during scheduled maintenance):

i)	Mechanical freeness of rotor shaft
ii)	Insulation resistance
iii)	Winding resistance (Measurement)
iv)	Earth resistance and continuity
v)	Operation of -- Space heater -- Temperature detector -- Interlocks/trips -- Annunciation circuits
vi)	Availability of all protective devices and circuits in line as per design, and all in operating condition.
vii)	Condition of remote tripping devices & limit switches
viii)	Limit & torque switches (in the case of motor operated valves) for proper functioning.
ix)	Oil level in lubricating gear case.
x)	Moisture absorption (Di-electric Absorption Test)*
xi)	Insulation deterioration (Polarisation Index Test)
xii)	Internal damage, discolouration and loose connection**
xiii)	Stator to rotor air gap measurement**
xiv)	Condition of commutator, carbon brushes(for correct brush pressure) and collector rings
xv)	Condition of supporting legs, pedestal and base plate
xvi)	Condition of the foundation and tightness of foundation bolts.
xvii)	Any carryover of oil or grease inside the windings
xviii)	Signature analysis (optional)
xix)	Tan delta test (optional)

xx)	Any other inspection recommended by the manufacturer

Note:

*Items (x) are needed for critical high voltage equipment only.
** items to be checked during major overhauling

In the case of Synchronous/Slipring motors, following additional Shutdown Inspection items shall be carried out during major overhauling:

i)	Tightness of the DC Poles fitted on the outer-Periphery of the rotor
ii)	Condition of end rings
iii)	Continuity of the leads connecting the poles and the slip rings via brushes
iv)	Any other inspection recommended by the manufacturer

6.2 STATIONARY EQUIPMENT

Items to be inspected **Frequency**

6.2.1 Switchboard and Panel

6.2.1A The following shall be Onstream Inspection items:

i)	General Cleanliness	W
ii)	Weather protection	W
iii)	Dust and vermin-proofness	W
iv)	External damages	W
v)	Control supply availability	W
vi)	Ventilation system	W
vii)	Corrosion effect (external)	W
viii)	Accessibility for maintenance /operation	M
ix)	Functioning of meters, and lamp indicators	M
x)	Oil level and leakage	M
xi)	Correctness of relay settings (for critical services)	TA
xii)	Thermography of panels, as applicable	HY
xiii)	Gas pressure of the enclosure for GIS switchgears	W
xiv)	Insulating Mats checking	Y
xiii)	Any other inspection recommended by the manufacture	

6.2.1B The following shall be Shutdown Inspection items (during scheduled maintenance):

i)	Dielectric strength of oil (in breakers) and Oil Contamination
ii)	Condition of earthing connection including earthing between panel door and panel.
iii)	Insulation and earth resistance
iv)	Electrical resistance of breaker
v)	Internal damages (breakage of barriers, arc chute cracks, jamming solenoid, dirt/dust accumulation in any part etc.)
vi)	Operation of -- Protection, control and interlock circuits -- Circuit breaker (rack-in-out mechanism, springs of driver) -- Simultaneous closing/opening of all the

	three phases. -- Contactor operation -- Space heater operation -- Safety shutters -- Adjustment of limit switches
vii)	Tightness of all bolts, cable connections, and terminals
viii)	Condition of contacts, contact alignment, and clearances with live parts
ix)	Breaker closing and opening time & total relay operating time
x)	Checking and calibration of relays
xi)	Checking of VCB bottles for healthiness (Inspection frequency 3Y)
xii)	For GIS switchgears, the inspection items shall be as per OEM recommendations.
xi)	Any other inspection recommended by the manufacturer

6.2.2 Transformer, Reactors & Bus duct

6.2.2A The following shall be Onstream Inspection items:

i)	Oil leakage	W
ii)	Oil level (in transformer, bushing and conservator tank)	W
iii)	Condition of silica gel	W
iv)	Oil/ Winding temperature meters working	W
v)	Load (Amperes)	W
vi)	Cleanliness	W
vii)	External damages	HY
viii)	Operation of cooling fans & surface temperature	W
ix)	Annunciation (for abnormal conditions)	TA
x)	Condition of cable end sealing and terminal boxes	Y
xi)	Insulators and bushing (check for any cracks) for outdoor transformers	TA
xii)	Corrosion effect (external)	HY
xiii)	Condition of oil soak pit and oil drainage arrangement	Y
xiv)	Sealing of bus duct entry on both sides of wall (for vapour /dust/water tightness)	Y
xv)	Visual inspection of transformer foundation and yard up keeping.	Q
xvi)	Transformer oil testing as per IS:1866	Y
xvii)	OLTC oil testing as per IS:1866	Y
xviii)	DGA of Transformer oil	3Y
xix)	Checking of water sprinkler/ NIFP for transformer fire fighting system.	Y
xx)	Any other inspection recommended by the manufacturer	

6.2.2B The following shall be Shutdown Inspection items (during scheduled maintenance):

i)	Terminal connection in primary & secondary
ii)	Operation of protection and annunciation circuits
iii)	Internal damages, condition of supports, bus duct, flexibles and insulators
iv)	Insulation resistance of primary and secondary windings
v)	Earth resistance and earth continuity
vi)	Condition of Explosion vent diaphragm
vii)	WTI & OTI calibration
viii)	Transformers Cooling fans auto start interlock testing
ix)	Checking of Buchholz relay operation
x)	Completeness with all accessories

xi)	NGR checking
xii)	OLTC M&I as per OEM recommendation
xiii)	Tan-delta testing of Transformer/ Reactor – 3Y
xiv)	Any other inspection recommended by the manufacturer

6.2.3 Battery

6.2.3A The following shall be Onstream Inspection items:

i)	General cleanliness of battery and battery room	W
ii)	Functioning of ventilation system	W
iii)	Spillage of electrolyte	W
iv)	Level of electrolyte	M
v)	Cell voltage	M
vi)	Specific gravity of cell (for lead acid batteries)	M
vii)	Availability & condition of safety equipment (such as rubber apron, goggle, and acid proof hand gloves)	M
viii)	Condition of acid-proof flooring	M
ix)	No electrical fitting on top of Battery Bank (Electrical fittings shall be on the wall)	M
x)	Battery load test (minimum curative discharge@C10 for 2 hrs)	Y/as per OEM
xi)	Availability of Tap water in Battery room.	M
xii)	Condition of Battery Stand	M
xiii)	Any other inspection recommended by the manufacturer	

Note:
For critical/emergency and switchgear power plant applications, the frequency of inspection shall be Daily (D) basis, in case of items (i) to (v) and weekly (W) basis, in case of items (vi) to (xiii)

6.2.3B The following shall be Shutdown Inspection items:

i)	Joints, terminal and bolted connections for tightness (for full electrical contact)
ii)	Blockage of vent plugs
iii)	Corrosion effects on terminals and connectors
iv)	Condition of supports (racks)
v)	Damages such as cracks in containers
vi)	Capacity test
vii)	Any other inspection recommended by the manufacturer

6.2.4 Battery Charger & D.C. Board

i)	General cleanliness	W
ii)	Ventilation system	W
iii)	Float/Boost voltage & charging current	W
iv)	Overheating	W
v)	External damages	W
vi)	Tightness of connections	TA
vii)	Condition of contactors and switches	TA
viii)	Operation of charger circuit with annunciation	TA
ix)	Changeover circuits (emergency backup)	TA

x)	Earth leakage monitoring in Battery Charger	D
xi)	Any other inspection recommended by the manufacturer	

Notes:

1. For critical/emergency switchgear, and power plant applications the frequency of inspection shall be Daily (D) basis for items (i) to (v)

6.2.5. VFD/ U.P.S/Invertor

6.2.5A The following shall be Onstream Inspection items:

i)	General cleanliness, (accumulation of dust, and dirt on contactors, diodes, thyristors, transformers and other components) and external damage	W
ii)	Condition of ventilation and detection of any overheating	W
iii)	Dust free and temperature controlled environment in UPS/VFD/Inverter room (Indoor Installations)	W
iv)	Water level checking in VFD (for water cooled VFDs)	W
v)	Thermography of panels, as applicable	HY
vi)	Preventive maintenance and condition monitoring to be done as per the schedule specified by OEM	TA
vii)	Earthing connection healthiness including earthing between panel door and panel.	TA
viii)	Checking of cooling system and its flow	W
ix)	Cooling water parameters of VFD	W
x)	Any other inspection recommended by the manufacturer	

6.2.5B The following shall be Shutdown Inspection items (during scheduled maintenance):

i)	Internal damages including condition of heat exchangers.
ii)	Pitting of contacts
iii)	Voltage and wave forms as specified by the manufacturer
iv)	Tightness of wiring connections
v)	Operation of protective devices and changeover circuits
vi)	Functional checks for all circuits, and annunciation
vii)	Any other inspection recommended by the manufacturer

6.2.6 Capacitor Bank

6.2.6A The following shall be Onstream Inspection items:

i)	General cleanliness	Q
ii)	Structural support	Q
iii)	Damages (external)	Q
iv)	Condition of ventilation	Q
v)	Oil level	Q
vi)	Oil leakage	Q
vii)	Grounding connections	Q
viii)	Thermography	HY
ix)	Any other inspection recommended by the manufacturer	

6.2.6B The following shall be Shutdown Inspection items:

i)	Insulation resistance
ii)	Discolouration on cable connector clamps
iii)	Operation of protective device
iv)	Tightness of wiring connections
v)	Corrosion effects
vi)	Any other inspection recommended by the manufacturer

6.2.7 Switchyard Equipment (Circuit breaker, Isolator, C.T, P.T, L.A., Support Insulators)

6.2.7A The following shall be Onstream Inspection items:

i)	Overheating, and sparking of contacts	W
ii)	Oil level & leakage/SF6 availability	W
iii)	Visual inspection of Earthing connections, and overhead earth mesh condition	W
iv)	General Cleanliness	W
v)	Equipment Damages	W
vi)	Corrosion effects (External)	HY
vii)	Functioning of lamps and meters	M
viii)	No dry grass in switchyard	W
ix)	Any other inspection recommended by the manufacturer	

6.2.7B The following shall be Shutdown Inspection (atleast once in a year) items:

i)	Operation of switchyard equipment with control, trip, and annunciation circuits
ii)	Condition of insulators
iii)	Alignment between contacts for Isolators
iv)	Insulation resistance
v)	Earth resistance
vi)	Any other inspection recommend by the manufacturer

6.2.8 Lighting Fixture & Junction-box (installed for plant/yard/street and building lighting.)

6.2.8A The following shall be Onstream Inspection items;

i)	Cleanliness & external damages	W
ii)	Fixture support	W
iii)	Lighting Illumination level	Y
iv)	Condition of conduits, Junction boxes	M
v)	Plugging of un-used cable entries	HY
vi)	Changeover circuits (Emergency lighting)	M
vii)	Any other inspection recommend by the manufacturer	

6.2.8B The following shall be Shutdown Inspection items:

i)	Condition of gaskets including cleanliness
ii)	Operation switches & circuits
iii)	Insulation resistance
iv)	Earthing connections

v)	Loose connections
vi)	Corrosion effect, condition of paint (lighting fixtures, junction boxes, conduits, poles and switches)
ix)	Any other inspection recommended by the manufacturer

6.2.9 Test Instruments for Inspection

The following inspection items (common for all the instruments listed) shall be carried out:

- Cleanliness
- Breakages (of glass cover etc.)
- Calibration test, and other safety checks before use as per manufacturer's recommendation
- Zero setting, errors
- Bent pointers, sticky or jerky movement (Analog meters)
- Instrument Battery condition

List of instruments (with the frequency of inspection marked against each item) is given below:

i)	H.V. discharge rod	M/BU
ii)	Non-Contact Voltage detector	M/BU
iii)	Insulation Tester	M
iv)	Earth Resistance tester	M
v)	Cable fault locator	M
vi)	Multimeter	M
vii)	Tong tester	M
viii)	Relay test bench	Y
ix)	Motor test bench	Y
x)	Oil filtering equipment	Y/BU
xi)	Dielectric test equipment	Y/BU
xii)	Phase sequence meter	M/BU
xiii)	Portable voltmeter, ammeter, frequency meter, hydrometer, thermometer	M/BU
xiv)	H.V. testing unit	Y/BU
xv)	Lux meter	Y
xvi)	Infrared gun for Thermography	Y
xvii)	Oscilloscope	Y
xviii)	Non-Contact Temperature scanner	Y
xix)	RPM meter	Y

6.3 PROTECTIVE SYSTEMS

Items to be inspected	Frequency

6.3.1 Relay & Meter

6.3.1A The following shall be In-service Inspection items:

i)	Cleanliness	W
ii)	Breakages of glass & cover	M

iii)	Erratic operation (observation from log book entries)	D
iv)	Any other inspection recommended by the manufacturer	

6.3.1B The following shall be Shutdown Inspection items:

i)	Trip circuit operation (simulation test)	TA
ii)	Relay operation under fault conditions simulated (primary injection)	TA
iii)	Correctness of relay settings	TA
iv)	Changeover circuit operation	TA
v)	Checking and calibration of all meters (KWA/KVA demand, ammeter, volt meter)	Y
v)	Electromechanical relays testing	Y
vi)	Numerical relays testing	5Y
vii)	Any other inspection recommended by the Manufacturer.	

6.3.2 Earthing & Bonding

6.3.2A The following shall be General Inspection items:

i)	Visual checks for external damages to earth conductors, earth electrodes and earthing connections.	HY
ii)	Operation of earth leakage annunciation and trip circuits for lighting, power circuits and appliances (Simulation Tests)	Y
iii)	Corrosion effects and tightness of connections	HY
iv)	Identification of earth pits in the field with permanent markers.	HY
v)	Earth resistance on individual electrodes once in dry and one in wet weather	HY
vi)	Continuity of earthing conductors	Y
vii)	Bonding and earthing of all metallic structures, pipe racks, armour of cables, and electrical equipment enclosures	Y
viii)	Earth loop impedance (measurement)	TA

6.3.2B The following shall be the Special items for Inspection, applicable to different categories of installation:

i)	Neutral earthing of the electrical system	Y
ii)	Body earthing of the electrical equipment	Y
iii)	Tankage (bonding of external floating roof, ladder rollers, bypass conductors, external shunts, rails of staircase and lubrication on rollers)	HY
iv)	LPG bottling plants, loading gantries /tank truck loading Check for: a) Earthing continuity of loading arms, flexible hoses, and piping b) Earthing & bonding of rail tracks within the gantry premises c) Earth connections in carousal /tanks	HY
v)	Process equipment in the plant area (such as heat exchanger, vessel, column, piping etc.) whether grounded	Y

6.3.3 Lightning Protection

i)	Visual check for external damages to earth electrodes down conductors, lightning arrestors, supporting structures and insulators.	Y
ii)	Cleanliness of insulators	Y
iii)	Earth resistance and continuity	Y
iv)	Any other inspection items required as per IS:2309 or BS 6651 as applicable	Y
v)	Third harmonic current testing of lightning arrestor	3Y

6.3.4 Flameproof/ Weather protection

i)	Visual checks for external damages (to glasses, casting etc.)	M
ii)	Visual Inspection of external earthing connections	Q
iii)	Condition of gasket	Q
iv)	Checking unauthorised modifications in the flameproof equipment.	Y
v)	Checking completeness of bolts, glands, stoppers & their tightness and the enclosures having intended weather protection	Y
vi)	Corrosive effects	Y
vii)	Plugging spare cable entries	Q
viii)	Any other inspection as recommended by the Manufacturer or system designer.	

6.3.5 Fire alarm system (Electrical circuits)

i)	Operation of siren circuits (simulation test)	W
ii)	Operation of break glass field station actuation circuits	W
iii)	Checks to confirm no blown fuses, and no fused lamps	M
iv)	Checking of emergency supply system availability	W
v)	Any other inspection recommended by the manufacturer or system designer	

6.3.6 Cathodic protection (Electrical circuits)

For tankages, underground piping, submerged structures and cross-country pipelines)

i)	Performance of transformer-rectifier unit (TRU) and earthing connections	W
ii)	Pipe/structure to soil potential measurements for impressed current / sacrificial anode systems	HY
iii)	Anode current and all connections to anode / structures (conformity to design requirements)	HY
iv)	Any other inspection recommended by the Manufacturer or system designer	

Note:

The frequency of inspection is to be increased if abnormal external corrosion and breakdowns are encountered in the cathodically protected system.

6.3.7 Electric Heat Tracing.

i)	Visual checks for functioning of all panel indication lamps (indicating tracer circuit healthily condition)	W
ii)	Temperature measurements at inspection point	W
iii)	Current reading of each circuit and check for any blown out fuse	W
iv)	External damages to piping, insulation and tracers	M
v)	Weather proofness for outdoor panels and junction boxes especially whether doors / covers kept closed.	M
vi)	Tightness of connections*	
vii)	Sealing and termination*	HY
viii)	Insulation resistance of cables, panel boards and tracers*	
ix)	Continuity checks*	
x)	Any other inspection recommended by the manufacturer or system designer.	

Note:

*Shutdown Inspection items

6.3.8. Protective and Safety Appliances

The condition of following appliances shall be checked as per the requirements of IS: 4770 or as recommended by the manufacturer. The frequency of inspection shall be 'HY" or everytime before being put to use, whichever is earlier.

I) Hand Gloves, Safety suits, breathing apparatus etc.
II) Rubber shoes, insulating mats
III) Safety belts
iv) Ladders
v) Earthing devices
vi) Helmets
vii) Voltage detectors/ Multimeters/ Tong testers/ Insulation tester/Earth resistance tester etc.
viii) Goggles & face shields
ix) Earth leakage circuit breakers (ELCB)/ Residual current circuit breakers (RCCB).

6.4 DISTRIBUTION NETWORK

Items to be inspected	Frequency

6.4.1. Cable and conduit wiring

i)	Availability of permanent cable route markers and joint location markers in the field	Y
ii)	Condition of cable termination /joints and clamping arrangements	Y
iii)	Availability of identification tags	Y
iv)	Mechanical protection to under ground and overhead cables	Y
v)	Damages to cables, conduits, wires including clamps/cable supports	TA
vi)	Water tightness of conduit system	TA
vii)	Corrosive effects on conduits & junction boxes.	TA

Notes:

1. It shall be checked (through random trial pits) that the underground cables are protected with sand and bricks throughout and ensure that the cables are not

exposed at any location. Also Armouring, pipe sleeves and such other mechanical protection requirement shall be inspected.

2. Item vi) shall be applicable only for critical high voltage cables.

3. Items (v) to (vii) shall be Shutdown Inspection items.

6.4.2 Cable Duct/Trench/Tray support

i)	Congestion of cable in the duct (conformity for pipe fill 50%) – during initial installation and laying of new cables.	
ii)	Damages to cable trench including covers, duct, tray support and walkway gratings.	Y
iii)	Sealing cable trenches /ducts (prevention of entry of foreign materials-vermin, water, chemicals, dirt, reptiles, etc into trenches, ducts)	Y
iv)	Corrosion on the metallic tray supports	Y

6.4.3 Overhead line (Uninsulated)

i)	Cleanliness of insulators and bushings	Q
ii)	Condition of hardware, supporting structure and conductors	Q
iii)	Abnormal sagging and clearances	Q
iv)	Joints in the O.H. lines	Q
v)	Continuity of earth conductors	Q
vi)	Provision of guards, anticlimbing devices, danger boards, and phase markings	Q
vii)	Corrosion effects	Q
viii)	Infringement and growth of vegetation	Q
ix)	Any damages to insulators and other devices	Q
x)	Earthing of stay wire	Q
xi)	Physical inspection of Overhead line conductors (of both normal and standby O.H. lines) including ground clearance of guard wire.	TA

6.5 OUTDOOR SWITCHBOARD

	Items to be inspected	**Frequency**
i)	Earthing of fencing, gage, insulator supports and other metallic structures	HY
ii)	Condition of fencing & all metallic structures from corrosion effects	HY
iii)	Checking of pipe from transformer to soakpit for any leakage	HY
iv)	Provision of locking arrangement for gate and isolators (especially when the transformers & O.H. line are energised)	HY
v)	Provision of metal mesh, oil soakpit and fire partition walls (as applicable)	HY
vi)	Condition of trenches cover slabs and earth electrodes in the yard	HY
vii)	Visual inspection of transformer plinth and other concrete foundations	TA
viii)	Accessibility for maintenance and operation of switchyard equipment with mountings.	HY
ix)	Illumination level	Y

6.6 SWITCHGEAR ROOM/SUBSTATION BUILDING

	Items to be inspected	Frequency
i)	Illumination level	HY
ii)	Emergency lighting provision and its auto-changeover circuit operation	HY
iii)	Ventilation and Pressurisation system.	HY
iv)	Roof leakage - Pre-monsoon Pond test	Y
v)	Sealing of cable and bus duct entries (to make them water and vapour tight)	Y
vi)	Housekeeping including movement of door/ shutters.	M
vii)	Water drainage arrangement	Y
viii)	Provision of insulating mats conforming to IS:15652:2006 having ISI mark, shock treatment chart, fire extinguisher (suitable for electrical fires), updated SLD, sand filled buckets, MCP, Earthing rods, Electrical PPEs, and telephone	HY
ix)	Condition of trench, cover slabs, and chequered plates	HY
x)	Marking on the switchboard for identification of circuits and provision of danger, caution board. Marking should be across the fixed and removable portion of the rear side of the panel for safety.	HY
xi)	Damages and corrosion effects, if any	HY

6.7 SAFE PROCEDURES AND SYSTEMS

Checks for compliance:

i)	Compliance of Work Permit System	HY
ii)	Safety procedures adopted by external agencies	HY
iii)	Unauthorised additions or modifications of installations (whether temporary or permanent)	HY
iv)	Adherence to safety and fire fighting requirements as per standards	Y
v)	Compliance of items pointed out by Electrical Inspector during periodical statutory inspection (CEA Regulation 30)	Y
vi)	Physical inspection of electrical equipment installed in hazardous areas for integrity (tightness of enclosure nuts& bolts, sealing of un-used cable entries and earthing).	Y
vii)	Availability of updated operating and maintenance manuals	Y
viii)	Safety audit systems (internal & external)	Y
ix)	Training programs of electrical staff.	Y
x)	Availability of adequate illumination	Y
xi)	Preservation of idle equipment, cables, and spare parts	Y
xii)	Procedure for allowing temporary electrical facilities	Y
xiii)	Adherence to logging system of failures, system disturbances, break-downs, trippings and corrective actions taken.	Y
xiv)	Accessibility for operation and maintenance of electrical facilities	Y

7.0 PROCEDURES FOR ELECTRICAL TESTS AND RECOMMENDED VALUES

This section provides brief details of the tests normally carried out in field to determine the condition of the various electrical equipment/ system. The tests provide data to determine whether any corrective maintenance or replacement is necessary or desirable, to ascertain the ability of the element to continue to perform its design function adequately and finally to chart the gradual deterioration of the equipment over its service life.

The test results may vary depending on the age, site, installation & maintenance practiced followed. The results shall be judiciously used to enhance life of the equipment and systematic plan for its replacement.

Before initiating the inspection of electrical equipment and associated circuits, concerned engineer should familiarise himself with the complete previous history of the equipment/circuits, design parameters, service, likely areas of concern, manufacturer's recommendations and such other pertinent data to arrive at the appropriate inspection procedures/ program.

Many tests on the electrical equipment involve the use of high voltages and currents that are dangerous; hence safety rules should be instituted and practiced to prevent injuries to personnel performing the test. Also, the test procedures used should be designed to ensure that no intentional damage to equipment will result from the testing process.

Most of the defects/faults in electrical system can be discovered only through tests and not by external inspection alone.

For the basis on the type of inspection, Section 5.0 shall be referred. For competence of the person conducting the tests, Section 3-ii) shall be referred. Unless otherwise mentioned, the acceptable test values shall be the compliance of CEA Regulation 12 and the related standards published by Bureau of Indian Standards.

I) INSULATION RESISTANCE TEST:

Insulation tests are used to determine the quality or condition of the insulation systems of electrical equipment or circuits.

Insulation resistance is measured to ensure absence of leakage current and humidity. For a given insulation condition, the acceptable value of resistance depends on the size and type of the equipment, and voltage rating.

The insulation resistance is directly measured with the help of Insulation Resistance Tester which applies constant test voltage (d.c) on the insulation. This test voltage has to be applied for the time required for the absorption current to die down, (normally 1 minute). Electrical installations shall be tested for insulation resistance between all conductors and earth and between the conductors themselves.

As per the CEA Regulations 33:

(i) all equipment shall have the insulation resistance (IR) value as stipulated in the relevant Indian Standards;
(ii) on application of 500 V DC between each live conductor and earth for a period of one minute the insulation resistance of installation and equipment of voltage not exceeding 650 V shall be at least 1 MEGA OHM or as specified in the relevant Indian Standard;
(iii) on application of 2.5 kV-DC between each live conductor and earth for a period of one minute, the insulation resistance, of installation and equipment of voltage exceeding 650 V but not exceeding 33 kV shall be at least 5 MEGA OHM or as specified in the relevant Indian Standard.

If the insulation resistance values obtained are less than required value, the approved method of drying out/ repairs shall be applied until the required steady insulation resistance value is obtained.

II) MEASUREMENT OF EARTH- RESISTANCE

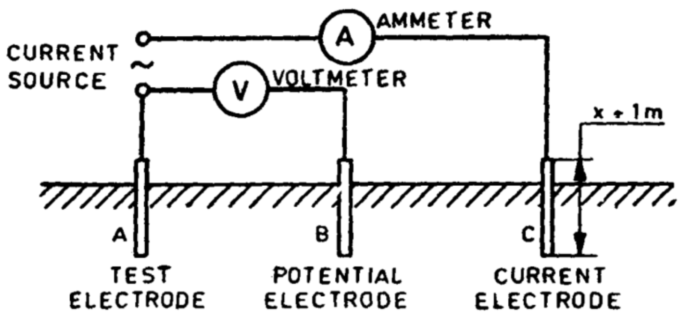
a) Earth resistance can be directly read through an earth resistance tester which has associated Test, auxiliary Current and Potential electrodes. This instrument which is a combination of ohmmeter and generator works on 'fall of potential' principle. Test voltage is derived from the generator of the earth resistance tester.

Two auxiliary earth electrodes, besides the test electrode, are placed at suitable distance from the test electrode as shown in figure below. A measured current is passed between the electrode 'A' to be tested and an auxiliary current electrode 'C', and the potential difference between the electrode 'A' and auxiliary potential electrode 'B' is measured. The resistance of the test electrode 'A' is then given by:

$$R = \frac{V}{I}$$

Where,
R = Resistance of the test electrode in ohms
V = Reading of the voltmeter in volts
I = Reading of the ammeter in amps.

All the three electrodes shall be so placed that they are independent of the resistance area of each other. If the test electrode is in the form of rod, pipe or plate, the auxiliary current electrode 'C' shall be at least 30m away from it, and the auxiliary potential electrode 'B' shall be placed mid-way between them.



Though the Fall of Potential is extremely reliable, highly accurate it has the drawback of being extremely time consuming, individual ground electrodes must be disconnected from the system to be measured and there are situations where disconnection is not possible. A clamp on earth tester performs the test in which the electrodes are not disconnected. The tester induces a known voltage in a loop circuit that includes ground, measures the resultant current flow and calculates the loop resistance. The limitations of the clamp-on tester are that it is only effective in situation with multiple grounds in parallel, it cannot be used on isolated grounds, as there is no return path.

Both the methods are acceptable in their appropriate application.

b) Allowable earth-Resistance Values

The resistance value of an earthing system to general mass of the earth should not exceed -

- For the electrical system and equipment, a value that ensures the operation of the protective device in the electrical circuit but not in excess of 4 ohms. However, for generating stations and large sub-stations this value shall not be more than 1 ohm.

- For lightning protection, the value of 4 ohms as earth resistance shall be desirable, but in no case it shall be more than 10 ohms.
- 7 Ohms for storage tanks
- 1 Ohm for main earth grid, and bonding connections between joints in pipelines & associated facilities.
- 2 Ohms for each electrode to the general mass of the earth[Note]

Note:

1. In areas with high soil resistivity (e.g. quartzite, granite, lateritic soil etc.), individual pit resistance value up to 5 ohm is acceptable, but grid resistance shall not be more than 1 ohm.
2. In exceptional cases, where the individual pit resistance of less than 5 ohm is not achievable, number of rods/pipes/plates may be connected in parallel to achieve a combined pit resistance of 5 ohms. In this case also grid resistance shall not be more than 1 ohm.
3. Typical diagrams of resistances to general mass of earth are provided at Annexure-V
4. The electrical earthing lay out diagram with earth pit numbers need to be prepared, approved and should be kept available.

III) EARTH CONTINUITY TEST

All protective and bonding conductors must be tested to ensure that they are electrically safe and correctly connected. Method for measuring resistance of protective conductor by using the neutral conductor as return lead is as follows:

A temporary link is made at the distribution board between neutral and protective conductor systems (Don't forget to remove the link after testing). The low resistance tester is then connected to the earth and neutral of the point from which the measurement is taken (see {Fig below}). This gives the combined resistance of the protective and neutral conductors back to the distribution board.

Then

$$Rp = R \times \frac{An}{An + Ap}$$

where

Rp - is the resistance of the protective conductor

R - is the resistance reading taken

An - is the cross-sectional area of the neutral conductor

Ap - is the cross-sectional area of the protective conductor.

This method is only valid if both conductors have the same length and both are copper; in most cases where steel conduit or trunking is not used as the protective conductor, the test will give correct results.

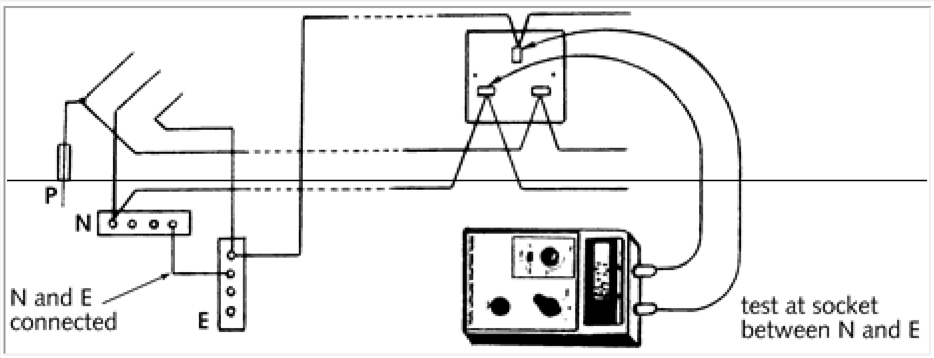


Fig : Protective conductor continuity test using the neutral conductor as the return lead

IV) POLARISATION INDEX TEST

The polarization index is a specialized application of the dielectric-absorption test. This test is used to determine the insulation resistance level of cable, transformers, motors and similar electrical equipment. Using a power driven insulation tester, the test voltage is applied to the equipment for a period of 10 minutes. The insulation resistance values at the end of 1 minute and 10 minutes period are recorded. The ratio of the final resistance to initial resistance is called the Polarisation index.

A fair index is greater than 2.0; a poor to questionable index is 2.0 to 1. When index level starts at 2.5 to 4 base level and begins to fall one or two years later to 1.5 or 2 it is apparent that either the insulation/ cable has absorbed moisture, or the insulation has become weak to an unsafe level.

The recommended values of PI for Rotating Machines based on IEEE Std. 43-2000 are as follows:

Thermal Class Rating (Insulation Class as per IEC 60085-01 :1984)	Minimum PI
Class A	1.5
Class B	2.0
Class F	2.0
Class H	2.0

Note: If the 1 min insulation resistance value is above 5000 MΩ, the calculated PI may not be meaningful. In such cases, the PI may be disregarded as a measure of winding condition.
These values shall be considered only relative and are used to know the trend of insulation deterioration over a period of time.

V) MOISTURE ABSORPTION TEST (DIELECTRIC ABSORPTION RATIO TEST)

Moisture absorption is usually evaluated from the ratio of two values of insulation resistance measured with Insulation tester after 60 seconds and 30 seconds respectively. This ratio is called the Coefficient of moisture (dielectric) absorption, denoted by ‘K’.

$$K = \frac{R_{60}}{R_{30}}$$

Damp installation will have a coefficient value close to 1. As the insulation dries out, the coefficient rises and when it becomes 1.3 or greater the insulation is considered to be dry.

The following table can be used as reference (Ref Table 20.20.2 of NFPA 70B):

Condition	60:30 Second Ratio	10:1 Min Ratio
Dangerous	----------------------------------	Less than 1
Poor	Less than 1.1	Less than 1.5
Questionable	1.1 to 1.25	1.5 to 2
Fair	1.25 to 1.4	2 to 3
Good	1.4 to 1.6	3 to 4
Excellent	Above 1.6	Above 4

VI) CATHODIC PROTECTION (ELECTRICAL TEST)

The underground or submerged structures such as pipelines, mounded bullets shall be protected against electrolytic corrosion by cathodic protection, either by the “impressed current” or the “sacrificial anode” methods.

Periodic testing of cathodic protection system such as structure to soil voltage, anode current, soil resistivity, performance of transformer and rectifier shall be carried out to ensure continued protection.

Current output and voltages shall be adjusted to maintain the degree of cathodic protection.

Allowable values of structure to soil voltage shall not be less than (-) 0.85 volts with respect to copper /copper sulphate half cell. Current density requirement depends on the condition of coating and soil resistivity. Better the quality of coating, lower will be the requirement of current. The upper limit for the PSP shall not exceed (-) 1.2 V to avoid disbonding of insulation wrap coating.

VII) CABLE FAULT DETECTION

Annexure IV describes one of the procedures for detection of cable fault location, which shall be used as a guideline if specific instruction from the cable manufacturer is not available.

VIII) TESTS ON LIGHTNING PROTECTION SYSTEM

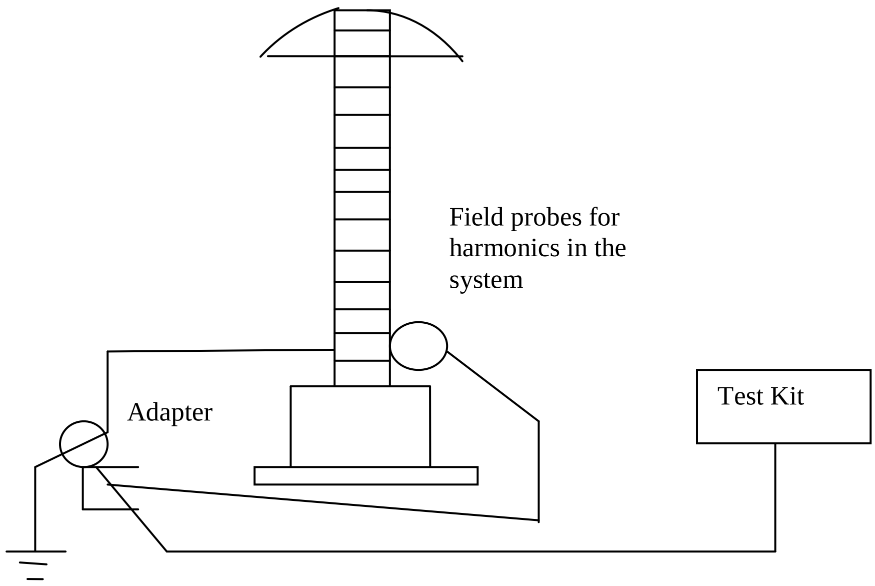
a) Building and Structures: The ohmic resistance of lightning protective system complete with air terminations but excluding earth electrode connections should not exceed 1 ohm. The continuity of lightning conductors and bonding connections of structures shall be tested to ensure that there are no open circuits. Also, checks shall be made to ensure that the clearances from other structures are maintained to prevent flashover to the structure during lightning.

b) Lightning arrestor: On Line Measurement of Third Harmonic Resistive Leakage Current.

The total current (IT) through the Surge Arrester having Capacitive component (IC) and Resistive Current (IR) flows through the Leakage Current monitor. The IR component has 3rd, 5th and other harmonics present in it. When degradation of the metal oxide discs occur, the variation of 3rd harmonic Resistive currents is more pronounced than other harmonics currents, total current (IT) and total Capacitive current (IC).

Test Procedure for Online measurement of Third Harmonic Resistive Current:

Typical connections are shown in figure below -



A clamp type CT probe is connected to the ground wire which allows the leakage current to be detected. The probe output passes through a shielded cable to the detector unit. A band pass filter is built into the initial stage to pass the 3rd harmonic and to cut off the 5th & higher harmonics. After the 3rd harmonic is selected, it is amplified and then displayed. A compensating antenna is also provided, output of which is fed to the test kit to compensate for the harmonics present in the system voltage. The harmonics present in the EHV system are compensated and filter circuits are provided for bypassing undesired currents and only 3rd harmonic resistive current is measured.

The following parameters are measured:

- True RMS value of total current, flowing through ground circuit.
- Peak value of total current
- True RMS value of third harmonic leakage current.
- Ambient Temperature.

Interpretation of Test results:

The non-linear voltage-current characteristic of a metal-oxide arrester gives rise to harmonics in the leakage current when the arrester is energized with a sinusoidal voltage. The harmonic content depends on the magnitude of the resistive current and the degree of non-linearity, which is a function of voltage and temperature. The third harmonic content of the resistive current is typically 10 % to 40 % of the Total Resistive current.

An increase in the third harmonic resistive component of leakage current brings the arrester to thermal overloading and finally causes breakdown. If the increase in the 3rd harmonic current is monitored and detected earlier, then arrester can be repaired or replaced, thus preventing damage.

The parameters of currents recorded are compared with previous measured values on the same arrester. The values are also compared with arrester of similar make and type, operating under similar conditions.

Acceptable limits of Third Harmonic Resistive Current as per CBIP Manual on EHV Substation Equipment Maintenance (Publication No. 294) (Refer Annexure -1, Table 11.9)
Table 1:

Life of LAs	Acceptable value of THRC	Remarks
New LA	Upto 20 µA	Normal
In service LA	Upto 150 µA	Normal
	150 to 350 µA	To be tested for IR & if found low, to be removed from service
	>350 µA for Gapless type	To be removed from service
	>500 µA for Gapped type	To be removed from service

IX) TESTING OF TRANSFORMER

i) **Tan Delta Testing (Power Factor and dissipation Factor) -** for Power and Distribution Transformers

The dielectric loss in an insulation system is the power dissipated by the insulation when subjected to an applied alternating voltage. Good insulation usually has a very low loss, while a high loss may indicate problems in the insulation structure.

A dielectric loss testing program provides several important benefits. Periodic tests performed during the service life of the equipment can indicate that the insulation is either aging normally or deteriorating rapidly.

The dielectric loss is usually determined by a bridge measuring instrument, such as the Schering Bridge. The test can be performed at any voltage within the normal operating range of the equipment under test, however usually performed at rated voltage or a maximum of 10kV.

A visual inspection of the apparatus should be performed to identify external damage or unusual conditions. The instruction of the test kit should be strictly followed.
The recommended value of Power Factor as per IEEE Std. 62-1995 is <0.5% for New Transformer and should be < 2% for service aged transformers.

Additional specialized tests like the Partial Discharge and Sweep frequency response analysis (SFRA) may also be conducted to assess the health of the transformer.

ii) **Partial Discharge Testing -** for Instrument Transformers (Wound Type)

Partial Discharge testing provides a good assessment of the insulation condition of the Instrument Transformers. Partial Discharge testing should be done for equipment having solid insulation and the highest equipment voltage is 7.2 kV and above and for equipment having liquid immersed insulation and equipment voltage 72.5 kV and above.

The testing shall be done as per IS 11322 (Method for Partial Discharge Measurement in Instrument Transformers) and shall be carried out after all dielectric tests are completed. The applied voltage shall be raised to the pre-stress voltage before reducing it to the partial discharge measuring voltage. The permissible partial discharge levels are given in the table below:

Type of Earthing	Type of Instrument Transformer	Pre-Stress Voltages	Measuring Voltage	Type of Insulation	Permissible Partial Discharge Level
Networks with an isolated or resonant earthed star point	Current Transformer	1.3 U_m	1.1$\mathbf{U}_m$	Liquid Immersed	100 pC
				Solid	250 pC
	Phase to Earth Voltage Transformer	1.3 U_m	1.1$\mathbf{U}_{m/\sqrt{3}}$	Liquid Immersed	10 pC
				Solid	50 pC
	Phase to Phase Voltage Transformer	1.3 U_m	1.1$\mathbf{U}_m$	Liquid Immersed	10 pC
				Solid	50 pC
Network with an effectively earthed starpoint	Current Transformer	0.8 X 1.3 U_m	1.1$\mathbf{U}_{m/\sqrt{3}}$	Liquid Immersed	10 pC
				Solid	50 pC
	Phase to Earth Voltage Transformer	0.8 X 1.3 U_m	1.1$\mathbf{U}_{m/\sqrt{3}}$	Liquid Immersed	10 pC
				Solid	50 pC
	Phase to Phase Voltage Transformer	1.3 U_m	1.1$\mathbf{U}_m$	Liquid Immersed	10 pC
				Solid	50 pC

iii) Transformer Oil Testing

Proper care shall be taken for taking oil samples for testing. It should be ensured that the sample bottle is clean and dry. The bottle shall be properly rinsed with the same oil which has to be tested, before filling up the sample. The Oil Testing shall be carried out as per IS 1866. The various tests and the recommended limits for the characteristics of Oil based on IS 1866 are as follows:

Property	Highest Voltage of Equipment (kV)		
	<72.5	72.5 to 170	>170
Appearance	Clear, free from sediment and suspended matter		
Density at 29.5°C (g/cm^3), Max	0.89	0.89	0.89
Viscosity at 27°C (cSt), Max	27	27	27
Flash Point, (°C), Min	140	140	140
Pour Point, (°C), Max	-6	-6	-6
Neutralization Value (mg KOH/g), Max	0.03	0.03	0.03
Water Content (ppm), Max	20	15	10
Interfacial Tension (mN/m), Min	35	35	35
Dielectric Dissipation Factor at 90°C and 40 Hz to 60 Hz.	0.015	0.015	0.010
Resistivity (90°C) X 10^{12} (Ohm-cm), Min	6	6	6
Breakdown Voltage (kV), Min	40	50	60
Oxidation stability of uninhibited oil i) Neutralization Value	0.4	0.4	0.4

(mg KOH/g), Max ii) Sludge (percent by mass), Max	0.1	0.1	0.1
Oxidation stability for inhibited oil Induction period (hours)	Similar values as before filling		

As per IS 1866/2000 testing frequency for Tranformer oil testing for various parameters are as below.

Property	Frequency of Testing
Appearance	In conjunction with other Quantitative tests
Water content	After filling or refilling prior to energizing, then after
	three and 12 months, subsequently along with DGA
BDV	After filling or refilling prior to energizing, then yearly
Total acidity	Yearly
IFT	After filling or refilling prior to energizing, then yearly
Resistivity	After filling or refilling prior to energizing, then yearly
Tanδ	After filling or refilling prior to energizing, then yearly
Flash Point	Yearly
Sediment and sludge	Yearly

iv) DISSOLVED GAS ANALYSIS (DGA)

This test is used to determine the amount of specific gases generated in Transformer oil during service. The amount of gases and certain combinations of those is the first indication of a possible malfunction that may eventually lead to failure if not corrected. Some of the mechanisms which lead to generation of gases due to the chemical decomposition of oil are arcing, partial discharges, low-energy sparking, severe overloading, overheating of the insulation etc. Certain empirical values are provided to give an indication of the impending failure.

For DGA testing the sample should be obtained using a clean, moisture free, gas tight container. Care should be taken to purge the container of all free gas at the time of taking the sample.

The first step in evaluating DGA results is to consider the concentration levels (in ppm) of each key gas. It is recommended that values for each of the key gases be trended over time so that the rate-of-change of the various gas concentrations can be evaluated. Basically, any sharp increase in key gas concentration is indicative of a potential problem within the transformer. Below is a table which has been derived from ANSI/IEEE C57.104 information. The suggested action levels for key gas concentrations.

Gas Description		Normal Limits* (<)	Action Limits** (>)	Potential fault Type
Hydrogen	H2	150	1000	Corona, Arcing
Methane	CH4	25	80	Sparking
Acetylene	C2H2	15	70	Arcing
Ethylene	C2H4	20	150	Severe overheating
Ethane	C2H6	10	35	Local Overheating
Carbon Mono Oxide	CO	500	1000	Severe overheating
Carbon dioxide	CO2	10000	15000	Severe overheating
Total Combustibles.	TDCG	720	4630	
* As the values exceed this limit, sample frequency should be increased with consideration given to planned outage in near term for future evaluation.				
** As value exceeds this limit, removal of transformer from service should be considered.				

The test should be performed in a laboratory and ASTM D 3612-93 should be followed for extraction and analysis of the key dissolved gases. Refer IS 9434 for the sampling and testing procedure.

Interpretation:

Based on Key Gas Method (IEEE PC 57.104 D11d)

KEY GAS	FAULT TYPE	TYPICAL PROPORTIONS OF GENERATED COMBUSTIBLE GASES
C_2H_4	Thermal Oil	Mainly C_2H_4. Smaller propostions of C_2H_6, CH_4 and H_2. Traces of C_2H_2 at very high fault temperatures.
CO	Thermal Oil and Cellulose	Mainly CO. Much smaller quantities of hydrocarbon gases in same proportions as thermal faults in oil alone.
H_2	Electrical Low Energy Partial Discharge	Mainly H_2. Small quantities of CH_4, Traces of C_2H_4 and C_2H_6.
H_2 & C_2H_2	Electrical High Energy (Arcing)	Mainly H_2 & C_2H_2. Minor traces of CH_4, C_2H_4, and C_2H_6. Also CO if cellulose is involved.

Rogers Ratio (IEEE PC 57.104 D11d)

Ratio 1	Ratio 2	Ratio 3	Suggested Fault Type
CH_4/H_2	C_2H_2/C_2H_4	C_2H_4/C_2H_6	
<0.1	<0.01	<1.0	Case 0: Normal
≥ 0.1, <0.5	≥1.0	≥1.0	Case 1: Discharge of low energy
≥ 0.1, < 1.0	≥0.6, <3.0	≥2.0	Case 2: Discharge of high energy
≥1	<0.01	<1.0	Case 3: thermal fault, low temperature < 300°C
≥1	<0.1	≥1.0, < 4.0	Case 4: Thermal Fault, < 700 °C
≥1	<0.2	≥4.0	Case 5: Thermal Fault, > 700 °C

Additional test like the Furan analysis may also be conducted to assess the condition of the insulation paper, and based on the furan analysis a degree of polymerization test can be carried out on the insulation paper sample.

X) VLF TESTING OF CABLES

There are two types of tests for cables viz. Maintenance Tests and Diagnostic Tests or Condition Assessment Tests.

i) Maintenance Test – Is a field test made during the operating life of a cable system. It is intended to detect deterioration of the cable system and to check the serviceability so that suitable maintenance procedures can be initiated.

Recommended Test Voltages for withstand test (Based on IEEE 400.2-2004):
Suggested field test voltages with 0.1 Hz VLF Voltage Source for shielded power cables **(based on IEEE 400.2- 2004)** is given in table below

VLF test voltages for sinusoidal waveform

Cable rating rms voltage in KV (ph-ph)	Voltage for Acceptance tests rms voltage in kV (ph – earth)	Voltage for Maintenance tests rms voltage in kV (ph – earth)
6.6	8	6
11	13	10
22	25	20
33	38	30

Suggested duration for Maintenance test voltage is **15 min.**

ii) Condition assessment / Diagnostic Tests:
There are two diagnostic tests viz. Dissipation Factor and Partial Discharge Test.

1. Dissipation factor (Tan δ) tests.
The Dissipation factor **(Tan δ)** is a diagnostic test for the evaluation of the cable insulation at operating or Test voltage levels. The quantity Tan **δ** / Dissipation factor is a measure of the losses of the insulating dielectric in an AC electric field.

Recommended Test Voltages:
The Dissipation factor is measured at 0.1 Hz with a test Voltage of $\mathbf{V_0}$, where $\mathbf{V_0}$ is the nominal operating voltage (Ph-E). The voltages may be applied in steps up to **Vo** and the trend of Tan δ values may be plotted. The Tan δ values at higher voltages are compared to those at lower voltages and an analysis is done. If a cable's insulation is perfect, the Tan δ value will not change as the applied voltage increases. Values over a period of time are compared to assess the condition of the cable.

Interpretation of Test results:

The acceptable values of Tan δ for XLPE/ PILC cables at V_o (as per IS 7098 -Part 2) are as mentioned below.

Tan δ at Vo (at ambient temperature)	∆ Tan δ between 0.5 Vo and 2Vo	Interpretation
< 4.0×10^{-3}	< 2.0×10^{-3}	Condition of cable insulation is good
> 4.0×10^{-3}	-	Cable needs to be replaced within 6 months

In this test, voltage is to be increased in steps. While increasing the voltage if ∆Tan delta between 0.5V0 and the applied voltage is > = 2.0×10^{-3}, cable is to be considered as aged and testing to be stopped.

Through the Dissipation factor test, the Cable insulation system can be monitored over time and a cable system history can be developed.

2. **Partial discharge measurement for cables**

Note: The PD testing shall be carried out only after VLF Tan delta values are acceptable.

Partial Discharge measurement is a sensitive method of detecting small imperfections in the insulation such as voids or skips in the insulation shield layer. Partial Discharge measurement tests can be done either as On-line or Off-lines tests. It is recommended to adopt the Off-line PD test method.

The Voltage Sources for Off-line PD measurements can either be **Power frequency** voltage source or a **Very Low frequency Voltage** source. However to be able to test at higher voltage VLF kit is utilized as its VA rating will be less than power frequency test kit.

Recommended Test Voltages:

The applied test voltages for PD measurements in XLPE/ PILC-cables should be as follows, as recommended by **IEEE -400.3-2006**

Cable type	Applied Voltage
New Cables	Max 3 V_o (with the concurrence of the cable manufacturer)
Service aged cables	Max 2 V_o

V_0 – nominal operating voltage (Ph-E)
The applied voltage is to be raised in steps starting from 0.5V0.

Interpretation of Test results:

Although there are no prescribed values for Tolerance limits recommended by Standards, based on the IEEE 400.3 – 2006 testing, the results may be interpreted as below based on the PD activity, PD Inception Voltage (PDIV) and PD Extinction Voltage (PDEV)

Result	High PD *	Low PD *	Remarks
PDEV < 1Vo	Bad cable	Bad cable	Plan for replacement immediately
PDIV < 1Vo	Bad cable	Bad cable	Plan for replacement immediately
PDIV < 1.3 Vo & PDEV > 1 Vo	Bad cable, plan for replacement immediately	Good cable Re-test after 12 months	
PDIV > 1.3 Vo & PDEV > 1 Vo	Some Concern. Re-test after 6 months	Good cable Monitor Re-test after 24 Months	
PDIV > 2 Vo & PDEV > 1 Vo	Some Concern. Re-test after 24 Months	Very Good Cable	

* Reference High and Low PD Values are provided in the table below.

However, in order to achieve accurate interpretation of test results, it is required to compare with earlier test data and monitor trends.

Reference Table for PD Values:

There are no standards for acceptable values for PD. Based on certain white papers the values given in the following tables can be used as reference. These values provide a basis for developing a database of in-service cables based on their insulation condition. It is recommended that each site develop their own reference tables to assess the risk.

Type of Cable	PD Value in pC	Remarks	PD Category
PILC	0-3000	Discharge within acceptable limits.	Low
	3000- 6500	Some Concern, monitoring recommended	
	6500-10000	Some Concern, regular monitoring recommended	High
	> 10000	Major Concern, repair or replace.	
XLPE	0-250	Discharge within acceptable limits.	Low
	250-350	Some Concern, monitoring recommended	

Type of Cable	PD Value in pC	Remarks	PD Category
	350-500	Some Concern, regular monitoring recommended	High
	>500	Major Concern, repair or replace.	

As discussed above, each of the diagnostic tests have their merits and de-merits. The suitability, practicality and effectiveness of these tests at Site depend on various factors such as the age and type of the insulation, the voltage level required to detect a defect and availability of test equipment.

Meaningful interpretation of the test results will require development of a database to better define acceptance criteria.

XI) THERMOGRAPHY:

Heat is often an early symptom of equipment damage or malfunction for electrical equipment. Checking the temperature of electrical equipment on a regular basis helps in quickly identifying unusual temperature conditions and reduces the likelihood of unplanned downtime due to equipment failure.

In thermography the thermal image of the equipment is taken, the infrared image captures the equipment temperature profile.

Thermography can be used to measure bearing temperatures in large motors, hot spots in electrical switchgear, identify faulty terminations, and identify electrical equipment like transformers, LA, circuit breakers operating at high temperatures.

It is recommended that each organization should develop a thermography program for electrical equipment.

For additional details ASTM E1934 (Standard Guide for examining electrical and mechanical equipment with infrared thermography) may be referred.

As per the Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems – International Electric Testing Association (NETA) the Delta T Criteria for Electrical System is as follows:

Priority	Delta T between similar components under similar load	Delta T over ambient air temperature	Recommended Action
4	1 to 3 Deg. C	1 to 10 Deg. C	Possible deficiency; warrants investigation.
3	4 to 15 Deg. C	11 to 20 Deg. C	Indicates probable deficiency; repair as time permits.
2	-------------	21 to 40 Deg. C	Monitor until corrective measures can be accomplished
1	> 15 Deg. C	> 40 Deg. C	Major discrepancy; repair immediately

8.0 DOCUMENTATION

Documentation and record keeping form an integral part of total inspection management system. The various records, which shall be maintained in any unit, are summarised below:

8.1 FAILURE ANALYSIS REPORTS

Failure analysis shall be conducted on

i) High Voltage equipment
ii) Repetitive failures of any kind
iii) Power system failure affecting plant operation
iv) Failure due to arcing or sparking, which caused unsafe condition/accidents.
v) Failure to newly installed or repaired systems
vi) Critical equipment and systems.

For this, various data and records shall be regularly maintained through Failure analysis reports (in the formats suggested for few, as per Annexure II), and monitored by Electrical in-charge.

8.2 HISTORY CARDS

History cards for following equipment shall be maintained by each Unit-in-charge or Maintenance Planning Cell, which should be the basis for carrying out failure analysis and enabling replacement with identical equipment or components during emergencies:

(i) Rotating equipment (Motors, Generators etc.)
(ii) Stationary equipment (Switchboard, Transformers, Reactors, Battery charger, UPS, switchyard etc.)
(iii) Protective system (Protective relays, Earthing, Cathodic protection etc.)
(iii) Distribution network (Cables, Overhear lines etc.)
(iv) Other critical electrical equipment and systems

Effort should be made to maintain the equipment design data, commissioning data, maintenance & failure data in soft form. This will help in east retrieval and analysis.

Formats for few of the above have been suggested at Annexure - I

8.3 TEST RECORDS AND OTHER DATA

Records for the following tests and other data listed shall be available:

i) Earth resistance tests

a. Tanks, gantry structures & process area

b. Vessels/exchangers/columns

c. Motors/generators

d. Earthing pits

e. Bonding and grounding of loading arms and piping

f. Substations/switchyards

g. Lightning protection system

ii) Insulation resistance tests of cables, motors, transformers and other critical electrical equipment.

iii) Cathodic protection parameters (potentials at identified locations of tank bottoms, structures/ pipelines etc.)

iv) Transformer oil tests

v) Calibration tests of meters / instruments

vi) Simulation test on protective relay circuits.

vii) Relay test records

viii) Test records on battery

ix) Other Records

a) Compliance reports of previous audit reports and Electrical Inspector's observations during periodical statutory inspections under CEA Regulation 30 (for the last 5 years)

b) Factory acceptance test certificates, Commissioning & field test records of critical equipment before energisation and after subsequent repairs.

c) Updated equipment list (load summary)

d) Updated single line diagrams and control schematics.

e) Communication and fire alarm system

f) Line clearance records.

g) List of designated persons. (Annexure III)

h) Reports on investigation of accidents (for the last 5 years), if any

i) Specifications for spare parts (for ordering purposes) with original Manufacturer's catalogues and descriptive technical data.

j) Operation and maintenance instruction manuals

k) Site specific SOPs and SMPs.

l) Reference documents (International and Indian Standards, CEA Regulation 2010, OISD standards and latest statutory regulations)

m) Relay co-ordination drawings and table of relay settings.

n) Hard copies of the relay settings & logics downloaded from Numerical relay should be signed and documented.

o) Hard copies of protection logic and control set points downloaded from DCS/ PLCs should be signed and documented.

p) Substation log register with updated entries and observations.

9.0 PRECOMMISSIONING CHECKS

Before commissioning electrical equipment after repairs and maintenance, the following minimum Pre-commissioning checks shall be carried out. Wherever manufacturer's recommendations are available, the same shall prevail.

In the case of newly installed facilities also, the same Pre-commissioning checks shall be applicable but additionally the following shall be ensured:

I) The statutory clearances from the State/ Central Electrical Inspectorate, Directorate General of Mines Safety, Petroleum and Explosives Safety Organisation, others statutory bodies (as applicable) shall be obtained.

II) Manufacturer's test certificates shall be obtained (for the successful passing of shop tests.

III) Installations conform to acceptable engineering standards and are appropriate to the respective hazardous area classifications. Installations with all individual Isolating devices (for safe disconnection of electrical circuits) shall be easily accessible for regular maintenance and emergency operation.

9.1 ROTATING MACHINERY

9.1.1 Generators

The following items shall be checked/tested, before start up:

i) Check Name plate details.
ii) External body of generator for any damage.
iii) Checking of Exciter/ Field/ Stator coils, Brushes (condition, spring pressure).
iv) Testing of AVR/ DVR including rotating rectified assembly and its components.
v) Checking of Safety Interlocks.
vi) Primary injection testing of generator panel.
vii) Secondary injection testing of protection relays.
viii) Check protection relays are set as per recommended settings.
ix) Checking of Annunciation circuit.
x) Condition of terminal box: missing/ loose nuts & bolts.
xi) Foundation bolts: tightness
xii) Cable connections
xiii) Blockage of ventilator openings
xiv) Condition of bearings and insulation resistance
xv) Oil lubrication (adequacy & Oil quality)
xvi) Alignment of coupled machines
xvii) Healthiness of space heaters.
xviii) Measure & record Insulation resistance & Polarisation Index values.
xix) Earthing connections (body & neutral)
xx) Protection circuits (simulation tests)
xxi) Auto/manual starting and changeover system
xxii) Checking of synchronising panel
xxiii) Generator set(s) have nomenclature such as G-1, G-2, Set-1 or Set-1 for ease of identification.
xxiv) **In case of Accoustic Enclosure**
Check the following:
   a. Measure the noise level to ensure that it is as per CPCB norms. (Max 70db within 1 metre the D.G package in any direction as per CPCB norms)
   b. Adequacy of Illumination inside the enclosure
   c. Functionality of Gas Detector.

   d. Functionality of Emergency Shut Down Switch which shall be outside the enclosure.
   e. Functionality of Blower fans.

xxv) Checks/ testing as recommended by OEM.

The following items shall be checked after start up:

i) Voltages building up in all the phases and also phase sequence.
ii) Exciter voltage
iii) Exciter current
iv) Load on the generator
v) Testing of speed and voltage raise/ lower operation from control panel
vi) Overheating of alternator/exciter/bearings
vii) Speed whether steady or hunting and operation of AVR.
viii) Sparking of brushes
ix) Commutator surface for uniformity (projection, if any)
x) Carbon dust collection (whether consolidated between the commutator segments)
xi) Audio visual annunciation
xii) Noise level/ any abnormal sound
xiii) Brush spring pressure.

9.1.2 Motors and Controlgear

The items listed below shall be checked/ tested before start up:

i) Check name plate details.
ii) Ensure motor ‘type’ is as per approved area classification drawings.
iii) Functional checks of motor control and protective circuits with interlocks and all audio visual annunciation (through simulation test)
iv) Checking of Annunciation circuit.
v) Check protection relays are set as per recommended settings.
vi) Condition of terminal box: missing/ loose nuts & bolts.
vii) Foundation bolts: tightness
viii) Measure & record Insulation resistance & Polarisation Index values.
ix) Cleanliness (free from dirt, dust and moisture)
x) Insulation resistance (before and after connection of the power cables)
xi) Polarisation Index and Dielectric Absorption tests (for critical equipment only)
xii) Sliprings, brushgear polish and cleanliness of machine winding.
xiii) Brushes in holders (check for clearance and pressure)
xiv) Connection and operation of space heaters, where provided. (ensure its automatic switching off when motor is started and switching on when motor is stopped)
xv) Provision of emergency stop switches and coupling guard
xvi) External damages, and missing components
xvii) Freeness of rotation of motor shaft, and lubrication.
xviii) Cable termination (check also for proper size and type of cable)
xix) Ratings of power & control fuses are as per approved drawings. And ensure -thermal, short circuit & earth fault settings (protective system)
xx) Earthing connections/earth resistance
xxi) Flameproofness, corrosion and weather protection as per area classification.
xxii) Voltage drop
xxiii) Alignment with coupled machine.
xxiv) Checks/ testing as recommended by OEM.

The items listed below shall be checked after start up:

i) Healthiness of Cooling system
ii) No load run of motors with observations for
   a. Supply voltage and frequency
   b. Direction of rotation.

c. Abnormal sound
d. Temperature
e. Vibration
f. No load current
g. Speed

Note:

Run the uncoupled motor for a minimum period of 4 hours for LT Motors and 8 hours for HT Motors and ensure trouble free operation.

9.2 STATIONARY EQUIPMENT /SYSTEMS

9.2.1 Switchboards & Panels

The following shall be checked/tested:

i) Tightness of foundation bolts.
ii) Check enclosures and cable boxes of incomer, bus-coupler and all outgoing feeder for any foreign object, condition of support insulators, phase barriers.
iii) Switchgear earthing by two separate and distinct earthing connections.
iv) Primary injection testing of switchgear Incomer and Outgoing panels.
v) Secondary injection testing of protection relays.
vi) Check protection relays are set as per recommended settings.
vii) Functionality check/ testing of CBs, MCCBs, Energy meter, Power packs etc.
viii) Operation of interlocks and safety devices
ix) Relay and meter calibrations (simulation)
x) Check for proper cabling and termination.
xi) Cleanliness (free from dirt, dust, moisture etc.)
xii) Check for any tool or foreign material inside the panel
xiii) All circuit wiring, terminations intact, and ferrule numbers checked.
xiv) Tightness of connections/clamping of wires, and tags of all the components.
xv) Vermin proofness (whether unused openings closed)
xvi) Simulation of Protection and annunciation circuits including checking of relay settings, and fuse ratings.
xvii) Provision of caution notices, tags, and danger board
xviii) Provision of insulating mats conforming to IS:15652:2006 having ISI mark
xix) Continuity checks of wires
xx) Insulation resistance.
xxi) Conformity with updated schematic and single line diagrams (ratings/settings)
xxii) Timer checks
xxiii) Short in CTs, blockage in relays
xxiv) External damage and dents
xxv) Cable bends within the switchboard (whether required bending radius is maintained)
xxvi) Contact alignment of draw out type switchgear
xxvii) Oil level, and oil condition for the oil-immersed gear
xxviii) Healthiness of space heaters.
xxix) Control supply availability
xxx) Provision of fire fighting equipment suitable for electrical fires.
xxxi) Electrical & manual closing and tripping of all circuit breakers (remote and local)
xxxii) Provision of phase barriers and partitions (to avoid inadvertent contact with live parts)
xxxiii) Condition of supporting structure.
xxxiv) Earthing of panel door with the panel.
xxxv) Checks/ testing as recommended by OEM.

9.2.2 Instrument Transformers (CT's and PT's)

The following checks/tests shall be carried out:

i) Polarity
ii) Continuity
iii) Ratio error
iv) Tightness of wiring connections
v) Wiring (continuity and completeness)
vi) Checks/ testing as recommended by OEM.

9.2.3 Transformer & Busduct

The following checks/tests shall be carried out:

i) Check name plate details
ii) Provision of all the accessories
iii) Primary injection testing of Transformer panel.
iv) Secondary injection testing of protection relays.
v) Testing of transformer winding/ oil alarm/ trip ckts, buchholz relay operation.
vi) External damages (especially on bushings, cooling fins, radiators)
vii) Insulation resistance & polarisation index testing of HV and LV windings.
viii) Body and neutral earthing/earth resistance
ix) Dielectric strength testing of Transformer oil (Conforming to IS:335)
x) Check for any oil leakage.
xi) Oil level in the conservator, bushings and thermometer pockets
xii) Condition of silica gel.
xiii) Blockage, if any, in the breather pipe
xiv) Explosion vent diaphragm not having any dents, accumulation of any oil/air (whether released)
xv) Buchholz relay (frictionless movement and floats)
xvi) Protective checks on trips and alarms (simulation)
xvii) Arcing gaps for the bushings
xviii) Earthing connection for the surge diverter
xix) Operation of the tap changer circuits on all the tap positions (simulation)
xx) Identical indication of tap position on transformer and on control panel
xxi) Operation of tap changer limit switch on the maximum tap positions.
xxii) Oil condition and oil level in tap changer tank
xxiii) Insulation resistance of all control circuits and transformer windings.
xxiv) Cooling system (automatic starting and stopping of fans)
xxv) Cleanliness of transformer surface
xxvi) Space heater operation (marshalling box)
xxvii) Parallel operation (auto/manual modes) protection and interlock circuits (simulation tests).
xxviii) Neutral grounding resistor especially for earthing connection and earth resistance.
xxix) Phase sequence (when transformers have to be paralleled)
xxx) Sealing of busduct entries through walls (for vapour, dust, water tightness)
xxxi) Vermin & dust proofness and earth connections of bus ducts
xxxii) Busduct supports
xxxiii) Expansion joints and flexible connection of busduct
xxxiv) Cable terminations
xxxv) Radiator valves are in open position.
xxxvi) Provision of caution boards
xxvi) Magnetic core balance test
xxvii) Vector group test
xxviii) Availability of conservator oil level indicator, minimum level marking and drain plug
xxix) Availability of valves for filtration, drainage and fillings with necessary plugs

xxx) Diagram plate in a visible position showing the internal connection, vector diagram and terminal details.
xxxi) Fire buckets confirming to IS 2546:1974 with the suitable stand.
xxxii) Checks/ testing as recommended by OEM.

After commissioning the transformer, the following pints shall be observed, and recorded:

i) Oil leakage, if any
ii) The no-load current
iii) Alarm, if any, or any relay flag has operated
iv) Voltage and current on all three phases
v) Transformer hum or abnormal noise, if any
vi) Current, voltage, and temperature readings (hourly for 24 hours when transformer is loaded)
vii) Phase sequence checking (parallel operation)
viii) Oil & winding temperature

9.2.4 Battery & Charger

The items listed below shall be checked/ ensured:

i) Battery Bank not exposed to direct sunlight.
ii) Healthiness of Battery charger Float and Boost charging operations
iii) Proper ventilation and provision of acid proof flooring in the battery room
iv) Check battery banks for healthy cell voltage, specific gravity of cells and electrolyte level.
v) Cell voltage, proper cell connections to maintain correct polarity.
vi) Corrosion problems especially to terminals, if any.
vii) Damages of battery container /terminal , if any
viii) Check for spillage of electrolyte and ensure Battery Room is dry
ix) Tightness of wiring connections
x) Healthiness of protection and annunciation circuit of Battery Charger
xi) Functioning of exhaust fans
xii) Checks/ testing as recommended by OEM.

9.2.5 Lighting System

The following shall be checked/ tested:

i) Installation and components meet the requirements set by environmental conditions and conform to approved drawings/specifications
ii) Ensure no fuses blown and no lamps fused
iii) Circuit loading and balancing of loads between phases
iv) Provision of safety features such as:
   a. Separation sheets
   b. Fuse base screening
   c. Door switches & padlocks
v) Continuity and completeness of wiring connections
vi) Tightness of wiring connections at the terminals
vii) Cable terminals
viii) Ratings of fuses, MCBs, ELCBs and switches
ix) Insulation resistance between phases and between phases & earth.
x) Weatherproofing and vermin proofness.
xi) Earthing connection/earth resistance values
xii) Size and type of cables, wires and conduits used.
xiii) Painting (corrosion effect)
xiv) Functional checks of lighting circuits for operation

xv) Operation of emergency lighting circuits and its automatic starting when normal use supply fails (simulation)
xvi) Condition of lighting fixtures, panels & distribution boards
xvii) Available illumination levels areawise to confirm operation and safety requirements through field inspection with UIC. Ensure that minimum lux level for normal and emergency lighting is maintained in line with OISD-STD-149.
xviii) Lighting circuit identifications and markings on light fixtures in the field.
xix) Checks/ testing as recommended by OEM.

9.2.6 CABLES

The items listed below shall be checked/ ensured:

i) Identification of the cable with provision of cable route markers and joint location markers and cable tags
ii) Voltage rating, size and type of the cable (to ensure correct specifications)
iii) Cable terminals (especially for flameproof, watertight terminations)
iv) Proper cable support/ clamping arrangement
v) Continuity of core to confirm no open circuit.
vi) Proper cable termination, Armour earthing and bonding. In case of single core cables, armour should be earthed at one end only. Trefoil formation should be ensured for single core cables. Conduits and clamps for trefoil & single core cables shall be non-ferrous type.
vii) Insulation resistance and Polarisation index testing of cables
viii) Checks/ testing as recommended by OEM.

9.2.7 SPECIAL EQUIPMENTS

Special equipment like UPS, VFDs, Battery chargers, Generator AVR/ DVRs, Impressed current Cathodic protection (ICCP) panels, PLCs, PLCCs, GIS, ECS etc. should be installed and commissioned strictly as per OEM check-lists and guidelines.

10.0 REFERENCES

The following codes, standards and publications have either been referred to or used in the preparation of this standard, and the same shall be read in conjunction with this standard:

- i) *CEA (Measures relating to Safety and Electric Supply) Regulation, 2010*
- ii) *BIS (Bureau of Indian Standards)- IS:2705, IS:3156, IS:3043, IS:1554, IS:2309, IS:5216, IS:335, IS:266, IS:900, IS:3156, IS:10029, IS:1255, IS:732, IS:5572, IS:2148, IS:7389, IS:3072, IS:4770, IS:10118, IS:1866, IS:2516, IS:5124,*
- iii) *National Electrical Code, 1985*
- iv) *Model code of safe practice Electrical-Part 1, 1974 (Institute of Petroleum publication)*
- v) *Guide for Inspection of Refinery Equipment-Chapter XIV-Electrical System-(API-Publication) 1976*
- vi) *OISD-STD-105 'Work Permit System'*
- vii) *British Standard Code of Practice BS-6651, CP-1013*
- viii) *Regulations for the electrical equipment of buildings. Fifteenth eidtion 1976 (Institution of Electrical Engineers - IEE's publication)*
- ix) *Oil Mine Regulation, 1984*
- x) *Petroleum Rule, 2002*
- xi) *Asian Electricity Journal, Oct 96.*
- xii) *Fault finding solutions article - Megger*
- xiii) *OSHAS: CFR 1910 -147, 331*
- xiv) *IEEE Std. 43-2000: IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery*
- xv) *NFPA 70B: Recommended Practice for Electrical Equipment Maintenance*
- xvi) *CBIP Manual on EHV Substation Equipment Maintenance (Publication No. 294)*
- xvii) *Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems - NETA*
- xviii) *ANSI/IEEE C57.104: IEEE Guide for the Detection and Determination of Generated Gases in Oil-Immersed Transformers and Their Relation to the Serviceability of the Equipment.*
- xix) *IEEE 400.2- 2004: IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)*
- xx) *IS 7098 -Part 2: Crosslinked polyethylene insulated thermoplastic sheathed cables - specification*
- xxi) *IEEE -400.3-2006: IEEE Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment*
- xxii) *IS 11322: Method for Partial Discharge Measurement in Instrument Transformers*
- xxiii) *IS 1866: Code of practice for electrical maintenance and supervision of mineral insulating oil in equipment.*
- xxiv) *CPWD, General Specifications on Electrical Works: Part-I(Internal) and Part-IV (Sub-station), 2013*

ANNEXURE I

HISTORY CARDS

ELECTRO MAGNETIC RELAY INSPECTION AND TEST RECORD

CIRCUIT LOCATION________________CIRCUIT DESIGNATION_____________________

RELAY______________________PHASE OR LOCATION IN PANEL__________________

MANUFACTURER___________TYPE__________STYLE NO._________FUNCTION______

C.T. RATIO_____________________________P.T. RATIO___________________________

TAP RANGE_____________________________INSTANTANEOUS RANGE____________

TIME OPERATIONS INDICATOR_______AND INSTANTANEOUS INDICATOR______AMP

Relay Inspection date	
Cover - Glass tight - Glass clean - Gasket tight	
Relay condition - Dust - Rust - Iron filings	
Bearings sticky	
Shorting bars in place	
Connections tight	
Contacts - Dirty - Pitted	
Operations indicator - Armature free - Target free	
Instantaneous attachment - Armature free - Target free	
Disc rubbing inspection	
Magnet condition	
Auxiliary contact condition - NO - NC	
Auxiliary coil pick-up for contact multiplier	
CT terminal condition / tightness checking	
Disc movement starting current	
Disc Rotating spring condition / availability	
Inst Trip operation	
Time contact make spring adjustment	
Flag operation	
Latch operation	
Moving Contact Spring condition	

Note: For Numerical relay testing format by OEM to be followed. Also, it should be ensured that the ‘relay internal failure signal’ is configured for alarm.

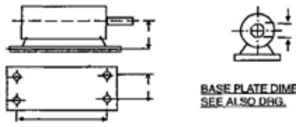
CABLE MAINTENANCE CARD

Card No. ____________________

Make	Type	Year of Installation	Tag No.	Size
Voltage	Current	Length	Initial No. of Joints	Cable route line marker

Date	Type of fault	Fault location	Distance From length (m)	Job carried out	Executed by

MOTOR HISTORY CARD

	MOTOR DETAILS :	PLANT :
PURCHASE ORDER : DATE OF COMMISSIONING :	MFGR. REF. : DRG. NO. :	TAG NO. : SERVICE :
MOTOR TYPE : ____ SERIAL NO. ____ MAKE ____ MOUNTING ____ FOOT / FLANGE MOUNTED FRAME SIZE ____ WINDING CONNECTION ____ STAR / DELTA ____	HP / KW ____ RPM ____ VOLTS ____ PHASE ____ FREQUENCY ____ FLC ____ NLC ____ POWER FACTOR ____ EFFICIENCY ____	STARTING METHOD ____ INSUL. CLASS ____ TEMP. CLASS ____ DUTY ____ TYPE OF PROTECTION ____ TYPE OF ENCLOSURE ____ DIRECTION OF ROTATION (VIEWED FROM NDE) : ____ CW / CCW
STARTING TIME - UNCOUPLED ____ SECONDS ____ STARTING TIME - COUPLED ____ SECONDS ____ STARTING CURRENT ____ X F L C ____ STARTING TORQUE ____ X F L T ____ VOLTAGE AT STARTING ____	WINDING RESISTANCE PER PHASE ____ WINDING INSUL. RESISTANCE ____ GD² (MOTOR) ____ SLIP ____ % AT ____ % LOAD ____ SOUND LEVEL ____	____ ____ ____ WEIGHT ____ KG ____ ROTAR WEIGHT ____ KG ____
DE BEARING ____ NDE BEARING ____ TYPE OF GREASE ____ DE GREASING INTERVAL ____ WH ____ NDE GREASING INTERVAI ____ WH ____	DE ON LINE GREASING FACILITY ____ YES / NO ____ NDE ON LINE GREASING FACILITY ____ YES / NO ____ ____ GREASE QUANTITY ____ GRAMS ____ GREASE QUANTITY ____ GRAMS ____	FOR OIL LUBRICATED BEARINGS ____ TYPE OF OIL ____ VISCOSITY OF OIL ____ COUPLING TYPE ____ COUPLING SERIES ____
MOTOR SPACE HEATER ____ YES / NO ____ VOLTS ____ WATTS ____	SPARE MOTOR AVAILABLE ____ YES/NO ____ SPARE MOTOR DETAILS ____	 BASE PLATE DIMENSIONS. SEE ALSO DRG.

NO LOAD CURRENT (Amps.)	R Y B												
RUNNING CURRENT (Amps.)	R Y B												
AFTER 2 Hrs. OF RUNNING DE. BRG. TEMP. / AMB.T.													
AFTER 2 Hrs. OF RUNNING NDE BRG. TEMP. / AMB.T.													
VIBRATIONS (MM / SEC) – DE	A H V												
VIBRATIONS (MM / SEC) – NDE	A H V												
BEARING CONDITION (G S E) – DE	A H V												
BEARING CONDITION (G S E) - NDE	A H V												
GREASING DONE – DE													
GREASING DONE – NDE													
MOTOR WINDING I.R. VALUE (MΩ) + POWER CABLE	RE YE BE												
WINDING CONTINUITY CHECKED													
MOTOR BODY & FAN COVER CLEANING DONE													
TERMINAL BOX CONNECTION TIGHTENED													
EARTHING CONNECTION CHECKED													
DATE OF SENDING MOTOR TO E.W.S.													
REASON FOR SENDING MOTOR TO E.W.S.													
DATE OF HANDING OVER TO OPS													
SIGNATURE & DATE													

MOTOR STARTER HISTORY CARD

THERMAL O/L RELAY & FUSE CO-ORDINATION CHECKED												
INSIDE MODULE & OUTGOING CABLE CONNECTION CHECKED												
POWER CONTACTORS FIXED & MOVING CONTACTS CONDITION ALIGNMENT CHECKED												
POWER CONTACTOR FIXED & MOVING CONTACTS CHANGED.												
THERMAL O/L RELAY MANUAL RESETTING MECHANISM & SETTING CHECKED.												
THERMAL O/L RELAY CALIBRATED / REPLACED												
POWER JUNCTION BOX INSPECTED.												
POWER CABLE LUGS REPLACED AT – M.C.C. END / J.B. END / M.T.B. END												
PUSH BUTTON CONTROL STATION CONNECTION CHECKED.												
RED MARK AT FLC IN AMMETER CHECKED / DONE												
AMMETER CALIBRATED / REPLACED												
POWER CABLE I.R. VALUE (MΩ) RE RY / YE YB / BE BR												
CONTROL CABLE I.R. VALUE (MΩ)												
SPACE HEATER CABLE I.R. VALUE (MΩ)												
SIGNATURE & DATE												

	STARTER & CABLE DETAILS	PLANT :
MCC NO. MODULE NO.	MCC P.O. NO. MODULE RATING	MAKE DATE OF COMMISSIONING : MODULE DRG. NO.
INCOMING PLUG IN CONTACTS RATING ____ OUTGOING PLUG IN CONTACTS RATING ____ SWITCH FUSE UNIT RATING ____ POWER FUSE RATING ____ POWER CONTACTOR RATING ____ CONTROL FUSE RATING ____ CONTROL SWITCH RATING ____	TYPE ____ TYPE ____ TYPE ____ TYPE ____ TYPE ____ TYPE ____ TYPE ____	MAKE ____ MAKE ____ MAKE ____ MAKE ____ MAKE ____ MAKE ____ CONTROL VOLTAGE ____ MAKE ____
THERMAL O/L RELAY – TYPE : ____ – RANGE : ____ – SETTING : ____ – MAKE : ____	CONTACTOR MOUNTED / INDIVIDUAL MOUNTED ____ WITH / WITHOUT SPP ____ DIRECT / CT / OPERATED ____	IF CT OPERATED CT RATIO ____ VOLTAGE RATING ____ TYPE ____ VA ____ ACCURACY CLASS ____ MAKE ____
AMMETER TYPE – TAUT BAND TYPE/ORDINARY ____ RANGE WITH SUPRESSED SCALE ____ ACCURACY CLASS ____ MAKE ____	MOUNTING DIMENSIONS ____ DIRECT / CT / OPERATED ____	IF CT OPERATED CT RATIO ____ VOLTAGE RATING ____ TYPE ____ VA ____ ACCURACY CLASS ____ MAKE ____
POWER JN. BOX NO. OF ENTRIES ____ ENTRY SIZE ____ JN BOX CONNECTION-WITH/WITHOUT CONNECTING BLOCK ____	PUSH BUTTON STATION NO. OF ENTRIES ____ ENTRY SIZE ____	INTERLOCKS DETAILS
POWER CABLE - FROM MCC TO JN. BOX SIZE ____ POWER CABLE - FROM JN. BOX TO MOTOR SIZE ____ CONTROL CABLE SIZE ____ SPACE HEATER CABLE SIZE ____ POWER CABLE - INITIAL I.R. VALUE ____	LENGTH (Mts.) ____ LENGTH (Mts.) ____ LENGTH (Mts.) ____ LENGTH (Mts.) ____ CONTROL CABLE INITIAL I. R. VALUE ____	TAG. NO. ____ TAG. NO. ____ TAG. NO. ____ SPACE HEATER CABLE INITIAL I.R. VALUE ____

TRANSFORMER HISTORY CARD

LOCATION :		
X MER NO. :		
MAKE :		
CAPACITY :		% IMPEDANCE =
VOLTAGE RATIO :		
CURRENT RATIO :		
SERIAL NO. :		
YEAR OF MANUFACTURING :		
CONNECTION SYMBOL :		
CORE + WINDING WEIGHT :		
TOTAL OIL QUANTITY :		
OLTC MAKE :		
NO. OF TAPS :		
OIL QUANTITY :		

SAFETY TRIPS	SET VALUE	TYPE	MAKE
O.T.I. :			
W.T.I. :			
M.O.G. :			
BUCHHOLTZ :			
DIFFL PROTN.:			
REF. PROTN.:			
O/C PROTN.:			
E/F PROTN MAIN:			
STAND BY :			
OTHER PROTN. :			

	RN	YN	BN
M.B. TEST ( )	( )		
		( )	
			( )

MAGNETISING CURRENT : 1U : 2U : 1V : 2V : 1W : 2W :

DATE										
OIL TEST RESULTS B.D.V. (KV BREAK/NO BREAK)										
DENSITY / FLASH POINT-ºC										
INTERFACIAL TENSION [(0.018N/M (min)]										
TOTAL ACIDITY [0.5 mg Koh / gm (max)]										
DIELECTRIC DISSIPATION FACTOR (Tans)										
WATER CONTENT PPM [(35 PPM (max)]										
D. G. ANALYSIS										
MAIN TANK OIL FILTERATION										
OLTC OIL FILTERATION										
OIL APPEARANCE										
PRIMARY IR VALUE										
SECONDARY IR VALUE										
SILICA GEL REACTIVATION										
EXP. VENT DIAPHRAGM REPLACEMENT										
RELAY TESTING										
OTI VERIFICATION										
WTI VERIFICATION										
BUCHHOLTZ VERIFICATION										
POLARISATION INDEX										
REMARKS										
BREAK DOWNS / MODIFICATIONS MAJOR PARTS REPLACEMENT										

EARTH PIT HISTORY CARD

EARTH RESISTANCE RECORD CARD

EARTH PIT LOCATIONAL DRAWING

SUBSTATION NO.-

GANTRY / TANK NO.-

NO. OF EARTH PITS-

BASIS DRG. NO.

LOCATION OF SUBSTATION / TANK / GANTRY

FIXED ROOF TANK ☐

FLOATING ROOF TANK ☐

DIAMETER OF TANK

CAPACITY OF TANK

HEIGHT OF TANK

PRODUCT OF TANK

EARTH ELECTRODE DETAILS

EARTH CONDUCTOR DETAILS

EARTH PIT NO. / DATE																
E1																
E2																
E3																
E4																
E5																
E6																
E7																
E8																
REMARK ANY ABNORMALITY NOTICED AND CORRECTIVE ACTIONS TAKEN																
SIGNATURE AREA OFFICER AREA MANAGER																

BATTERY BANK HISTORY CARD

LOCATION	
SERVICE	
MAKE	
TYPE	
MODEL	
CAPACITY	
NO.OF CELLS	
TOTAL VOLTAGE	
YEAR OF COMMISSIONING	
SPECIFIC GRAVITY	

MONTH	DATE	AV. CELL VOLTS	TOTAL VOLTAGE	REMARKS	SIGN
JANUARY					
FEBUARY					
MARCH					
APRIL					
MAY					
JUNE					
JULY					
AUGUST					
SEPTEMBER					
OCTOBER					
NOVEMBER					
DECEMBER					

Note: For individual Battery Bank, monthly data sheet should be maintained.

ANNEXURE II

FAILURE ANALYSIS REPORT

INSTALLATION..UNIT ....

EQUIPMENT NAME: ....EQUIPMENT TAG NO.: ....

DATE ....

----

1. Present Failure/Abnormality
   Date:
   Nature:

Last Failure/Abnormality
Date:
Nature:

2. Component Damage/Abnormality

Cause of Damage.

3. Principal Cause of Failure: Facts / Observations

4. Reasons – why it happened.

5. Repair/Replacement Carried out

6. Steps taken to prevent repetition

7. Lessons learnt/ Recommendations

Signature/name/Designation
(of the Officer preparing the Report)

ANNEXURE III

DETAILS OF DESIGNATED PERSONNEL

INSTALLATION .... DATE:.........................

Sl.No.	Name	Designation	Technical Competency	Clause No.of CEA Regulation 2010 For which Designated	The work responsibility entrusted to designated person	Signature of person in Acceptance

----

Signature/name/Designation
(of the Officer preparing the Report)

ANNEXURE IV

CABLE FAULT DETECTION

GENERAL

When at some local point in a cable, insulation has deteriorated to a degree that a breakdown occurs allowing a surge of current to ground, the cable is referred to as a faulted cable. The use of particular fault finding equipment depends on the factors such as type of fault, length of cable, location of cable, cable construction etc.

Broad guidelines for methods and equipment necessary

The methods and equipment necessary are:

• Diagnosis (Fault resistance and loop test)	- Ohm meter - Insulation Tester
• Pre-location	- High voltage Bridge or High Resistance fault locator - Impulse current Equipment - Pulse reflection method (pulse echo)
• Fault Conditioning (Sometimes necessary before pre-location to reduce fault resistance)	- Burn down set
• Pin-pointing	- Surge Generator - Surge detector (electromagnetic & acoustic signals)
• Route tracing	- Audio Frequency Set
• Fault Confirmation	- Acoustic Detector - Audio Frequency set occasionally.
• All above functions	- Combination Sets of portable equipment for full fault location capability.

Type of fault:

In general, faults can be said to be open or short circuits, However, in practice, many conditions can arise i.e. a break may not be “clean”- it may have resistance across it or, more usually, to the sheath or earth. A contact fault may be “hard down” or exhibit hundreds of ohms, kilo-ohms or even megohms. Also faults may occur on one or more of the cores of conductors.

Fault locating procedure:

- Fault Indication
- Disconnecting and Earthing
- Fault Analyses and Insulation Test
- Cable Fault Prelocation
- Cable Route Tracing
- Precise Cable Fault Location (Pinpointing)
- Cable Identification
- Fault Marking and Repair

- Cable Testing and Diagnosis

(a) Contact fault:

Pulse Echo Set if fault resistance is suitable. If not, H.V. Or High Resistance bridge or Impulse current set can be used.

(b) Flashing Fault:

Impulse Current Set

Choice of instruments

- For XLPE Insulated cable, a full set of equipment incorporating Impulse current equipment will be required, because it is impossible to burn down faults on this type of cable and pulse echo is, therefore, not possible for contact faults.

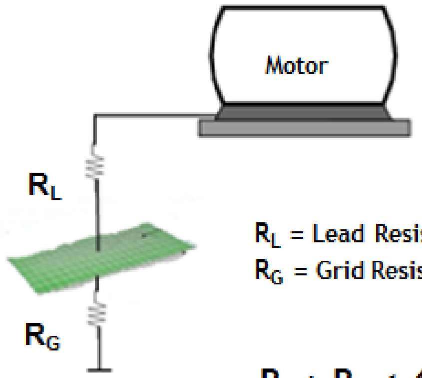
- For long cables, say up to 15 Km presents few problems in pre-location but Pin-pointing equipment is essential because even a low-pre-location error results in a wide search area.

- For short route lengths a rough “one Instrument” approach may be successful. For Instance, assuming pre-location is possible, the application of modern-powerful Surge generator to jest a few hundred meters of cable and careful patrolling of the route often gives a “spot-on” location within a short time.

ANNEXURE-V

TYPICAL DIAGRAMS OF RESISTANCES TO GENERAL MASS OF EARTH

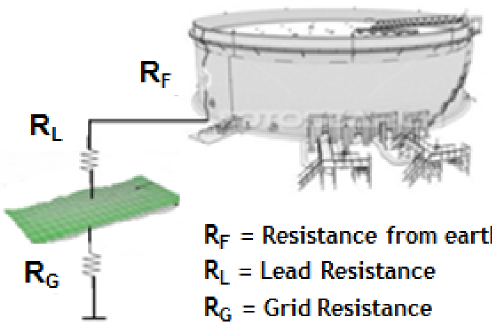
✓ **4 Ohms for Electrical Systems**



R_L = Lead Resistance
R_G = Grid Resistance

$$R_L + R_G \leq 4 \text{ Ohm}$$

✓ **7 Ohms for Storage Tanks**



R_F = Resistance from earth plate to any part of fitting or fitting to fitting
R_L = Lead Resistance
R_G = Grid Resistance

$$R_F + R_L + R_G \leq 7 \text{ Ohm}$$

OISD - STD - 142

FOR RESTRICTED CIRCULATION ONLY

INSPECTION OF FIRE FIGHTING EQUIPMENT AND SYSTEMS

OISD - STANDARD - 142

First Edition, February 1996

Oil Industry Safety Directorate

Government of India

Ministry of Petroleum & Natural Gas

8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Website: www.oisd.gov.in

Tele: 0120-2593800, Fax: 0120-2593802

OISD - STD - 142
First Edition
February, 1996

FOR RESTRICTED CIRCULATION ONLY

INSPECTION OF FIRE FIGHTING EQUIPMENT AND SYSTEMS

Prepared by:

COMMITTEE ON “INSPECTION OF FIRE FIGHTING EQUIPMENT AND SYSTEMS

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)
Website: www.oisd.gov.in
Tele: 0120-2593800, Fax: 0120-2593802

Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director

Oil Industry Safety Directorate

FOREWORD

The Oil Industry in India is 100 years old. Because of various collaboration agreements, a variety of international codes, standards and practices have been in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This, coupled with feed back from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by the Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safe operations. Accordingly, OISD constituted a number of functional committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on “Inspection of Fire Fighting Equipment and Systems”, has been prepared by the Functional Committee on “Inspection of Static Equipment”. This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. This document is meant to be used as supplement and not as a replacement for existing codes and practices. It shall be borne in mind that no standard can be a substitute for the judgement of a responsible qualified Inspection Engineer. Suggestions are invited from the users after it is put into practice to improve the document further. Suggestions for amendments to this document should be addressed to

The Co-ordinator,
Committee on “Inspection of Static Equipment”,

Oil Industry Safety Directorate

Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Website: www.oisd.gov.in

Tele: 0120-2593800, Fax: 0120-2593802

This standard in no way supercedes the statutory requirements of bodies like IBR, CCE, Factory Inspectorate or any other Government Body which must be followed as applicable.

NOTE

OISD publications are prepared for use in the oil and gas industry under the Ministry of Petroleum and Natural Gas. These are the property of Ministry of Petroleum and Natural Gas and shall not be reproduced or copied and loaned or exhibited to others without written consent from OISD.

Though every effort has been made to assure the accuracy and reliability of data contained in these documents, OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use.

These documents are intended only to supplement and not replace the prevailing statutory requirements.

Committee on
INSPECTION OF FIRE FIGHTING EQUIPMENT AND SYSTEMS

NAME	REPRESENTING
LEADER	
Shri R. K. Sabharwal	Indian Oil Corporation (R & P Division)
Shri Y. P. Ajmani (Since March, 1993)	Oil & Natural Gas Corporation
MEMBERS	
Shri B. Ravi	Indian Oil Corporation (Marketing)
Shri S. F. Kanchwala	Bharat Petroleum Corporation Limited (Refinery)
Shri G. Somani	Indian Oil Corporation (R & P Division)
Shri A. C. Kelkar	Indian Oil Corporation (Marketing)
Shri P. K. Khaitan	Oil & Natural Gas Corporation
Shri Sham Lal	Oil & Natural Gas Corporation
Shri J. L. Vishwakarma	Hindustan Petroleum Corporation Ltd., Bombay Refinery
Shri S. S. Murthy	Hindustan Petroleum Corporation Ltd., Visakh Refinery
Shri V. Bharadwaj	Bharat Petroleum Corporation Limited (Marketing)
Shri S. Neelakantan	Madras Refineries Limited
Shri K. Narayanan	Cochin Refineries Limited
Shri R. Rehman	Hindustan Petroleum Corporation Ltd., (Marketing)
CO-OPTED MEMBERS	
Shri P. L. Nigania	Indian Oil Corporation, Gujarat Refinery
Shri A. A. Raichur	Hindustan Petroleum Corporation Ltd., Bombay Refinery
Shri S. N. Banerjee	Bharat Petroleum Corporation Limited (Refinery)
Shri K. Baskaran	Madras Refineries Limited
MEMBER COORDINATOR	
K.R. SONI	Oil Industry Safety Directorate

In addition to the above, various other experts from the industry contributed in the preparation, review and finalisation of this document.

INSPECTION OF FIRE FIGHTING EQUIPMENT AND SYSTEMS

CONTENTS

SEC-V FOAM FIRE EXTINGUISHING SYSTEM

SEC-VI WATER SPRINKLER SYSTEM

SEC-VII FIXED WATER SPRAY SYSTEM FOR FIRE PROTECTION

SECTION I

INSPECTION OF FIRE FIGHTING EQUIPMENT AND SYSTEMS

1.0 INTRODUCTION

The complex nature of present day petroleum industry involving critical operating conditions and high level of product inventory call for an efficient fire fighting system. The fire fighting system should be designed, constructed, tested and maintained as per standard engineering practice for safe and efficient operation. The design of each fire fighting equipment or fire fighting system shall be carried out as described in the relevant chapters. Various fabrication and inspection stages shall be decided upon and a quality control/quality assurance programme evolved to ensure quality product.

2.0 SCOPE

This standard covers the design, construction, inspection and testing requirements of new and installed fire fighting equipment and Installations. The requirement given herein are MINIMUM. The Standard also covers performance requirements of equipment.

This Standard covers the following types of fire extinguishing systems:

1) Dry Chemical Powder
2) Carbon dioxide
3) Halon
4) Foam
5) Water Sprinkler
6) Fixed Water Spray

SECTION II

DRY CHEMICAL POWDER (DCP) FIRE EXTINGUISHING SYSTEM

1.0 DEFINITIONS AND TYPES OF DCP FIRE EXTINGUISHING SYSTEMS

1.1 DEFINITIONS

1.1.1 Extinguisher (DCP) Portable/ Trolley mounted:

DCP extinguisher consists of a cylinder containing finely powdered chemicals which are expelled by means of an inert gas contained either in a compressed gas cartridge located within the DCP cylinder as in case of portable extinguishers or stored in a separate cylinder located outside DCP cylinder as in case of trolley mounted extinguishers.

1.1.2 Mobile DCP Tender:

It consists of a cylindrical vessel containing extinguishing agent i.e. DCP, and a series of cylinders containing expellent gas i.e. compressed nitrogen, all mounted on a truck or trailer.

1.1.3 Cylinder

For this standard, a cylinder means a cylindrical container/vessel containing DCP or expellent gas as the case may be.

1.1.4 Cartridge

For this standard, cartridge is a small cylinder containing expellent gas and located within the DCP cylinder.

1.1.5 Operating Pressure

The operating pressure is the pressure developed in the DCP container with the discharge nozzle closed, when the full designed quantity of expelling gas in a cartridge or cylinder is released into it.

1.1.6 Test Pressure

The hydrostatic pressure at which the container together with its cap assembly and discharge hose is to be tested.

1.1.7 Burst Pressure

It is the pressure at which the material fails. The burst pressure test is conducted as a proof test to ensure that the material is capable of withstanding working pressure. The burst pressure should be greater than 3 times the operating pressure.

1.2 TYPES OF DRY POWDER EXTINGUISHING EQUIPMENT & SYSTEMS

The various types of extinguishers/systems covered in this standard are:

1.2.1 Portable

Portable extinguishers have a maximum dry powder filled weight of 10 kg. and a maximum gross weight of 23 kg. The expellant gas is contained in a cartridge within the cylinder.

1.2.2 Trolley Mounted

In principle, the basic operation of Trolley Mounted DCP Fire Extinguishers and Portable DCP Extinguishers are similar. Trolley mounted extinguishers are manufactured to 25.0, 50.0, 75.0, 100.0 and 150 Kg. capacity. The expellant gas is located in a cylinder outside the DCP container

1.2.3 Trailer Mounted

Trailer Mounted extinguishers are manufactured in the 200 kg to 500 kg capacity range. Expellant gas is located in a cylinder outside the DCP container.

1.2.4 Mobile Tender

Dry Powder Tender is of 1, 2, 3 & 4 Tons capacity on an automobile chassis. The expellant gas is contained in a series of cylinders mounted on a truck.

2.0 DESIGN OF DCP CYLINDERS

2.1 DESIGN PRESSURE

The portable trolley mounted fire extinguishers and the DCP cylinder on mobile tenders shall be designed to withstand pressure of 22.5 kg/sq cm. The maximum operating pressure shall not exceed 15kg/sq.cm. This pressure will be adequate to achieve required performance characteristics.

2.2 MATERIAL OF DCP CYLINDER

The material of various parts of the DCP cylinder shall be as given below:

i)	Shell of all portable cylinders upto 10 kg	IS-513 grade capacity ‘EDD’or “DD”
ii)	Shell of all trolley mounted cylinders upto 150kg	IS-2002 grade A or IS-2041
iii)	Shell of mobile tender	IS-2002 gr 2A or IS-2041.
iv)	Nozzle pipe	IS-1239/IS-1978
v)	Flanges	ASTM A-105 or Equivalent
vi)	Plunger and nozzle of all portable cylinders upto 10 kg capacity	Type I of IS- 319
vii)	Cap nozzle and drain plug of all trolley mounted extinguishers upto 150 kg capacity.	Type I of IS-319/ SS
viii)	Discharge nozzle on trigger for cylinder, portable and trolley mounted.	IS-617
ix)	Washers for all sizes of extinguishers	IS-5382/IS-2171
x)	Inner container	IS-513/IS-2171

2.3 DESIGN THICKNESS

The thickness of plate material for the DCP cylinder shall be calculated as per the formula given below:

$$t = \frac{PD}{200\,fj + P}$$

Where

t = minimum thickness of shell plate exclusive of corrosion allowance in mm.

P = Design pressure in kg/cm2
D = outside diameter of DCP cylinder in mm.
f = allowable stress value for the material used in kg/mm2
j = weld joint efficiency factor

Thickness of the shell including dished ends shall not be less than 2 mm for portable extinguishers upto 10 Kg, 3.15 mm for 25 Kg, 50 Kg & 75 Kg and 6.3 mm for 100 Kg & above trolley mounted extinguishers respectively.

2.4 CAPACITY

The capacity of portable extinguishers shall be of 1, 2, 5 and 10 kg weight of Dry Chemical Powder and of trolley mounted extinguishers of 25, 50, 75, 100 and 150 Kg weight. The mobile tender capacity shall be of 300 Kg, 500 Kg, 1, 2, 3 & 4 Tonnes by weight.

3.0 CONSTRUCTION

3.1 WELDING

The cylinder body shall be of welded type. All ferrous fittings shall be welded to the body while all non-ferrous fittings shall be brazed.

i) All welding shall be carried out using qualified welders and agreed welding procedures.

ii) The weld joint design for the long seam as well as the circumferential seam shall be of the square edge butt type for plate thicknesses 3.0mm and less and single “V” butt for thicknesses higher than 3.0mm.

iii) All welding shall be carried out using shielded metal arc welding (SMAW) or gas tungsten arc welding (GTAW) techniques only. The electrode for welding shall conform to AWS/ASME classification. The electrode diameter shall be chosen considering plate thickness to be welded.

iv) All butt welds shall be full penetration welds.

v) All other requirements as outlined in section II of IS-2825 shall be followed.

3.2 SAFETY VALVE

All trolley mounted DCP extinguishers shall be provided with safety valve preferably on its top dished end to requirements of IS-2825.The set pressure shall be 17 Kg/sq.cm.

3.3 OPERATING PRESSURE

Suitable test shall be done to demonstrate that sufficient space is provided so that internal pressure does not exceed 15 Kg/sq.cm. and the body shall not show any sign of leakage if the discharge nozzle is closed and the extinguisher is operated at 27 + 2ºC.

3.4 DRY CHEMICAL POWDER

The types of Dry Chemical Powder and requirements shall be as per IS-4308 with Sp.Gr. in the range of 0.95 to 1.0. Permanent marking of dry chemical powder filling height shall be considered to avoid over pressurisation of cylinder.

3.5 EXPELLANT GAS

The Expellant gas used shall be carbon dioxide (CO2) or nitrogen (N2). The maximum quantity of expellant gas to be used for various capacities of Dry Chemical Powder Extinguishers shall be such that the internal pressure of the DCP cylinder shall at no point of time exceed 15 kg/sq.cm.

3.6 HOSE

The length of the discharge hose shall be as specified in IS-2171 and IS-10658.The hoses shall be designed to withstand the design pressure of the DCP cylinder.

3.7 DISCHARGE NOZZLE

The discharge nozzle shall be designed to discharge the powder as per performance characteristics outlined in 4.0.

3.8 CAP/FILLER OPENING

The size of cap/filler opening shall be as per IS-2171 (latest edition).

3.9 VENT HOLES

Necessary vent holes shall be provided as per IS-2171

3.10 SAFETY CLIP

Safety clip shall be provided to prevent accidental actuation of piercing mechanism.

3.11 COATING

The internal and external surfaces of the cylinder body shall be coated with Zinc or lead-tin alloy. Thickness of Coating for various sizes shall be as specified in standards IS-2171 and IS-10658.

3.12 PAINTING

The extinguisher shall be painted fire red conforming to shade No.536 of IS-5. The paint shall conform to IS-2932.

4.0 PERFORMANCE CHARACTERISTICS

The performance characteristics for each size of extinguisher shall be as given below

Capacity of Extinghisher	Duration of Discharge	Throw Range
(Kg)	(Sec.)	(Mtrs.)
1-2	10 - 15	3-4.5
5	15 - 20	3.5 - 5.5
10	23-30	5 - 7.5
25	25-30	6-8
50	40-50	8-10
75	50-60	10-12
100	70-80	10-17
150	100-110	15-17

5.0 INSPECTION AND TESTING OF NEW EXTINGUISHERS DURING CONSTRUCTION

5.1 SHELL AND ATTACHMENTS

5.1.1 Material Identification

Material used for the cylinder shell shall be identified to ensure conformity with manufacturing standard. Raw material/bought out material for other components shall also be identified.

5.1.2 Welding

The following checks shall be carried out prior to, and during welding:

a) Review and approval of the welding procedure.

b) Qualifying of the welding procedure and welders.

c) Inspection of edge preparation and joint fit-up

d) Ensuring that during welding only approved procedure and approved electrodes are being used.

5.1.3 Testing

The following tests shall be carried out after completion of welding:

i) Dye Penetrant Inspection:

Dye penetrat examination shall be carried out on the fillet welds of all nozzles and attachments.

ii) Radiography

Spot Radiography of welds on all

cylinders shall be carried out using X-rays/Gamma Rays. 10% of the weld joints shall be radiographed which shall include at least 50% of the "T" joints. Interpretation of radiographs shall be as per IS-2825.

iii) Hydraulic Test

Extinguisher shell/ container and the cap assembly with the hose assembly shall be tested to an internal pressure of 30 kg/sq.cm. The test pressure shall be held for a minimum period of two and a half minutes.

iv) Bursting Test

One prototype shall be tested and certified by either of customer/third party inspector. Hydraulic burst test shall be carried out on a prototype and no failure shall occur at a pressure below 45 kg/sq.cm. Actual burst pressure shall be recorded. In case the prototype does not rupture during Bursting Test then it should be destroyed to prevent its use.

v) Coating and Painting

Internal and external coating and external painting shall be checked and coating thickness established as per 3.11. The thickness of external paint shall be 50 microns minimum.

5.2 SAFETY VALVES

Safety devices shall be tested at 17 Kg/sq.cm gas per requirements of IS-2825.

5.3 HOSE

A sample discharge hose of minimum 0.5 mt length shall be tested upto bursting which shall not be less than 45 kg/sq.cm. Actual burst pressure of the hose shall be recorded.

5.4 CARBON DIOXIDE CARTRIDGE AND CYLINDER

Requirements for CO2 cartridge and cylinder are as specified in Section III of this Standard.When carbon-dioxide cylinder is connected to trolley mounted DCP extinguisher, the valve of CO2 cylinder should be provided with safety pin & seal.

5.5 PIERCING MECHANISM

The clearance between the cartridge holder and the plunger rod tip should be sufficient to ensure clear opening in the cartride seal when pierced.

5.6 REPAIRS

i) Any repairs to welding shall be carried out as per IS-2825 and the same offered for reradiography. In case of repairs additional radiography shall also be done as per IS-2825. Only one time repairs shall be allowed.

ii) Any extinguisher, which fails in hydrostatic test, shall be reoffered for inspection. If the failure is in the parent metal then the extinguisher shall be rejected. Weld failures shall be suitably repaired as per IS-2825 and reinspected.

5.7 PERFORMANCE TESTS

Performance & expansion space tests etc. shall be carried out as per IS-2171/IS-10658.

6.0 PERIODIC INSPECTION OF EXTINGUISHERS/MOBILE EQUIPMENT

6.1 LIKELY LOCATIONS OF DETERIORATION

6.1.1 Corrosion

i) Internal Corrosion:

Extinguisher (DCP Vessel) is prone to internal corrosion at the interface between the dry powder top level and empty space. Corrosion may take place where the internal coating is damaged and or where there is a holiday in the coating.

ii) External Corrosion:

The external surface of the extinguisher is prone to atmospheric corrosion particularly at areas where paint has peeled off. Support ring of the fire extinguisher is prone to water, soil and coercive corrosion. Metallic tubing for the transfer of inert gas is likely to corrode due to the atmosphere.

6.1.2 Damage/Deterioration

i) Shell

Shell may be damaged due to improper handling. Dents/ deformations may occur.

ii) Neck Ring

Neck rings are prone to breakage at the weld joint.

iii) Cap/Neck joint

The thread joint between cap and neck is prone to damage/wear/ deterioration.

iv) Cartridge Holder

The cartridge holder is prone to internal corrosion. Also the port holes are prone to erosion.

v) Spring

The spring is prone to lose its stiffness.

vi) Nozzle

The nozzle may be eroded due to frequent use of extinguisher.

vii) Hose

The rubber hose is prone to ageing.

6.2 FREQUENCY AND PROCEDURE FOR INSPECTION

The extinguisher and its components shall be inspected at frequencies specified and as per procedure given below:

6.2.1 Body

i) Visual Inspection

The shell of the DCP extinguisher shall be visually inspected externally once a month and internally once every three months to check for any mechanical damage or corrosion.

ii) Ultrasonic Inspection

Ultrasonic thickness measurements of the shell shall be carried out once every three years and readings shall be recorded.

iii) Hydrostatic Test

A Hydrostatic test of the cylinder shell along with cap and hose assembly shall be done at 30kg/sq.cm once every three years.

iv) Performance Test

Check performance test as per IS-2171 & IS-10658 on 1% of the newly procured/refilled DCP extinguishers selected at random.

v) Rejection

A DCP extinguisher body shall be removed from service and destroyed when the following conditions exist:

a) When it is corroded or damaged to such an extent at repair is required.

b) When the shell threads are damaged.

c) When it has failed in hydotesting.

d) When the extinguisher has been exposed to high temperatures due to proximity of fire.

vi) Coating and Painting

The internal coating and external painting shall be checked for damage/deterioration once in three months. The coating thickness shall be checked once every three years.

6.2.2 Other Components

The following components shall be visually inspected once every three months.

i) Cartridge Holder

The cartridge holder shall be checked for any damage due to corrosion or erosion. The port holes shall be checked for elongation.

ii) Inner container

The inner container shall be checked for physical damages like elongation of holes due to corrosion etc.

iii) Neck ring/Shell attachments

The soundness of the brazing/welding of the neck ring & attachment to the shell shall be checked.

iv) Cap

The threading of both cap and neck shall be checked. The thread engagement shall be at least 16mm. The cap washer shall be checked for deformation and cracks.

v) Plunger

The plunger shall be checked visually for any damage.

vi) Piercer

The piercing mechanism shall be checked for its proper functioning.

vii) Spring

The spring shall be inspected for its shape, size and functional aspects.

viii) Nozzle and Discharge Fittings

The nozzle and other fittings shall be checked for erosion.

ix) Cartridge and Seal

The cartridge and seal shall be checked for damage if any.

x) Dry Chemical Powder

The dry chemical powder shall be checked for signs of caking.

6.2.3 Hose

The hose condition shall be checked visually once a month. The hose on the portable extinguisher shall be replaced every three years. The hoses on the trolley mounted extinguishers and on the mobile tender shall be hydrostatically tested every three years and replaced every 6th year.

6.2.4 Safety Valve

The safety valve shall be visually inspected for corrosion or damage once every three months. The safety valve shall be bench tested at rated test pressure once every three years.

6.2.5 Gas Cartridge/Cylinder

The CO2 cartridge in the portable extinguishers and the CO2 cylinders in the trolley mounted extinguishers shall be inspected and tested as outlined in Section **III** of this standard.

6.2.6 Extinguisher Trolley

The lubrication of bearings/bushes and condition of wheel should be checked/serviced once in three months.

7.0 MARKING AND DOCUMENTATION:

7.1 MARKING

i) All DCP extinguishers shall have BIS certification mark/punch on the bottom ring.

ii) All DCP extinguishers shall be permanently punched at the bottom ring with Manufacturer’s name, year of manufacture, Manufacturer’s Sr. No. and Inspectors stamp.

iii) The date of hydrostatic test and the user’s identification number shall be clearly marked.

iv) Marking of the dry chemical powder filling height.

7.2 NEW EXTINGUISHERS

The manufacturer shall have BIS certification & shall furnish test certificates giving the following information:

i) Certificate number and date.

ii) Size, type and capacity.

iii) Material used for construction.

iv) Dry powder details viz. type, apparent density, moisture retention, fire knockdown properties, free flowing characteristics etc.

v) Operating & hypostatic test pressure.

vi) Bursting test pressure.

vii) Relief Valve testing and set pressure.

viii) Internal/external coating details.

ix) Identification marking as per relevant code.

x) Type and quantity of Expellant Gas.

7.3 INSTALLED EXTINGUISHERS

In addition to the required tag or labels, a permanent file record shall be kept for each extinguisher/installation. The record shall include the following information as applicable:

i) Identification number

ii) Date of manufacture

iii) Name of manufacturer and manufacturer's Sr. No.

iv) Capacity of the extinguisher

v) Location at which the extinguisher is installed.

vi) Date of installing the equipment.

vii) The inspection date and the name of person or agency performing the inspection.

viii) The date when last recharged and the name of the person performing the recharge.

ix) The hydrostatic test date and name of the person or agency performing the test.

x) Next hydro-test date.

xi) Inspection observations and maintenance carried out.

8.0 CONDEMNING OF CYLINDERS

DCP extinguishers shall be condemned as per the guidelines given in IS-2190.

9.0 REFERENCES

1. IS-2171-Specifications for portable fire extinguishers

2. IS-10658-Specifications for trolley mounted fire extinguishers

3. IS-4308-Specifications for dry powder for fire fighting

4. IS-2825-Code for unfired pressure vessels

5. ASME SEC VIII DIVN I-Boiler and pressure vessel code

6. BS-5423-Specification for portable fire extinguishers

7. NFPA-10-Portable Fire Extinguishers

8. IS-513-Cold-rolled low carbon steel sheets & strips

9. IS-2190-Code of Practice for selection, installation & maintenance of first-aid fire extinguishers.

SECTION – III

CARBON DIOXIDE FIRE EXTINGUISHING SYSTEM

1.0 DEFINITION & TYPES OF EXTINGUISHERS

1.1 DEFINITION

1.1.1 CO2 Extinguishers & Extinguishing Systems

The extinguishers & extinguishing systems which employ CO2 (conforming to IS-307) stored in pressure containers for extinguishing fires.

1.1.2 Filling Ratio

The filling ratio of CO2 shall not exceed 0.667. The filling ratio shall be determined as the ratio of mass of CO2 in container to the mass of water required to fill the container at 15 deg. C.

1.2 TYPES

1.2.1 Portable:

Portable extinguishers are ones which are small, hand operated and with all permanent fittings normally not exceeding a gross weight of 23 Kg. Portable extinguishers are manufactured in 2, 3 & 4.5 Kg. capacity.

1.2.2 Trolley Mounted:

Trolley mounted extinguishers are larger versions of the portable extinguishers. Basically the operation of trolley mounted carbon dioxide extinguishers and portable carbon dioxide extinguishers are similar. Since the weight of the cylinder becomes heavy, these cannot be transported by hand and therefore require to be put on trolleys. The 6.8, 9 & 22.5 Kg. carbon dioxide cylinders are trolley mounted.

1.2.3 Tender:

A carbon dioxide tender is one with a large quantity of carbon dioxide. The typical tender has 16 carbon dioxide cylinders of 45.0 Kg. capacity each.

1.2.4 Fixed Carbon Dioxide Fire Extinguishing Systems:

The fixed carbon dioxide fire extinguished systems are of two types:

i) Local Application Installation:

It consists of a fixed supply of carbon dioxide, normally connected to a fixed network of pipes, nozzles and discharge horns arranged to discharge the gas directly on the surface or object on which fire is anticipated.

ii) Total Flooding Installation:

It consists of fixed supply of carbon dioxide normally connected to a fixed network of pipe, nozzles and discharge horns arranged to evenly distribute sufficient quantity of the gas throughout the enclosure(s) and capable of extinguishing fire within the enclosure(s) regardless of location of fire.

2.0 DESIGN

2.1 PORTABLE & TROLLEY MOUNTED

The portable and trolley mounted carbon dioxide extinguisher cylinders shall be designed as per Code IS:7285-1988.

2.2 FIXED CARBON DIOXIDE FIRE EXTINGUISHING SYSTEM

The thickness for distribution piping for fixed carbon dioxide fire extinguishing system shall be suitably calculated. The internal storage pressure for this calculation shall not be less than the following:

For 60 Kg/cm2g charging pressure, an internal pressure of 70 Kg/cm2g at 27 deg. C.

If higher storage temperatures are approved for a given system, the internal pressure at maximum temperature.

3.0 MATERIAL OF CONSTRUCTION

3.1.1 Materials for Portable & Trolley Mounted Carbon Dioxide Extinguishers

i.	Shell	:	IS:7285 - 1988.
II.	Discharge valve	:	IS:3224 - 1979.
iii.	Safety device	:	IS:5903 - 1970.
iv.	Syphon tube	:	IS:407 Alloy 2 for Brass IS: 1545 for Copper IS: 738 for Aluminium
v.	Hose	:	Wire braided rubber hose.
vi.	Discharge horn	:	Non-metallic such as fibre glass, polyethylene etc.

3.1.2 Materials for Fixed Carbon Dioxide Fire Extinguishing System

i. Cylinders: As per IS:7285 - 1988.

ii. Piping :Piping shall be of non combustible material having physical and chemical characteristics, such that its integrity under stress can be predicted with reliability. Special corrosion resistant materials or coatings may be required in severely corrosive atmosphere. Black or galvanised steel pipe shall be either ASTM A 106 or API 5L Cast iron and non metallic pipe shall not be used.

iii. Fittings : Class 150 and cast iron fittings shall not be used. All fittings shall be forged conforming to ASTMA-105 and rating of fittings shall be of minimum class 1500 for a charged pressure of 60 Kg/sq.cm.

iv. Connecting hoses: Flexible hoses used shall be double wire braided rubber covered hose. However, it is preferred that all connecting hoses and its fittings shall be metallic only.

v. Copper Tubing: Copper tubing in this system shall meet the requirements of Code IS:2501 - 1972.

vi. Nozzles: Leaded tin bronze to IS: 318.

4.0 CONSTRUCTION

4.1 CYLINDER FABRICATION AND DIMENSIONS

Cylinders shall be made strictly as per Code IS:7285 from hot or cold drawn seamless tube, rolled or extruded.

Fabrication/jointing by welding shall not be acceptable. Any attempt at welding for joining and/or rectification will call for rejection of the cylinder.

The shape of the body shall be cylindrical with the difference between maximum and minimum external dia shall not exceed 2% of the nominal internal dia.

The filling ratio of CO2 shall not exceed 0.667. The filling ratio shall be determined as the ratio of mass of CO2 in container to the mass of water required to fill the container at 15 deg. C.

4.2 PAINTING

The extinguisher shall be painted externally with suitable primer followed by synthetic enamel paint of fire red conforming to shade no. 536 of IS:5 and the paint shall conform to IS:2932.

4.3 HOSES

4.3.1 Portable & Trolley Mounted Extinguishers

Hoses for portable and trolley mounted cylinders shall be wire braided rubber hose having a minimum bursting pressure of 275 Kg/cm2g in controlled discharge and 140 Kg/cm2g in un-controlled discharge system.

4.3.2 Fixed Systems

Connecting hoses shall be either wire braided rubber hose or metallic hose with a minimum burst pressure of 420 Kg/cm2.

4.4 DISCHARGE FITTINGS/HEADS/ VALVES

4.4.1 Portable & Trolley Mounted Extinguishers

A discharge tube shall be provided to 2 & 3 Kg. capacity extinguishers fitted to discharge valve by swivel joints.

A hose of not less than 10 mm diameter shall be provided for 4.5, 6.8, 9 and 22.5 Kg. capacity fire extinguishers. The length of the hose shall be not less than 1 m for 4.5 & 6.8 Kg., 2 m for 9 Kg. and 5 m for 22.5 Kg capacity fire extinguishers respectively.

4.4.2 Fixed Carbon Dioxide Fire Extinguishing System

All valves under constant high pressure shall have a minimum bursting pressure of 420 Kg/cm2 and those not under constant pressure shall have a minimum bursting pressure of 350 Kg/cm2 g.

Design nozzle discharge pressure shall not be less than 20.6 Kg/cm2 g.

All pipes and fittings, including manifold, shall have a minimum bursting pressure of 350 Kg/cm2 g.

The complete distribution system shall be free from leakage when tested at a pneumatic pressure of 140 Kg/cm2 g with nozzle outlets closed.

All pipe sections having dead ends shall be fitted with suitable pressure relief devices designed to operate between 168 and 210 Kg/cm2.

Nozzles used in the system shall be capable of withstanding a minimum shut off pressure of 140 Kg/cm2 g.

The discharge header shall be provided with suitable flushing arrangement to ensure easy elimination of foreign material, which can clog the spray nozzles.

The complete distribution system shall be generally made as per IS: 6382 - 1984.

5.0 PERFORMANCE CHARACTERISTICS

The performance characteristics for each size of the extinguisher shall be as shown below:

Nominal size of Extinguisher (Kg.)	Discharge Time (Sec.) Min.	Max.
2	8	18
3	10	20
4.5	10	24
6.8	10	30
9	12	36
22.5	20	60

6.0 INSPECTION & TESTING OF NEW EXTINGUISHERS & INSTALLATIONS

6.1 PORTABLE/TROLLEY MOUNTED EXTINGUISHER

6.1.1 Shell & Attachments

i. Material Identification

Material used for the cylinder shell shall be identified and if required tested to ensure conformity with manufacturing standard. Raw material/bought out material for other components shall also be identified.

ii. Fabrication

The following checks shall be carried out:

a. Review and approval of process of manufacturing.

b. Ensuring that no welding has been carried out.

c. Inspection prior to closing in operation.

d. Inspection of surface defects and removal by grinding, if any.

e. Thickness measurements to confirm for minimum agreed finished thickness.

iii. Testing

The following tests shall be carried out after completion of extinguisher cylinder:

a. Visual

The internal and external surfaces of the cylinder shall be inspected. Surface defects of more than 5% of the shell thickness shall be ground off and the final thickness at that area shall be not less than the calculated minimum wall thickness plus corrosion allowance.

b. Dye Penetrant Inspection

Dye Penetrant examination shall be carried out on all the formed and knuckled areas.

c. Hydrostatic Stretch Test

Each finished cylinder shall be subjected to hydrostatic stretch test at a pressure of 250 Kg/cm2g. Permanent stretch suffered by the cylinder shall not exceed the following limits:

1. In case of cylinders below 20 litre water capacity - 10% of the total stretch suffered during the test, and,

2. In other cases - 10% of the total stretch suffered during the test or 1/5,000 of the original volume of the cylinder whichever is less.

d. Pneumatic Test

Cylinders, which have passed hydrostatic stretch test, shall be subjected to a pneumatic test pressure equal to 60% of the test pressure and shall show no signs of leak.

e. Leakage Test

The extinguisher without its attachment shall be shelved for 7 days after filling and shall be checked/weighed at the end of the period. There shall be no loss of mass.

f. Bursting Test of Prototype Cylinders

One cylinder of the first batch which has been earlier successfully tested hydrostatically shall be subjected to hydrostatic pressure till it bursts.

The nominal hoop stress corresponding to the pressure at which destruction occurs shall be calculated and this value shall not be less than 0.95 of the minimum specified tensile strength of the material of the cylinder. The cylinder shall burst without fragmentation.

g. Coating & Painting

The thickness of external paint shall be 100 microns minimum.

6.1.2 Hose

A sample discharge hose with length of not less than 300 mm shall be tested upto bursting which shall not be less than 275 Kg/cm2 when there is controlled discharge and 140 Kg/cm2 when there is no controlled discharge at nozzle. Actual burst pressure of the hose shall be recorded.

Bursting pressure of hose used in tender shall be minimum 350 Kg/cm2.

6.1.3 Repairs

Any extinguisher, which fails in hydrostatic test, shall be re-offered for inspection. If the failure is in the parent metal then the extinguisher shall be rejected.

6.2 FIXED CARBON DIOXIDE FIRE EXTINGUISHER SYSTEM

6.2.1 Cylinders

Refer 6.1.1 of this section.

6.2.2 Piping & Fitting

i. Material Identification

Piping & fitting materials shall be identified and if required tested to ensure conformity with manufacturing standards.

ii. Fabrication

The following checks shall be carried out prior to and during welding:

a. Review and approval of welding procedure.

b. Qualification of the welding procedure and welders.

c. Inspection of edge preparation and joint fit up.

d. Ensuring that during welding only approved procedure and approved electrodes are being used.

iii. Testing

a. Radiography

Spot radiography of minimum 10 % of the welds of pipes shall be carried out.

b. Hydrostatic Test

The system shall be hydrostatically tested to the required test pressure.

c. Pneumatic Test

The complete distribution system shall be free from leakage when tested at a pneumatic pressure of 140 Kg/cm2g.

6.2.3 Safety Valves

Safety devices shall be tested at the required pressure.

6.2.4 Hose

A sample discharge hose shall be tested upto bursting pressure, which shall not be less than that specified. Actual burst pressure of the hose shall be recorded.

6.2.5 Repairs

Suitable weld repairs shall be carried out as necessary.

7.0 PERIODIC INSPECTION OF EXTINGUISHERS

7.1 LIKELY LOCATION OF DETERIORATION

7.1.1 Corrosion

The external side of the extinguishers, support, valves and discharge nozzles are prone to atmospheric corrosion.

7.1.2 Damage/Deterioration

i. Shell

Shell may be damaged due to improper handling. Dents/ deformations may occur.

ii. Neck Joint

The thread joint between cap and neck is prone to damage/wear/ deterioration.

iii. Nozzle

The nozzle may be eroded due to frequent use of extinguishers.

iv. Hose

The hose is prone to ageing.

v. Discharge Nozzle

Discharge nozzle may be clogged due to foreign material.

vi. Piping systems are prone to external corrosion/thinning.

vii. Valves used in the system may fail/get jammed.

7.2 FREQUENCY AND PROCEDURE FOR PERIODIC INSPECTION

The extinguisher and its components shall be inspected at frequencies specified and as per procedure given below:

7.2.1 Portable Extinguishers

i. Body of Cylinder

a. Visual Inspection

The shell of the extinguisher shall be visually inspected externally once a month to check for any mechanical damage or corrosion. Special attention shall be given to surface below clamping rings.

b. Hydrostatic Test

A hydrostatic test of the cylinder shell along with assembly shall be done before every refilling or once in 5 years as per IS-2190 whichever is earlier.

Ultrasonic thickness inspection of shell shall be carried out during each hydrotest.

c. Painting

The painting shall be checked for damage/ deterioration once in three months. The coating thickness shall be checked once in 3 years.

d. Refilling

Loss in weight of cylinder shall be checked once in three months. Refilling shall be done if loss in weight is more than 10%.

ii. Other Components

The following components shall be visually inspected once every three months.

a. Nozzle & Discharge Fittings

The nozzle and other fittings shall be checked for erosion etc. during refilling.

b. Trolley

Trolley shall be checked for proper functioning.

iii. Hose

The hose condition shall be checked visually once in three months. The hose on the portable extinguishers shall be replaced within three years.

iv. Gas Cylinder

The weight shall be checked & recorded.

v. Safety Valve

The safety valve shall be overhauled & reset during refilling or after 5 years whichever is earlier.

7.2.2 FIXED CARBON DIOXIDE FIRE EXTINGUISHER SYSTEM

i. Body of the Cylinder

a. Visual Inspection

The shell shall be visually inspected externally once a month to check for any mechanical damage or corrosion.

b. Ultrasonic Inspection

Ultrasonic thickness measurements of the shell shall be carried out once every three years and readings shall be recorded.

c. Hydrostatic test

The cylinder shall be hydrotested at 210 Kg/cm2 when the cylinder is sent for refilling or once in 5 years as per IS-2190 whichever is earlier.

d. Painting

The external painting shall be visually checked for damage/ deterioration once in three months. The coating thickness shall be checked once every three years.

e. Refilling

Loss in weight of cylinders shall be checked once in three months. Refilling shall be done if loss in weight is more than 10%.

ii) Other Components

The following components shall be visually inspected once a month.

a. Piping

Piping shall be inspected for evidence of corrosion. Thickness shall be gauged every three years.

b. Pipe Hangers/Straps

Pipe hangers/straps shall be examined to check that the pipe is securely supported. Surfaces underneath pipe supports shall be checked once every three years to check for corrosion.

c. Nozzle

Nozzles shall be checked to determine that the orifices are clear and unobstructed. When nozzle seals are provided, they shall be checked for signs of deterioration and replaced if necessary. Nozzles shall be checked for proper position and alignment.

d. Container Bracketing/Supports

Bracketing/supports shall be checked to determine that their condition is satisfactory.

iii. Hose

The condition of hose shall be checked visually once in three months. The hose shall be hydrostatically tested every three years and replaced within 6 years.

iv. Safety Valve

The safety valve shall be overhauled & reset once in a year. Visual inspection shall be done once in three months.

v. Copper Tubing

Copper tubing shall be inspected visually every three months for corrosion/damage visually.

vi. All Systems

All systems shall be thoroughly inspected and tested for proper operation by competent personnel annually.

8.0 MARKING AND DOCUMENTATION

8.1 MARKING

8.1.1 Marking On New Cylinders

All Carbon Dioxide cylinders shall be permanently punched with the following:

i. Manufacturer's name & identification number

ii. IS-2878.

iii. Carbon Dioxide.

iv. Working pressure, test pressure and the date of hydrostatic stretch test.

v. Gross, tare and net weight in Kgs. and water capacity in litres.

v. Nature of heat treatment.

All the markings (except the manufacturers marking which may be on the base) shall be punched on the neck of the cylinder.

8.1.2 Marking on the Valve

Valve fitted to the cylinder shall be clearly and durably marked in accordance with the following provision by stamping, engraving or similar process.

i. The specification of the valve.

ii. Year and quarter of manufacturing.

iii. Manufacture symbol

iv. Working pressure.

v. The name or chemical symbol of the gas for which the valve is to be used (in our case CO2)

vi. The type of screw thread on the outlet, namely left hand (LH) or right hand (RH).

vii. Inspector's stamp.

8.2 DOCUMENTATION

8.2.1 New Extinguishers/Installation

The manufacturer shall furnish test certificates giving the following information:

i. Certificate number and date.

ii. Size, type and capacity.

iii. Materials used for construction.

iv. Hydrostatic test pressure.

v. Any other test as stipulated in Code/OISD Std

vi. Records of non-destructive tests carried out.

vii. Relief valve testing, if any.

viii. Painting details.

ix. Identification marking as per relevant Code.

8.2.2 Installed Extinguishers/ Installations

In addition to the required tag or labels a permanent tag record shall be kept for each extinguisher/ installation. The record shall include the following information as applicable.

i. Identification number.

ii. Date of manufacture.

iii. Name of manufacturer.

iv. Capacity of extinguisher.

v. Location at which the extinguisher is installed.

vi. Date of installing the equipment.

vii. The inspection date and name of the person or agency performing the inspection.

viii. The date when last recharged and name of the person or agency performing the charge.

ix. The hydrostatic test date and name of the person or agency performing the test.

x. Next hydrotest date.

xi. Inspection observations and maintenance carried out.

9.0 CONDEMNING OF CYLINDERS

Carbon Dioxide cylinder may be condemned when it leaks, or when internal or external corrosion, denting, bulging or evidence of rough usage exists to the extent that the cylinder appears to be weakened appreciably.

Any cylinder which fails to pass the periodic examination or test or which loses in its tare weight by over 5% or which for any other defect is found to be unsafe for use shall be destroyed by flattening it as a whole or after being cut into pieces in such a manner that the pieces cannot again be joined together by welding or otherwise to form a cylinder.

All markings on the cylinder shall be defaced before it is destroyed. History sheets of such cylinders shall be closed and kept for one year. Reports of the details of such closed history cards shall be sent to the Chief Controller or Explosives, in writing, on the 1st of January, April, July and October every year.

10.0 REFERENCES

1. ASTM A-53, A-106, API 5L : Specifications for seamless /ERW mild steel pipes.
2. IS: 1239-Specifications for mild steel tubes, tubular & other wrought steel fittings
3. IS: 6382- Code of Practice for design & installation of fixed carbondioxide fire system.
4. IS: 7285- Specification for seamless manganese steel cylinders for high pressure gases.
5. IS: 3224- Specification for valve fittings for compressed gas cylinders excluding LPG.
6. IS: 5903- Recommendation for safety devices for gas cylinders.
7. IS: 2190- Code of Practice for selection, installation & maintenance of first-aid fire extinguishers
8. IS-2878- Specifications for portable fire extinguisher, carbon dioxide type.
9. IS-307 - Carbon-dioxide gas

SECTION - IV

HALON FIRE EXTINGUISHING SYSTEM

1.0 DEFINITION AND TYPES :

1.1 DEFINITION:

1.1.1. Halon:

The extinguishers and the extinguishing system which employs Halon stored in a pressure container for extinguishing fires.

1.1.2 Normally Occupied Area:

One which is intended for occupancy.

1.2 TYPES OF HALON EXTINGUISHING SYSTEMS:

1.2.1 Portable:

Portable extinguishers have capacities of 1.25, 2.5, 4.0, 5.0, and 6.5 Kg of Halon with a max gross wt of 23 Kg. Halon 1301 is not to be filled in portable extinguishers.

1.2.2 Total Flooding System:

In this system, Halon is arranged to discharge into and fill to the proper concentration in an enclosed space or enclosure.

1.2.3 Local Application System:

In Local Application System, a supply of Halon is arranged to discharge directly on the burning material.

2.0 DESIGN:

i) Portable

The Portable Halon cylinders shall be designed as pressure vessel to Code IS 2825.

ii) Total Flooding and Local Application Systems:

The thickness for distribution piping for total Flooding and Local Application Systems shall be calculated in accordance with relevant Code. The internal storage pressure for this calculation shall not be less than the following:

For 25 kg/sq.cm (360 psig) charging pressure, an internal pressure of 43 kg/sq.cm (620 psi) at 55 deg C.

For 42 kg/sq.cm (600 psig) charging pressure, an internal pressure of 70 kg/sq.cm (1000 psi) at 55 deg C.

If higher storage temperatures are approved for a given system, the internal pressure at maximum temp.

2.1 MATERIALS OF CONSTRUCTION :

2.1.1 Materials for Portable Halon Cylinders:

The material of various parts of Halon cylinder shall be as given below:

i. Shell : IS: 513 Grades or DD IS: 6240

ii. Neck Ring: IS: 2062, IS: 1875,
IS: 7283, IS: 9550.

iii. a. Valve Body: Leaded Tin Bronze Grade LTB-2 of IS : 318

b. Nozzle: Extruded Brass Section Grade I of IS: 291.

iv. Spring :IS: 4454 (Part I) Grade I.

v. Piercer/Spindle : IS: 6528.

vi. Siphon Tube : Brass Copper, Alloy No: 2 of IS: 407 or IS: 1545.

vii. a. Sealing Nuts: Extruded Brass Section of

b. Piercer disc: Grade I of IS : 291
or

c Discharge: Fitting Type I of IS : 319.

viii. Washer : Rubber of IS: 937.

ix. Sealing Disc : Copper of IS: 1972.

2.1.2 Materials for Total Flooding and Local Application Systems:

i. CYLINDERS:

Fire extinguisher manufacturers are presently using CO2 cylinders for filling Halon with the approval of Chief Controller of Explosives, India. Refer CO2 Fire Extinguishing System Section for material of Cylinders.

ii. PIPING:

Piping shall be of non-combustible material having physical and chemical characteristics, such that its integrity under stress can be predicted with reliability. Special corrosion resistant materials like Cupro-nickels or coatings may be required in severely corrosive atmosphere. Black or galvanised steel pipe shall be either ASTM A 53, 106, API 5L or IS 1239. Cast iron and non-metallic pipe shall not be used.

iii. FITTINGS:

Class 150 and Cast iron fittings shall not be used. All fittings shall be forged conforming to ASTM A 105 and rating of fittings shall be as given below

Charged Pressure Fitting Rating (Min)

25 kg/sq.cm (360 psi) Class 600

42 kg/sq.cm (600 psi) Class 1200

iv. CONNECTING HOSES:

All connecting hose and its fittings shall be metallic only. Non metallic hoses and fittings shall not be used.

v. COPPER TUBING:

Copper tubing in this system shall meet the requirements of IS-2501.

3.0 CONSTRUCTION:

3.1 CYLINDER FABRICATION:

i) The fabrication of portable cylinder body shall be by welding.
ii) All welding shall be carried out as per agreed welding procedure, using qualified welders.

iii) The weld joint design for the circumferential seam for portable cylinder shall be of square edge butt type for plate thickness 3.0 mm and less and single V butt for thickness higher than 3.0 mm.

iv) All welding shall be carried out using Shielded Metal Arc Welding or Gas Tungsten Arc Welding Process only. The electrode for welding shall conform to AWS / ASME / IS classification. The electrode diameter shall not be more than 2.5 mm for SMAW and 1.6 mm for GTAW while welding portable cylinders.

v) All welds shall be full penetration welds.

vi) There shall not be any longitudinal seam in the portable cylinders and the number of circumferential seams shall not be greater than two.

vii) Joints shall be radiographed to IS-2825

3.2 CYLINDER DIMENSION:

The shape of the body shall be cylindrical and filling ratio shall not be more than 75% by volume.

3.3 COATING:

On all internal and external surfaces of body of the portable cylinders, either of the following anticorrosive treatment shall be applied and thickness of coating shall be measured as given in IS: 3203.

i. Lead tin alloy (tin not less than 10%) shall be applied by hot dipping process or by electrical process, thickness not less than 0.012 mm.

ii. Copper coating by suitable process, thickness not less than 0.005 mm.

3.4 PAINTING:

The extinguisher shall be painted externally with suitable primer followed by synthetic enamel paint of fire red conforming to shade No: 536 of IS: 5 and the paint shall conform to IS: 2932.

3.5 SAFETY SYSTEM:

In a portable extinguisher with a spring loaded piercing device, the safety clip shall be provided for prevention of accidental operation of piercing mechanism and discharge of contents.

In squeeze grip valve assembly, the safety pin shall be provided for prevention of accidental operation which shall be fitted on cantilever hinged grip lever through valve body.

3.6 HOSE:

Hoses for portable cylinders of 4.0, 5.0 and 6.5 kg capacity shall be braided hose having a bursting pressure of not less than 5 MN/m2 (50 kgf/cm2). It shall have a nominal bore of 10 mm and a length of not less than 300 mm.

3.7 DISCHARGE FITTINGS:

The discharge nozzle of the portable cylinder shall be screwed to valve body/hose or it can be an integral part of valve body. The design of the nozzle and area of the orifice shall be such that it satisfies the performance requirements given in 4.0 of this Standard.

3.8 PRESSURE INDICATOR:

Pressure indicator shall be fitted to the extinguisher to indicate its internal pressure. The indicator shall be marked suitably with pressure at which the extinguisher shall be charged and also indicate when it is wholly or partially released.

4.0 PERFORMANCE CHARCTERISTIC:

The performance characteristics for each size of extinguisher shall be as given below:

Capacity of extinguisher (kg)	Min period for which throw of jet will be maintained (second)	Max period to discharge 95% of contents (second)	Range of throw of jet (not less than) (meter)
1.25	8	14	2
2.50	8	16	2
4.00	10	20	3
5.00	12	24	4
6.50	14	28	4

5.0 INSPECTION AND TESTING OF NEW EXTINGUISHERS AND INSTALLATIONS DURING CONSTRUCTION:

5.1 PORTABLE EXTINGUISHER:

5.1.1 Shell and Attachments:

i. Material Identification:

Material used for cylinder shell shall be identified and if required tested to ensure conformity with manufacturing standard. Raw material / bought out material for other components shall also be identified.

ii. Fabrication:

The following checks shall be carried out prior to and during welding:

a. Review and approval of welding procedure,

b. Qualification of the welding procedure and welders,

c. Inspection of edge preparation and joint fit-up,

iii. Testing:

The following tests shall be carried out after completion of welding:

a. Dye Penetrant Inspection:

Dye Penetrant examination shall be carried out on fillet welds of all nozzles and attachments.

b. Radiography:

All welds of cylinders shall be 100% radiographed. Interpretations of radiography shall be as per IS: 2825.

C. Hydrostatic Test:

The extinguisher having 1.25 kg capacity shall be hydrostatically tested at an internal pressure of 2.5 MN/M2 (25 kgf/cm2) for a period of 60 seconds. The test shall not reveal any leakage or visible distortion.

For higher capacities, it shall be tested at 3 MN/M2 (30 kgf/cm2) for a period of 60 seconds.

The test shall be carried out before the extinguishers are painted and after heat treatment, if any.

d. Leakage Test:

The fire extinguisher after being covered by a inverted glass transparent jar shall be dipped in suitable water tank filled with water for 24 hours, the level of which is sufficiently higher than the height of fire extinguisher. There shall not be any collection of even a single bubble on the inside top of the inverted glass after a lapse of 24 hours. The airbubble collected in first 6 hours shall be neglected.

e. Drop Test:

This test shall be done as per IS: 11108.

f. Ultimate Failure Test:

On a prototype test, Mechanical failure shall not occur at a pressure less than 40kgf/cm2 g.

g. Coating And Painting:

The thickness of anti corrosion coating shall be 25 microns min and that of external paint shall be 75 microns minimum.

5.1.2 Hose:

A sample discharge hose with nominal bore of 10 mm and a length of not less than 300 mm shall be tested upto bursting which shall not be less than 50 kg/cm^2 g. Actual burst pressure of the hose shall be recorded.

5.1.3 Pressure Indicator:

Ensure that the pressure indicator as in 3.8 of this Section is fitted to the extinguisher.

5.1.4 Repairs:

i. Any repairs to welding shall be carried out as per IS: 2825. Only one time repair shall be allowed.
ii. Any extinguisher which fails in hydrostatic test shall be reoffered for inspection. If the failure is in the parent metal then the extinguisher shall be rejected.

The weld failure shall be suitably repaired as per IS : 2825 and reinspected /tested.

5.2 TOTAL FLOODING AND LOCAL APPLICATION SYSTEMS:

5.2.1 CYLINDERS:

These are generally made using CO2 cylinders with the approval of Chief Controller of Explosives; CO2 Fire Extinguishing System Section may be referred for inspection etc. A halon cylinder of 75 kg capacity is tested to a pressure of 124 bars.

5.2.2 Piping and Fitting:

i. Material Identification:

Piping and fitting materials shall be identified and if required tested to ensure conformity with manufacturing standards.

ii. Fabrication:

The following checks shall be carried out prior to and during welding:

a. Review and approval of welding procedure.

b. Qualification of the welding procedure and welders.

c. Inspection of edge preparation and joint fit up.

d. Ensuring that during welding only approved procedure and approved electrodes are being used.

iii. Testing:

a. Radiography :

Spot radiography of the welds of pipes shall be carried out.

b. Hydrostatic Test:

The system shall be hydrostatically tested to the test pressure recommended by designer/vendor of the system.

5.2.3 Safety Valves:

Safety devices shall be tested at the required pressure.

5.2.4 Hose:

A sample discharge hose shall be tested upto bursting pressure, which shall not be less than 100 kg/cm2. Actual burst pressure of the hose shall be recorded.

5.2.5 Repairs:

Any piping system, which fails in hydrostatic test, shall be reoffered for inspection. The weld failure shall be suitably repaired and reinspected /tested.

6.0 PERIODIC INSPECTION OF EXTINGUISHERS:

6.1 LIKELY LOCATION OF DETERIORATION:

6.1.1. Corrosion:

The external side of the extinguishers, support, valves and discharge nozzles are prone to atmospheric corrosion.

6.1.2. Damage / Deterioration:

i) Shell:

Shell may be damaged due to improper handling. Dents/ deformations may occur.

ii) Neck Ring:

Neck rings are prone to breakage at weld joint.

iii) Neck Joint:

The thread joint between cap and neck is prone to damage/wear/deterioration.

iv) Nozzle:

The nozzle may be eroded due to frequent use of extinguishers.

v) Spring:

The spring is prone to lose its stiffness.

vi) Hose:

The hose is prone to ageing.

vii) Discharge Nozzle:

Discharge nozzle may be clogged due to foreign material.

6.2 FREQUENCY AND PROCEDURE FOR INSPECTION:

The extinguisher and its components shall be inspected at frequencies specified and as per procedure given below.

6.2.1 Portable Extinguishers:

i. Body of cylinder:

a. Visual Inspection:

The shell of the extinguisher shall be visually inspected externally once a month to check for any mechanical damage or corrosion.

b. Hydrostatic Test:

A hydrostatic test of the cylinder shell along with assembly shall be done before every refilling or once in 5 years whichever is earlier. Ultrasonic thickness inspection of shell shall be carried out during each hydrotest.

c. Painting:

The painting shall be checked for damage/deterioration once in three months.

d. Rejection Limit:

A Halon extinguisher shall be removed from service and destroyed when the following condition exists:

1. When the cylinder is corroded or damaged to such an extent that repairs by welding, brazing or by use of patch work is required.

2. When the cylinder or shell threads are damaged.

3. When the cylinder has been exposed to high temperature due to proximity of fire.

ii. Other Components:

The following components shall be visually inspected once every three months.

a. Neck Ring:

The soundness of the brazing/welding of the neck ring to the shell shall be checked.

b. Spring:

The spring shall be inspected for corrosion.

c. Nozzle and Discharge Fitting:

The nozzle and other fittings shall be checked for erosion.

d. Squeeze Grip Valve:

The squeeze grip valve shall be checked for damage.

iii. Hose:
The hose condition shall be checked visually once in three months. The hose on the portable extinguishers shall be replaced within three years.

iv. Pressure Indicator:

Pressure indicator shall be inspected every three months visually and calibrated at the time of recharging.

6.2.2 Total Flooding and Local Application Systems:

i. Body of the Cylinder

a. Visual Inspection:

The shell shall be visually inspected externally once every three months to check for any mechanical damage or corrosion.

b. Ultrasonic Inspection:

Ultrasonic thickness measurements of the shell shall be carried out once every three years and readings shall be recorded.

c. Hydrostatic Test:

The cylinder shall be hydrotested when the cylinder is sent for refilling or as per statutory requirements whichever is earlier.

d. Painting:

The external painting shall be checked for damage/deterioration once in three months. The coating thickness shall be checked once every three years.

ii. Other Components:

The following components shall be visually inspected once every six months.

a. Piping:

Piping shall be inspected for evidence of corrosion. Thickness shall be gauged every three years.

b. Pipe Hangers /Straps:

Pipe hangers/straps shall be examined to check that the pipe is securely supported.

c. Nozzle:

Nozzles shall be checked to determine that the orifices are clear and unobstructed. Where nozzle seals are provided they shall be checked for signs of deterioration and replaced if necessary. Nozzles shall be checked for proper position and alignment.

d. Container Bracketing /Supports:

Bracketing/ supports shall be checked to determine that their condition is satisfactory.

iii. Hose:

The condition of hose shall be checked visually once in three months. The hose shall be hydrostatically tested every three years and replaced within 6 years.

iv. Safety Valve:

The safety valve shall be visually inspected for damage once every three months and same shall be bench tested annually.

v. Pressure Indicator:

Pressure indicator shall be inspected visually every three months for corrosion/damage visually.

vi. Copper Tubing:

Copper tubing shall be inspected visually every three months for corrosion/ damage visually.

vii. All Systems:

All systems shall be thoroughly inspected and tested for proper operation by competent personnel annually.

7.0 MARKING & DOCUMENTATION:

7.1 NEW EXTINGUISHERS / INSTALLATION:

The manufacturer shall furnish test certificates giving the following information:

i) Certificate number and date.

ii) Size, type and capacity.

iii) Materials used for construction.

iv) Hydrostatic test pressure.

v) Relief valve testing, if any.

vi) Painting details.

vii) Identification marking as per relevant code.

7.2 INSTALLED EXTINGUISHERS / INSTALLATIONS:

In addition to the required tag or labels, a permanent tag record shall be kept for each extinguisher/ installation. The record shall include the following information as applicable.

i) Identification number

ii) Date of manufacture

iii) Name of manufacturer

iv) Capacity of extinguisher

v) Location at which the extinguisher is installed

vi) Date of installing the equipment

vii) The inspection date and name of the person or agency performing the inspection

viii) The pressure test record

ix) The date when last recharged and the name of the person or agency performing the charge

x) The hydrostatic test date and the name of the person or agency performing the test

xi) Next hydrotest date

xii) Inspection observations and maintenance carried out

8.0 REFERENCE S:

1) IS: 11108 Specification for Portable Fire Extinguishers - Halon 1211 Type.

2) IS: 2825 Code for Unfired Pressure Vessels.

3) NFPA : 12 A- Halon 1301 Fire Extinguishing Systems; 12 B- Halon 1211 Fire Extinguishing Systems

4) ASTM A 53, A106- Mild steel piping specifications

5) API 5L- Mild steel piping specifications

6) IS : 1239- Specifications for mild steel tubes, tubulars and other wrought steel fittings

NOTE: Serious concern has recently been expressed regarding depletion of stratospheric ozone layer by halon. The ozone layer acts as a protective barrier shielding the earth from harmful effects of solar ultraviolet radiations. While search for an “ideal substitute” for halons is continuing, it has been decided to completely stop indigenous production of halons in India by 2010 consistent with Montreal Protocol. Steps have also been initiated to reduce release of halons to atmosphere by actions like discontinuing discharge of halons from extinguishers/systems during their maintenance & testing, arranging recovery of halons from discarded halon extinguishers etc.

SECTION - V

FOAM FIRE EXTINGUISHING SYSTEM

1.0 DEFINITION & TYPES OF EXTINGUISHERS

1.1. DEFINITION

A system consisting of water supply, foam supply, proportionating equipment, foam makers, discharge devices and other allied equipment for the purpose of adequately distributing foam over a hazard is called a Foam Fire Extinguishing System.

1.2 TYPES

1.2.1 Portable

The type in which the foam producing equipment, materials, hose etc are transported by hand. The total liquid capacity of the inner and outer containers when filled to the specified level shall be 9 liters.

1.2.2 Foam Fire Engine/Trolley Mounted Foam Extinguisher

The capacity of a foam fire engine is more when compared to a portable fire extinguisher and it is mounted on wheels. The fire engines are of 50 lit and 150 lit capacity. The difference between a portable foam extinguisher and a fire engine is only in respect of its capacity.

1.2.3 Mobile

This includes any foam producing unit with capacity more than 150 litres which is mounted on wheels and which may be self propelled or towed by a vehicle. These units may be connected to a suitable water supply or may utilise a pre mixed foam solution.

1.2.4 Semi Fixed Systems

i. The type in which the system is equipped with fixed discharge outlets connected to piping, which terminates at a safe distance. The fixed piping installations may or may not include a foam maker. Necessary foam producing materials are transported to the location after the fire starts and are connected to the piping.

ii. The type in which foam solutions are pumped through the area from a central foam station, the solution being delivered through hose lines to portable foammakers such as monitors, foam towers etc.

1.2.5 Fixed Systems

These are complete installations piped from a central foam station, discharging through fixed delivery outlets, to the hazard to be protected. Any required pumps are permanently installed.

2.0 DESIGN

2.1 PORTABLE

The portable foam type fire extinguishers shall be designed and constructed as per code IS: 933, 934, 10204.

2.2 FOAM FIRE ENGINE/TROLLEY MOUNTED FOAM EXTINGUISHER

The 50 lit capacity foam type fire engine shall be designed and constructed as per code IS: 5507. The 150 lit capacity foam type fire engine shall be constructed as per code IS: 10474.

2.3 MOBILE

The foam trailor with a foam tank of capacity 500 lit. and above, mounted on trailor chassis and having a water-cum-foam monitor on the trailor, the system to be made as per user's requirements.

2.4 SEMI FIXED SYSTEM

The sizes for discharge outlets and connected piping for semi fixed foam fire extinguishing system shall be calculated in accordance with requirements specified in OISD-116.

2.5 FIXED SYSTEM

Since none of the Indian Refineries have fixed foam fire extinguishing system, it is not covered in this Standard.

3.0 MATERIAL OF CONSTRUCTION

3.1.1 Material for Portable Chemical Foam Extinguishers

i. Shell : IS : 513 Grade D.

ii. Inner Container: IS 410 - Cu Zn 37 alloy or Polyethylene to IS : 7328.

iii. Syphon Tube : IS: 513 Grade

iv. Neck Ring : Leaded Tin Bronze conforming to Grab 2 of IS : 318.

v. Cap : —do—-

vi. Seating Valve : —do—-

vii. Plunger rod for Double seal : —do—

viii. Nozzle : —do—-

ix. Plunger for : Extruded Brass Single Seal conforming to Grade 2 of IS: 291 or Type 1of IS : 319.

x. Nozzle : —do—-

xi. Cap Joint Washer: Natural rubber free from impurities and acid and alkaline resistant or Buffalo leather to IS: 581.

3.1.2 Materials for Portable Mechanical Foam Extinguishers

i. Shell : MS GR D, IS: 513 - 1973
ii. Syphon Tube : Brass Alloy No.2, IS: 407 -1966
iii. Neck Ring : LTB 2, IS: 318 - 1962
iv. Cap : LTB 2, IS: 318 - 1962
v. Nozzle : LTB 2, IS: 318 - 1962
vi. Plunger : Brass GR 2, IS: 291 1961
vii. Washer : Rubber, Type 1A, IS: 5382 - 1969
viii. Spring : GR I, IS: 4454 (Part 1) - 1975 shall be treated for corrosion resistance
ix. Piercer : 04 GR 13, IS: 6528 - 1972
x. Hose : Shall withstand Bursting PR of 50 Kg/CM2
xi. Gas Cartridge : IS 4947 - 1977 with anticorrosive coating.

3.1.3 Materials for Foam Fire Engines/Trolley Mounted Foam Extinguisher

i. Shell : IS: 2002/2062 or SS410S

ii. Inner Container: IS: 513 Grade O or Cu Zn alloy to IS:410.

iii. Neck Ring : Leaded Tin Bronze of Gr.2 of IS:318

iv. Cap : Extruded Brass Conforming to Grade 1 of IS : 291 or Type 1 of IS : 319.
v. Nozzle : —do—-
vi Discharge Fitting: —do—-

vii. Washers : Natural rubber free from impurities .Acid and alkaline resistant.

viii . Wheels : Cast Iron conforming to FG 200 of SS 210 or of MS.

ix. Cap & Nozzle : Plastics IS: 933.

x. Cap & Nozzle for inner container : Plastics IS:7328

3.1.4 Materials for Mobile Foam Trailor

i. Foam Tank: IS : 2002/2062 or SS 410S.

ii. Piping: ASTM A 53, API 5L, IS 1239

iii. Fittings: IS: 903.

iv. Hose Reel: IS: 884.

v. Hand Line Hoses: Type II of IS: 636.

3.1.5 Materials for semi fixed Foam Fire Extinguishing System

i. Piping : ASTM A 53, API 5L, IS-1239

ii. Fittings : ASTM A 105.

4.0 CONSTRUCTION

4.1 FABRICATION OF PORTABLE EXTINGUISHERS/FOAM FIRE TRAILOR

4.1.1 Welding

The cylinder body shall be welded. All ferrous fittings shall be welded to the body while all non-ferrous fittings shall be brazed.

i) All welding shall be carried out using qualified welders and agreed welding procedures.

ii) The weld joint design shall be of square butt type for plate thickness 3.0 mm and less and single V butt for thickness higher than 3.0 mm.

iii) All welding shall be carried out using shielded metal arc welding and gas tungsten arc welding techniques only. The electrode for welding shall conform to AWS/ASME classification. The electrode diameter shall not be more than 2.5 mm for SMAW and 1.6 mm for GTAW.

iv) All butt welds shall be full penetration welds.

v) All other requirements as outlined in Section II of IS: 2825 shall be followed.

4.1.2 Cylinder Dimensions

Cylinder dimensions shall be such that a space is provided in the body above the specified liquid levels and shall be sufficient in volume to ensure that, when the discharge nozzle is temporarily closed and the extinguisher put into operation at a temperature of 21 plus or minus 2 deg C, the pressure exerted shall not exceed 15 kgf/sq.cm. The temperature shall be the temperature of the solution and not the atmospheric temperature.

This requirement may be satisfied by providing an air space of not less than 5% of the total volume of the extinguisher.

The body of the 50 lit and 150 lit capacity foam fire engine shall be cylindrical with an outside diameter of 300 plus or minus 15 mm and 400 plus or minus 15 mm respectively.

4.1.3 Hose

The discharge hose shall have a length and bore as specified in IS : 5507. The hose shall have a minimum bursting pressure of 32 kgf/sq.cm.

4.1.4 Discharge Nozzle

The discharge nozzle shall be designed to discharge the foam as per performance characteristics outlined in para 5.0 of this Section.

4.1.5 Coating

On all surfaces of body of the inner container, sealing disc and spindle shall be coated with lead-tin alloy. The thickness of the coating shall be 0.012 mm minimum.

4.1.6 Painting

The extinguisher shall be painted fire red conforming to Shade No 536 of IS: 5. The paint shall conform to IS: 2932.

4.2 MOBILE FOAM FIRE TRAILOR AND SEMI FIXED FOAM EXTINGUISHING SYSTEM

4.2.1 Fabrication

The construction of foam tank of the mobile foam trailor and piping of the semi fixed foam extinguishing system shall be welded

i) All welding shall be carried out using qualified welders and agreed welding procedures.

ii) The weld joint design shall be of square butt type for plate thickness 3.0 mm and less and single V butt for thickness higher than 3.0 mm.

iii) All welding shall be carried out using shielded metal arc welding and gas tungsten arc welding techniques only. The electrode for welding shall conform to AWS/ASME classification. The

iii) All butt welds shall be full penetration welds

4.2.2 Painting

The foam trailor and piping shall be painted fire red conforming to Shade No 536 of IS : 5. The paint shall conform to IS : 2932.

5.0 PERFORMANCE CHARACTERISTICS

Capacity of extinguisher/ Fire Engine/ Trolley Litres	Min period during which the jet shall be maintained Sec	Throw range Mtr	Maximum period for min 90% discharge Sec
9	30	6	90
50	60	10	180

6.0 INSPECTION & TESTING OF NEW EXTINGUISHERS & INSTALLATIONS DURING CONSTRUCTION

6.1 PORTABLE EXTINGUISHERS AND FOAM FIRE ENGINES/TRAILORS

6.1.1 Shell & Attachments

i. Material Identification.

Material used for the cylinder shell shall be identified and if required tested to ensure conformity with manufacturing standard. Raw material/ bought out material for other components shall also be identified.

ii. Fabrication

The following checks shall be carried out.

a. Review and approval of the welding procedure.

b. Qualification of the welding procedure and welders.

c. Inspection of edge preparation and joint fit-up.

d. Ensuring that during welding only approved procedure and approved Electrodes are being used.

e. Inspection of surface defects and removal by grinding, if any.

f. Thickness measurements to confirm for minimum agreed finished thickness.

iii. Testing

The following tests shall be carried out after completion of welding.

a. Visual

The internal and external surfaces of the cylinder shall be inspected and a surface defect of more than 5% of the shell thickness shall be ground off and the final thickness in that same area shall be not less than the calculated minimum wall thickness plus corrosion allowance.

b. Dye Penetrant Inspection

Dye Penetrant examination shall be carried out on all the formed and knuckled areas and all fillet welds of all nozzles and attachments.

c. Radiography

Spot radiography of the welds on all cylinders shall be carried out. 10% of the weld joint shall be radiographed which shall include at least 50% of the T joints. Interpretation of the radiographs shall be as per IS : 2825.

d. Hydraulic Test

Extinguisher shell/container and the cap assembly shall be tested to an internal pressure of 25 kgf/ sq.cm. The test pressure shall be held for a minimum period of five minutes continuously.

e. Bursting Test

Hydraulic burst test shall be carried out on a prototype and no failure shall occur at a pressure below 60 kgf /sq.cm and 35 kgf/sq.cm for portable extinguisher and engines respectively. Actual burst pressures shall be recorded.

f. Coating and Painting

The extinguisher, after performance and hydraulic test shall be thoroughly cleaned with water free from chemical solution. The water shall then be completely drained off and the interior of the body shall be examined after 24 hours. It shall be free from all traces of rust. Superficial rust stains, which could be rubbed off with a dry cloth, may be ignored. The thickness of the coating shall be not less than 0.012 mm. The overall dry film thickness of external paint shall be 100 microns minimum.

6.1.2 Hose

A sample discharge hose of minimum 0.5 mtr length shall be tested upto bursting, which shall not be less than 32 kgf/sq.cm. Actual burst pressure of the hose shall be recorded.

6.1.3 CAP (Plastic)

For Testing Impact Resistance A steel hammer weighing 5 kg shall be allowed to drop vertically from a height of 1 m on to the fire engine cap moulding fitted to an engine. The engine shall be held such that the direction of the hammer blow is vertically down on to the top of the moulding. Thereafter the engine should be tested for internal hydraulic pressure of 25 kgf/sq.cm for a period of 5 minutes without leakage.

6.1.4 Repairs

Any extinguisher, which fails in hydrostatic test, shall be re-offered for inspection. If the failure is in the parent metal then the extinguisher shall be rejected.

6.2 FOAM TRAILOR AND SEMI FIXED SYSTEM

6.2.1 Tank and Piping

i. Material Identification.

Material used for the tank shell shall be identified and if required tested to ensure conformity with manufacturing standard. Raw material/bought out material for other components shall also be identified.

ii. Fabrication

The following checks shall be carried out.

a. Review and approval of the welding procedure.

b. Qualification of the welding procedure and welders.

c. Inspection of edge preparation and joint fit-up.

d. Ensuring that during welding only approved procedure and approved electrodes are being used.

e. Inspection of surface defects and removal by grinding if any.

f. Thickness measurements to confirm for minimum agreed finished thickness.

iii. Testing

The following tests shall be carried out after completion of welding.

a. Visual

The internal and external surfaces of the tank shall be inspected and a surface defect of more than 5% of the shell thickness shall be ground off and the final thickness to that same area shall be not less than the calculated minimum wall thickness plus corrosion allowance.

b. Dye Penetrant Inspection

Dye Penetrant examination shall be carried out on all fillet welds of nozzles and attachments.

c. Radiography

Spot radiography of the welds on all tanks and piping shall be carried out as per relevant code.

d. Hydrostatic Test

The bulk tanks of the fire tender shall be hydrotested to a pressure of 0.3 bar.

All piping except that handling expanded foam for other than subsurface application shall be subjected to a hydrostatic pressure test at 14.0 kg/sq.cm or 3.5 kg/sq.cm in excess of the maximum pressure anticipated whichever is greater. All operating devices and equipment shall be tested for proper function. All normally dry horizontal piping shall be inspected for proper drainage.

6.3 REPAIRS

Suitable repairs to welding in tank shall be carried out as necessary.

7.0 PERIODIC INSPECTION OF EXTINGUISHERS

7.1 LIKELY LOCATIONS OF DETERIORATION

7.1.1 Corrosion

i. Internal Corrosion.

Extinguisher and tank internal surface is prone to corrosion. The corrosion may take place where the internal coating is damaged and or where there is a holiday in the coating.

ii. External Corrosion.

The external surface of the extinguisher is prone to atmospheric corrosion particularly at areas where paint has peeled off. Support ring of the fire extinguisher is prone to water, soil and coercive corrosion. Pipe and pipe supports are likely to corrode due to atmospheric action.

7.1.2 Damage/Deterioration

i. Shell

Shell may be damaged due to improper handling. Dents/ deformations may occur.

ii. Neck Ring

Neck ring is prone to breakage at weld joint.

iii. Cap/ Neck Joint

The threaded joint between cap and neck is prone to damage/wear/deterioration.

iv. Spring

The spring is prone to loose its stiffness.

v. Nozzle

The nozzle may be eroded due to frequent use.

vi. Hose

It may show cracks/signs of ageing.

7.2 FREQUENCY AND PROCEDURE FOR PERIODIC INSPECTION

The extinguisher and its components shall be inspected at frequencies specified and as per procedure given below:

7.2.1 Portable Extinguishers and Foam Fire Engine/Trolley Mounted Fire Extinguisher

i. Body

a. Visual Inspection

The shell of the extinguisher shall be visually inspected once a month to check for any mechanical damage or corrosion.

b. Ultrasonic Inspection

Ultrasonic thickness measurements of the shell shall be carried out once in three years and readings shall be recorded.

c. Hydrostatic Test

A hydrostatic test of the cylinder shell with cap shall be done once in three years. Rusty or corroded extinguishers should be subjected to a pressure test even if they are not due for it and even if their performance is satisfactory.

d. Coating and Painting

The internal coating and external painting shall be checked for damage/deterioration once in three months. The coating thickness shall be checked once every three years.

e. Rejection Limit

An extinguisher shall be removed from service and destroyed when the following conditions exist:

1) When an extinguisher is corroded or damaged to such an extent that repairs by welding, brazing or by use of patchwork is required.

2) When the cylinder or shell threads are damaged.

3) When the cylinder has been exposed to high temp due to proximity of fire.

ii. Other Components

The following components shall be inspected once in three months.

a. Inner Container

Withdraw the inner container for checking visually the sealing system.

b. Neck Ring

The soundness of the brazing/welding of the neck ring to the shell shall be checked.

c. Cap

The threading of both cap and ring shall be checked. The cap washer shall be checked for deformation.

d. Plunger

The plunger shall be checked visually for any damage.

e. Piercer

The piercer mechanism shall be checked for its proper functioning.

f. Spring

The spring shall be inspected for its shape, size and functional aspects.

g. Nozzle and Discharge Fittings

The nozzle and other fittings shall be checked for erosion.

h. Wheels

Wheels shall be checked for mobility.

iii. Hose

The hose condition shall be checked visually once in three months. The hose of the engine and mobile trailer shall be hydrostatically tested every three years and replaced every 6th year.

7.2.2. Mobile & Semi-fixed Installations

i. Foam Chambers/pourers on all storage tanks

Visual inspection to be done once in four months and pressure testing as and when tank is taken out of service for M&I.

ii. Foam Tanks

These shall be visually inspected every day for leakage etc. A thorough internal/external inspection, thickness survey and checking for leakage by water filling shall be done once in 3 years or earlier if necessary.

iii. Accessory Equipment

Proportionating devices, foam maker, aspirator shall be visually inspected once in 4 months.

iv. Piping

Above ground piping shall be examined for external corrosion and proper drainage once in three months. Pressure testing of normally dry piping shall be done during M&I of the tank or earlier in case visual inspection indicate questionable strength due to corrosion or mechanical damage.

v. Control Valves

Shall be checked visually once in three years.

vi. Vapour Seals

Shall be checked visually once every year.

vii. Automatic and Manual Actuating Devices

Shall be checked visually for proper functioning once every year.

viii. Relief Valve

Relief valves shall be bench tested once every three years.

8.0 MARKING & DOCUMENTATION

8.1 NEW ENTINGUISHER

The manufacturer shall submit with each order of fire fighting equipment a test certificate confirming that the fire fighting equipment have been manufactured and tested in accordance with the required Standard.

The test certificate shall clearly furnish the following information:

i. Certificate number and date,

ii. Size, type and capacity,

iii. Material used for construction,

iv. Foam properties,

v. Hydrostatic test pressure,

vi. Bursting test pressure,

vii. Internal/external coating details,

viii. Identification marking as per relevant code.

8.2 INSTALLED SYSTEMS:

In addition to the required tag or labels, a permanent file record shall be kept for each installation. The record shall include the following information as applicable:

i. Identification number,

ii. Date of manufacturing / commissioning,

iii. Name of manufacturer,

iv. Capacity,

v. Location at which it is installed,

vi. Date of installation,

vii. The inspection date and the name of the person or agency performing the inspection,

viii. The date when last recharged and the name of the person performing the recharge,

ix. The hydrostatic test date and the name of the person or agency performing the test,

x. Next hydrotest date,

xi. Inspection observation and maintenance carried out.

9.0 CONDEMNING OF CYLINDERS

Foam cylinders may be condemned when it leaks or when internal or external corrosion, denting, bulging or evidence of rough usage exists to the extent that the cylinders are likely to be weakened appreciably.

Any cylinder which fails to pass periodic examination or test or which for any other defect is found to be unsafe for use shall be destroyed by flattening it as a whole or after being cut into pieces in such manner that the pieces cannot be again joined together by welding or otherwise to form a cylinder.

10.0 REFERENCE

1. IS 933 - Portable chemical fire extinguisher - foam type.

2. IS 934 - Portable chemical fire extinguisher soda acid type

3. IS 951 - Crash tender combined foam and carbon dioxide, functional requirements?

4. IS 2097 - Specification for foam making branches

5. IS 2190 - Code of practice for selection, installation & maintenance of first aid fire extinguishers

6. IS 4989 - Specifications for foam concentrate for producing mechanical foam for fire fighting.

7. IS 5490 - Refills for portable fire extinguishers & chemical fire engines

8. IS 5507 Chemical fire engine, 50 litre capacity, foam type

9. IS 8150 - Chemical foam engine, 4 litre capacity - for marine use

10. IS 10204 - Portable fire extinguishers - mechanical foam type

11. NFPA 11A - Low expansion foam & combined agent systems

12. NFPA 11C - Mobile foam apparatus

13. NFPA 16 - Installation of deluge
foam water sprinkler systems and foam water spray systems

14. NFPA 20 - Installation of centrifugal fire pumps

15. OISD 116 - Fire protection facilities for petroleum refineries and oil/gas processing plants.

SECTION VI

WATER SPRINKLER SYSTEM

1.0 DEFINITION AND TYPES:

1.1 DEFINITIONS:

1.1.1 Sprinkler System:

A sprinkler system, for fire protection purposes, is an integrated system of underground and overhead piping designed in accordance with fire protection engineering standards. The installation includes one or more water supplies. The portion of the sprinkler system above ground is a network for specially sized or hydraulically designed piping installed generally overhead and to which sprinklers are attached in a systematic pattern. The valve control in each system riser is located in the system riser or its supply piping. Each sprinkler system riser includes a device for actuating an alarm when the system is in operation. The system is usually activated by heat or smoke detector or manually and discharge water over the fire affected area.

1.1.2 Risers:

Risers are vertical pipes in a sprinkler system.

1.1.3 System Riser:

The aboveground supply pipe directly connected to the water supply.

1.1.4 Feed Mains:

Mains supplying risers or cross mains.

1.1.5 Cross Mains:

Pipes directly supplying the lines in which the sprinklers are placed.

1.1.6 Branch Line:

Lines of pipe from the point of attachment to the cross main upto the end sprinkler, in which the sprinklers are directly placed.

1.1.7 Sprinkler Alarms:

A local alarm unit is an assembly of apparatus so constructed and installed that any flow of water from a sprinkler system equal to or greater than that from a single automatic sprinkler of the smallest orifice size installed on the system will result in an audible alarm on the premises within 5 minutes after such flow begins.

1.2 TYPES OF SPRINKER SYSTEMS:

1.2.1 Wet-Pipe Systems:

A system having automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers activated by fire.

1.2.2 Dry-Pipe Systems:

A system having automatic sprinklers attached to a piping system with nitrogen or air, under pressure, the release of which permits the water pressure to open a valve known as a dry pipe valve. The water then flows into the sprinkler piping system and out through the sprinklers.

1.2.3 Pre-Action System:

A system having automatic sprinklers attached to a piping system containing air that may or may not be under pressure. A supplementary fire detection system installed in the same area actuates the sprinkler system opening the valve and permitting water into the sprinkler system.

1.2.4 Deluge System:

A system having open sprinklers attached to a piping system connected to a water supply through a valve which is opened by the operation of a fire detection system installed in the same areas as the sprinklers; opening of the valve leads to water discharge from all sprinklers through the piping system.

1.2.5 Combined Dry-Pipe and Pre-Action System:

A system having automatic sprinklers attached to a piping system containing air under pressure with a supplemental fire detection system installed in the same areas as the sprinkler. Actuation of fire detection system activates tripping devices which open dry - pipe valves simultaneously and without loss of air pressure in the system. It also opens approved air exhaust valves of the system with water, which usually precedes the opening of the sprinklers. The fire detection system also serves as an automatic fire alarm system.

2.0 DESIGN:

Conventional Sprinkler systems shall be designed for a max working pressure of 12.5 kg/sq.cm. (175 psi). Sprinklers used in high voltage electrical systems, control rooms, electronic systems etc. shall be designed to relevant specifications.

2.1 FITTINGS:

Fittings used in Sprinkler system shall be designed to withstand the working pressures involved, but not less than 12.5 kg/sq.cm. (175 psi) of water.

2.2 COUPLINGS & UNIONS:

Screwed unions shall not be used on pipe larger than 1 1/2".

2.3. REDUCERS & BUSHINGS:

A one piece reducer fitting shall be used wherever a change is made in the size of the pipe.

2.4 VALVES:

Drain valves and test valves shall be designed to withstand 12.5 kg.sq.cm (175 psi) of water. Check valves shall be installed in each connection if there is more than one source of water supply.

2.5 HANGERS:

The maximum distance between hangers shall not exceed 3.7 mtr. (12') for 1 1/4" size pipes and 4.6 mtr. (15') for sizes 1 1/2" and larger.

2.6 SPRINKLERS:

The sprinklers may be of orifice size 12.7, 15.9 & 19.1 mm. The size of orifice of the sprinkler shall be selected on the basis of level of exposure of fire. Large orifice sprinklers should be used where exposure is severe. Sprinklers shall not be used for system working pressure exceeding 12.5 kg/sq.cm. (175 psi).

2.7 SPRINKLER ALARMS:

All remote sprinkler water flow alarm systems shall be installed in accordance with the following applicable NFPA Standards:

i) NFPA 71, Central Station Signalling Systems

ii) NFPA 72B, Auxiliary Protective Signalling Systems

iii) NFPA 72C, Remote Station Protective Signalling.

iv) NFPA 72D, Proprietary Protective Signalling.

2.8 RELIEF VALVES:

A wet pipe system shall be provided with a relief valve not less than 1/4" in size set to operate at pressure not greater than 12.5kg/sq.cm (175 psi). However, when the maximum system pressure exceeds 11.8 kg/sq.cm (165 psi), the relief valve shall be set to operate at 0.6 kg/sq.cm (10 psi) in excess of the maximum system pressure.

A dry pipe system shall have an approved relief valve which shall be provided between compressor and controlling valve set to relieve at a pressure of 0.3kg/sq.cm (5 psi) in excess of maximum system air pressure.

2.9 PRESSURE GAUGES:

The pressure gauges shall be of approved type and shall have a maximum limit not less than twice the normal working pressure at the point installed. It shall be installed on the following locations:

i. Wet Pipe system

On the sprinkler riser, above and below each alarm clock valve. (Wet Pipe System)

ii. Dry Pipe System

a) On the water side and air side of dry pipe valve.

b) At the pump supplying the air receiver.

c) At the air receiver.

d) In each independent pipe from air supply to dry pipe system and

e) At the exhausters and accelerators. (Dry Pipe System)

iii. Others

a) Above and below preaction valve and below deluge valve

b) On air supply to Preaction and Deluge valve. (Preaction & Deluge Systems.)

3.0 MATERIALS:

Pipe or tubes used in sprinkler systems shall be of materials given below:

3.1 Ferrous Piping (Welded & Seamless)

Welded and seamless steel pipe for ordinary uses, Specification for Black and

Hot dipped Zinc Coated (Galvanised) pipes ANSI/ASTM A120

Specification for Black and Hot dipped Zinc coated (Galvanised) welded and seamless steel pipe for fire protection use ASTM A 795

Specification for welded and seamless steel pipe ANSI/ASTM A 106 Wrought steel pipe ANSI B 36.10

Specification for Electrical resistance welded steel pipe ASTM A 135

3.2 Copper Tube (Drawn Seamless)

Specification for seamless copper tube ASTM B 75

Specification for seamless copper water tube ASTM B 88

Specification & general requirements for wrought seamless copper and copper alloy tube ASTM B 251

Brazing filler metal AWS A 5.8

Solder Metal ASTM B 32

3.3 Pipe Thickness:

All welded and seamless steel pipe shall have the minimum wall thickness for pressure upto 20.0 kg/sq.cm (300 psi) as per the following.

For sizes upto 4 inch ..Sch 40

For 6 inch to 12 inches ..Sch 30

For 14 inch and above ..Sch 20

Also refer Clause 5.8 of OISD Std 116 for guidelines on Material Specifications.

4.0 CONSTRUCTION:

4.1 THREADED PIPE AND FITTINGS:

Joining compound or tape shall be applied to the threads of the pipe and not in the fitting.

Headers shall have end flange to flushout the lines for removing the scales.

4.2 PIPE BEND:

The minimum radius of a pipe bend shall conform to the following:

Pipe size	Min radius of bend
2" and less	6d
2-1/2 and above	5d

where ‘d‘ is the nominal diameter of the pipe.

4.3 WELDING:

All ferrous piping and fittings shall be welded while all copper alloy piping and fittings shall be brazed.

All welding shall be carried out using qualified welders and welding procedures in compliance with the requirements of AWS D 10.9, Level Ar-3.

Welding procedure, welders and welding machine operators shall be qualified as per ASME SEC IX.

Welding shall not be performed if there is impingement of rain, snow, sleet or high wind on the weld area.

When welded outlets are formed:

i) Holes in piping shall be cut to full inside diameter of fitting or shaped/contoured nipple.

ii) Discs shall be retrieved.

iii) Opening in piping shall be smooth.

iv) All slag and other welding residue shall be removed.

v) Fittings or shaped contoured nipples of any length shall not penetrate beyond the internal diameter of the piping.

When reducing a pipe size in the run of a main, cross main, or branch, a suitable reducing fitting designed for that purpose shall be used.

Torch cutting and welding shall not be permitted as means of modifying or repairing sprinkler systems.

Pipe joined with mechanical groove shall be joined by a listed combination of fittings, gaskets and grooves. When grooves are cut or rolled on the pipe they shall be dimensionally compatible with the fitting.

Mechanical grooved coupling including gaskets used on dry pipe shall be marked for dry pipe service.

5.0 INSPECTION & TESTING OF WET/DRY SPRINKLER SYSTEMS

5.1 SPRINKLER PIPING AND FITTINGS:

i) MATERIAL:

Pipe/fittings shall be checked / tested to ensure conformance with the required standards.

ii) FABRICATION:

Inspection of the following shall be carried out prior to and during welding:

a) Review and approval of the welding procedure,

b) Qualification of welding procedure and welders,

c) Inspection of edge preparation and joint fit up,

d) Ensuring that during welding only approved procedure and approved electrodes are being used.

iii) TESTING:

Radiography of the welds shall be carried out for 10 % of the weld joints on all piping and fittings with size 2" and greater.

5.2. ACCEPTANCE TESTS :

5.2.1. Flushing of Underground Connections:

Underground mains and leading connections to system risers shall be flushed before connection is made to sprinkler piping in order to remove foreign materials which may have entered the underground piping during the course of the installation. For all systems, the flushing operations shall be continued until water is clear.

Underground lines and leading connections shall be flushed at a flow rate as given in the Table below or at hydraulically calculated water demand rate of the system, whichever is greater.

Pipe Size	Flow Rate (USGPM)	Flow Rate (L/min)
4"	390	1476
6"	880	3331
8"	1560	5905
10"	2440	9235
12"	3520	13323

The above mentioned flow rates ensure a flow velocity of 3 mt/sec as required by NFPA.

Provision shall be made for the disposal of water issuing from test outlets to avoid property damage.

5.2.2. Hydrostatic Test:

All new systems including guard piping shall be hydrostatically tested for 2 hours at not less than 13.8 kg/sq.cm (200 psi) pressure or at 3.4 kg.sq.cm (50 psi) in excess of max. pressure, when the max pressure to be maintained in the system is in excess of 10.3 kg/sq.cm (150 psi). The test pressure shall be read from a gauge located at a suitable point in the individual system or portion of the system being tested.

5.2.3. Permissible Leakage:

The inside sprinkler piping shall be installed in such a manner that there will be no visible leakage when the system is subjected to the hydrostatic test pressure.

5.2.4 Test Blanks:

Whenever a test blank is used, it shall be of the self-indicating type. Test blanks shall have red painted lugs protruding beyond the flange in such a way as to clearly indicate their presence. The installer shall have all test blanks numbered so as to keep track of their use and assure their removal after the work is completed.

5.2.5 Specific Test for Dry- Pipe Systems

i. Differential dry-pipe valves:

The clapper of the differential type dry-pipe valve shall be held off its seat during any test in excess of 3.4kg/sq.cm (50 psi) to prevent damaging the valve.

ii. Air test:

The pneumatic system is subjected to an air pressure of 2.8 kg.sq.cm (40 psi) and allowed to stand for 24 hours. All leaks which allow a loss of pressure by 0.1 kg/sq.cm (1.5 psi) in 24 hours shall be rectified.

iii. Operating test of Dry-Pipe valve:

A working test of the dry-pipe valve alone and with quick opening device, if installed, shall be made before acceptance by opening the system test pipe. Trip and water delivery times shall be measured from the time inspector's test pipe is opened and shall be recorded.

5.2.6 Performance Test

Frequency of performance tests shall be as per OISD-116.

5.2.7 Test of Drainage Facility:

Test for drainage facilities shall be made while the control valve is wide open. The main drain valve shall be opened and remains open until the system pressure stabilizes.

5.3 LIKELY LOCATIONS OF DETERIORATION:

5.3.1 External Corrosion

System components installed outdoors or in the presence of a corrosive atmosphere are prone to atmospheric corrosion.

5.3.2 Internal Corrosion

This will vary depending upon the water chemistry.

5.4 FREQUENCY AND PROCEDURE FOR INSPECTION:

During weekly, or other scheduled plant inspection, equipment shall be checked for obvious defects such as broken or missing parts, nozzle loading, or other evidence of impaired protection.

Strainers, except individual nozzle strainers shall be thoroughly inspected after each operation, or flow test and cleaned, if necessary. Routine inspection and cleaning shall be performed at intervals of not more than 12 months or more frequently based on experience.

All piping & its components shall be examined to determine condition and proper drainage at intervals of not more than one year as per OISD Standard 116.

Threaded portion of the lines connecting the deluge release valve, block valve, diaphram unit spring and water alarm turbine shaft shall be checked more critically.

6.0 DOCUMENTATION:

The manufacturer shall furnish test certificates giving the following information:

i. Certificate Number & Date,

ii. Hydraulic Calculations,

iii. Materials used for Construction,

iv. Hydrostatic test pressure,

v Coating details, if any,

vi. Location at which it is installed,

vii. Date of installation,

viii. The inspection date and name of
the person or agency performing the inspection,

ix. The acceptance test date and the name of the person or agency performing the tests,

x. Next test date,

xi. Inspection observations and maintenance carried out.

7.0 REFERENCE:

1. NFPA 13 - Installation of Sprinkler systems

2. ASTM Material specifications - A 120/ A 795/ A 135/ A 106/ B 36.10/ B 75/ B 88/B 32/B 251

3. OISD 116 - Fire protection facilities for petroleum refineries and oil/gas processing plants

SECTION - VII

FIXED WATER SPRAY SYSTEM FOR FIRE PROTECTION

Fixed water spray system, also called procto-sprays or drenchers, are meant to protect an equipment from exposure to extraneous heat.

1.0 DEFINITION AND APPLICABILITY

1.1 DEFINITION:

1.1.1 Water Spray:

Water in a form having a predetermined pattern,particle size, velocity and density discharged from specially designed nozzles or devices is termed as water spray.

1.1.2 Water Spray Nozzles:

A special discharge device, which will distribute the water in special, directional pattern, peculiar to it, when supplied with water under pressure.

1.1.3 Water Spray System:

A special fixed pipe system connected to a reliable source of fire protection water supply, and equipped with water spray nozzles for specific water discharge and distribution over the surface or area to be protected. The piping system is connected to the water supply through an automatically or manually actuated valve, which initiates the flow of water. An automatic valve is actuated by operation of automatic detection equipment installed in the same area as the water spray nozzles. In certain cases, the automatic detection equipment may also be located in another area.

The water spray system could be of high velocity or medium velocity. High velocity water spray systems are installed to extinguish oil fires involving liquids with flash point of 65°C or higher. Medium velocity water spray systems are installed to control the burning and to provide cooling and/or exposure protection.

1.1.4 Automatic Fire Detection Equipment:

Equipment which will automatically detect heat, flame, smoke, flammable gases, or other conditions likely to produce fire or explosion and cause automatic actuation of alarm and protection equipment. The detector rating shall be atleast 30°C above the highest ambient temperature. The detection piping and equipment shall be supported independently as far as possible. The system should actuate the deluge valve within 20 seconds.

1.1.5. Exposure Protection:

Application of fixed water spray on to the equipment to limit absorption of heat to a level which will minimize damage and prevent failure irrespective of internal or external heat.

1.2. APPLICABILITY:

Fixed water spray is applicable for protection of specific hazards and equipment and may be installed independently of or supplementary to other form of fire protection system or equipment.

High velocity water spray system are installed for protection of the following:

i. Transformers, oil filled equipment of power stations

ii. Turbo-alternators

iv. Oil fired boiler rooms, oil quenching tanks etc.

Medium velocity water spray systems are used for:

i) General area protection

ii) Horizontal storage vessels (LPG bullets etc.)

iii) Vertical storage tanks

iv) Spheres

v) Protection of specific spots/areas in an equipment.

2.0 DESIGN:

Before a fixed water spray system is installed or existing equipment is modified, complete specifications, hydraulic calculations and working plans shall be prepared.

The practical location of on the piping and nozzles with respect to the surface to which the spray is to be applied or to the zone in which the spray is to be effective , is determined largely by the physical arrangement and the protection needs of the installation requiring protection. Once the criteria are established, the size of nozzles to be used, the angle of the nozzle discharge cone and the water pressure needed can be determined.

The first factor to determine is the water quantity required absorbing the expected release of heat from exposure or heat of combustion. When this is determined, a nozzle may be selected that will provide that quantity at a velocity adequate to overcome air currents and to carry the spray to the equipment to be protected. Each nozzle selected must also have the proper angle of discharge to cover the area to be protected by the nozzle.

Also refer para on Water Spray Application Rate in OISD Standard 116.

There are limitations to the use of water spray, which shall be recognised. Such limitations involve the nature of the equipment to be protected, the physical and chemical properties of the materials involved and the environment of the hazard like electrical clearance, frothing etc.

Both medium and high velocity water spray systems are designed at a minimum flow rate as stipulated in relevant OISD Standard. The density of water application depends upon the flash point of the liquids handled and also the ceiling height distance of sprayers from the risk. There shall be atleast one sprayer to each 9 Sq.m. area of the floor of risk. The distance between adjoining sprayers shall not exceed 3 metres. In case of vessels like spheres/bullets, the number and distance of sprayers shall be selected based on the sprayers density, angle of discharge and the diameter of the vessel.

2.1. SIZE OF WATER SPRAY SYSTEMS:

Many factors govern the size of a water spray system, including the nature of hazard or combustibles involved, amount and type of equipment to be protected, adequacy of other protection, and the size of the area, which could be involved in a single fire. The size of the system needed may be minimized by taking advantage of possible subdivision by fire walls, by limiting the potential spread of flammable liquids by dikes, curbs, or special drainage; by water curtains or heat curtains; or by combination of these features.

Because most water spray system must perform as deluge type systems with all nozzles or devices open, and because a high density of water discharge is often needed, there is a heavy water demand.

The size of a single water spray system be limited only by the available water supply so that the designed discharge rate will be calculated at the minimum pressures for which the nozzles are effective. Experience has shown that in most installations, a design discharge rate of 3,000 gpm (11,356 lt/min) should not be exceeded for a single system. Separate fire areas should be protected by separate systems.

2.2 WATER SUPPLIES:

Fixed spray systems are usually supplied from one or more of the following:

i) Connection from a reliable waterworks system of adequate capacity and pressure.

ii) Automatic fire pumps having reliable power and a water supply of adequate capacity and reliability.

iii) An elevated (gravity) tank of adequate capacity and elevation.

In some situations where the water supply is extremely limited, a cycle system, which collects and reuses water, may be acceptable. It is imperative, however, that foreign material and fuel be separated from the water before it is returned to the water spray system.

2.3 WATER DEMAND RATE:

The water supply must be adequate to supply at the effective pressure all of the spray nozzles that may be expected to operate in a fire in the protected area. Additional water may be required for hose streams and should be considered when the system is designed. The duration of the discharge required will vary according to the nature of the hazard, the purpose for which the system is designed, and other factors which can be evaluated only for each installation.

Water demand is specified in terms of density of a uniformly distributed spray measured in lt/min/sq.mtr (gpm/sq.ft) of area protected. The discharge rate per unit of area depends on whether the spray system is installed for extinguishment of fire, control of fire, exposure protection, or prevention of fire, and upon the characteristics of the materials involved.

Also refer Annexure 1 of OISD Standard 116 for Typical Water Demand Rate Calculations.

2.4 PIPE SIZES:

Pipe sizes must be calculated for each system in order that the water at the spray nozzles will have adequate pressure. In medium velocity water spray systems, water pressure at nozzle outlet shall be 1.4 to 3.5 kg/cm2.

2.5 SELECTION AND USE OF SPRAY NOZZLES:

The selection of spray nozzles takes into consideration such factors as the character of the hazard to be protected, the purpose of the system, and possible severe wind or draft conditions.

High velocity spray nozzles, generally used in piped installations, discharge in the form of a spray filled cone, while low velocity spray nozzles usually deliver a much finer spray in the form of either a spray filled spheroid or cone. Due to difference in size of orifices in the various nozzles and the range of water particle sizes produced by each type, nozzles of one type should not be substituted. In general, higher the velocity and the coarse the size of water droplets, the greater the effective reach or range of spray.

Some open (nonautomatic) spray nozzles produce spray by giving the water high rotary motion in spiral passages inside the nozzle body.

The sprayers shall not be less than 6 mm in orifice size and shall normally have cone angles between 60° to 125°. Sprayers with cone angles below 60° are permissible for local protections only. Sprayers shall be installed normal to the exposed area of the vessel and positioned at distance as calculated from vessel diameter, spray cone angles, density etc. Minimum clear distance between water spray nozzles and live uninsulated electrical components shall conform to the guidelines given in NFPA-13.

2.6 STRAINERS:

Strainers are ordinarily required in the supply lines of fixed piping systems to prevent clogging of the nozzles. They should be selected with baskets having holes small enough to protect the smaller water passages in the nozzles used.

Water spray nozzles having very small water passage may have their own internal strainer as well as a supply line strainer to remove larger foreign material.

2.7 DRAINAGE:

Fixed pipe open nozzle water spray systems discharge large quantities of water. To limit the spread of flammable liquids, special drainage and disposal facilities including fire traps should be provided. Pitched floors, curbs, dikes, sumps or trenches etc. designed for safe disposal may be required alone or in combination as best adapted for specific situation.

The drainage system shall be adequate for:

a) Water discharged from fixed fire protection systems at maximum flow conditions

b) Water likely to be discharged by hose streams

c) Surface water

d) Cooling water normally discharged to the system.

2.8 MATERIALS:

Only approved materials and devices shall be employed in the installation of systems as described below:

2.8.1 Corrosion Protection:

System components installed outdoors, or in the presence of a corrosive atmosphere, shall be constructed of materials, which will resist corrosion, or be covered with protective coatings. The threaded ends of galvanized pipe, after installation, shall be protected against corrosion.

2.8.2 Spray Nozzles:

Care shall be taken in the selection of nozzle types. Distance of 'throw' or location of nozzle from surface shall be limited by the nozzle's discharge characteristics.

Care shall also be taken in the selection of nozzles to waterways, which are easily obstructed by debris, sediment, etc., in the water.

2.8.3 Piping:

Pipes used in water spray systems shall conform to ASTM A-53, A 106,API 5L or IS 1239. Piping shall be designed to withstand a working pressure of not less than 12.2 bars (175 psi).

2.8.4 Fittings:

All fittings shall be of a type specifically approved for fire protection systems and of a design suitable for working pressures involved, but not less than 12.2 bars (175 psi) cold water pressures. Ferrous fittings shall be of carbon steel.

Galvanized fittings shall be used where galvanized pipe is required.

2.8.5 Hangers:

Hangers shall be of approved type for use with the piping involved. Hangers used out doors or in locations where corrosive conditions exist shall be galvanized or suitably coated for protection against the corrosive condition of the location.

2.8.6 Pressure Gauges:

Pressure gauges shall be of approved type and shall have a maximum limit not less than twice the normal working pressure when installed.

2.8.7 Strainers:

Pipeline strainers shall be specifically approved for use in water supply connections. Strainer shall be capable of removing from the water all solids of sufficient size, which can obstruct the spray nozzle. In addition, the strainer shall be capable of continued operation without serious increase in head loss, for a period estimated to be ample when considering the type of protection provided, the condition of the water and similar local circumstances. Pipe strainer designs shall incorporate a flush out connection. Individual strainers for spray nozzles where required, shall be of approved type.

2.2.8 Control Equipment:

Automatic valves shall be special system water control valves approved for the use intended.

Automatic detection equipment shall be of a type listed by a testing laboratory for the indented usage such as with special systems water control valves. When used, electrical type detection equipment shall meet the area electrical area classification requirements.

3.0 CONSTRUCTION:

3.1 HEADERS:

Refer Criteria for Underground / above ground network in OISD Standard 116.

Weld Procedure and Welder qualification shall be done as per relevant code before commissioning the job.

Stage wise inspection with visual and other NDE methods shall be carried out as required. Repairs shall be carried out as per approved procedure and shall be reinspected prior to final acceptance.

3.2 THREADED PIPES & FITTINGS:

Steel pipe with wall thickness less than schedule 30 (in sizes 8" and larger) or schedule 40 (in sizes less than 8") shall not be joined by threaded fittings.

All threaded fittings and pipes shall have threads cut to ANSI B2.1, Pipe Threads (except dry seal).

Joint compound or tape shall be applied to threads of the pipe and not in the fittings.

Sprinkler headers shall have end flange to flushout the lines to remove the scales.

4.0 ACCEPTANCE TESTS:

4.1 FLUSHING OF PIPING:

Underground mains and lead-in connections to the system risers shall be flushed thoroughly before connection is made to the system piping in order to remove foreign materials which may have entered the underground piping during the course of installation or which may have been present in the existing piping. All system piping shall be flushed where practicable; otherwise, cleanliness shall be determined by visual examination.

4.2 HYDROSTATIC PRESSURE TEST :

All new system piping shall be hydrostatically tested in accordance with the specifications.

4.3 WATER DISCHARGE TEST:

When practicable, full flow tests with water shall be made in system piping as a means of checking the nozzle lay-out, discharge pattern, any obstructions and determination of relation between design criteria and actual performance and to ensure against clogging of the smaller piping and the discharge devices by foreign matter carried by the water.

When practicable, the maximum number of systems that may be expected to operate in case of fire shall be in full operation simultaneously in order to check the adequacy and condition of the water supply.

The discharge pressure at the highest, most remote nozzle shall be atleast that for which the system was designed.

4.4. OPERATING TESTS:

All operating parts of the system shall be fully tested to ensure that they are in operating condition. The operating tests shall also include a test of automatic detection equipment.

5.0 PERIODIC INSPECTION AND TESTING:

5.1 LIKELY LOCATIONS OF DETERIORATION (CORROSION):

i. External Corrosion:

System components installed outdoors or in a corrosive atmosphere shall be constructed of materials, which will resist corrosion, or be covered with protective coatings. The threaded ends of galvanized pipe, after installation shall be protected against corrosion.

ii. Internal Corrosion:

This will vary depending upon the water chemistry and the system should be checked for thickness at a pre-determined frequency. Threaded portion of the lines connecting the deluge release valve, Clock valve diaphram unit spring, water alarm turbine shaft shall be inspected more critically.

5.2 FREQUENCY AND PROCEDURE FOR INSPECTION:

During monthly, or other scheduled plant inspections, equipment shall be checked for obvious defects such as broken or missing parts, nozzle loading, or other evidence of impaired protection.

Strainers, except individual nozzle strainers shall be thoroughly inspected after each operation, or flow test and cleaned, if necessary. Routine inspection and cleaning shall be performed at intervals as per OISD Standard 116.

5.2.1 Piping System:

At intervals of not more than one year, all piping shall be examined to determine condition and proper drainage.

Flow test on open head spray systems shall be made yearly or more frequently as determined by experience.

5.2.2. Control Valves and Automatic Detection Devices

Control valves and automatic detection equipment shall be tested annually by qualified personnel.

Where normally opened valves are closed following system operation or test, suitable procedures shall be instituted to ensure that they are reopened and that the system is promptly and properly restored to full normal operating condition. Main drain flow test shall be made after valves are reopened.

5.2.3 Spray Nozzles:

All spray nozzles shall be inspected for proper positioning, external loading, and corrosion and cleaned if necessary, at intervals of not more than 12 months or more frequently if necessary based on experience.

5.2.4 Performance Test

Frequency of performance tests shall be as per OISD-116.

5.2.5 Flushing:

Lead-in connections to system risers shall be flushed atleast annually.

6.0 DOCUMENTATION:

The manufacturer shall furnish test certificates giving the following information:

i) Certificate Number & Date,

ii) Hydraulic Calculations,

iii) Materials used for construction,

iv) Hydrostatic test pressure,

v) Coating details if any,

vi) Location at which it is installed,

vii) Date of installation,

viii) The inspection date and name of the person or agency performing the inspection,

ix) The acceptance test date and the name of the person or agency performing the tests,

x) Next test dates,

xi) Inspection observations and maintenance carried out.

7.0 REFERENCE:

1. NFPA 15 - Water spray fixed systems

2. ASTM A 120

3. ASTM A 106 & API 5L - Specifications for seamless/ERW mild steel pipes

4. OISD 116 - Fire protection facilities for petroleum refineries and oil/gas processing plants.

OISD –STD- 153

FOR RESTRICTED
CIRCULATION ONLY

MAINTENANCE AND INSPECTION
OF
SAFETY INSTRUMENTATION
IN
HYDROCARBON INDUSTRY

OISD - STANDARD - 153

Second Edition, ………., 2013
Amended Edition, September 2001
First Edition, March, 1993

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Website: www.oisd.gov.in

Tele: 0120-2593800, Fax: 0120-2593802

OISD - STANDARD - 153
Second Edition ……….., 2014
Amended Edition, September 2001
First Edition, March 1993

FOR RESTRICTED CIRCULATION ONLY

MAINTENANCE AND INSPECTION

OF

SAFETY INSTRUMENTATION

IN

HYDROCARBON INDUSTRY

Prepared by:

COMMITTEE ON PROCESS INSTRUMENTATION, MAINTENANCE & INSPECTION

OIL INDUSTRY SAFETY DIRECTORATE
Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)

Website: www.oisd.gov.in

Tele: 0120-2593800, Fax: 0120-2593802

Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director

Oil Industry Safety Directorate

FOREWORD

The Oil Industry in India is nearly 100 years old. Because of various collaboration agreements, a variety of international codes, standards and practices have been in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This, coupled with feed back from some serious accidents that occurred in the recent past in India and abroad, emphasized the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installation particularly using sophisticated instrumentation.

With this in view, the Ministry of Petroleum & Natural Gas, in 1986, constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD), staffed from within the industry, in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safe operations. Accordingly, OISD constituted a number of Functional Committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on "Maintenance & Inspection of Safety Instrumentation in Hydrocarbon Industry' is prepared by the Functional Committee on "Process Instrumentation Maintenance and Inspection'. This standard is based on the accumulated knowledge and experience of Industry members and the various national and international codes and practices. It is hoped that provisions of this document, when adopted, may go a long way to improve the safety and reduce accidents in Oil and Gas Industry. Users of this standard are cautioned that no standard can be a substitute for a responsible, qualified Instrumentation Engineer. Suggestions are invited from the users after it is put into practice to improve the document further.

This standard in no way supercedes the statutory regulations of Chief Controller of Explosives (CCE), Factory Inspectorate or any other statutory body which must be followed as applicable.

Suggestions for amendments to this document should be addressed to:

The Co-ordinator,
Committee on
"Process Instrumentation, Maintenance & Inspection"

OIL INDUSTRY SAFETY DIRECTORATE
8th Floor, OIDB Bhavan,
Plot No. 2, Sector - 73
Noida – 201301 (U.P.)

NOTES

OIL INDUSTRY SAFETY DIRECTORATE (OISD) publications are prepared for use in the Oil and gas industry under Ministry of Petroleum and Natural Gas. These are the property of Ministry of Petroleum and Natural Gas and shall not be reproduced or copied and loaned or exhibited to others without written consent from OISD.

Though every effort has been made to assure the accuracy and reliability of data contained in these documents, OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use.

These documents are intended only to supplement and not to replace the prevailing statutory requirements.

FUNCTIONAL COMMITTEE (SECOND EDITION)
ON
PROCESS ISNTRUMENTATION, MAINTENANCE AND INSPECTION

LIST OF MEMBERS

Name	Designation / Organisation	Status
S/Shri		
Atish Chakrabarty	DGM (Projects), IOCL	Leader
A K Arora	Addl. Director, OISD	Member Co-ordinator
H C Sathyanarayan	General Manager (Instt.), MRPL	Member
Rajiv Gupta	DGM (Instt.) EIL	Member
Dharmendra K. Sharma	Chief Manager (Instt), HPCL	Member
R K Sharma	Chief Maint. Manager (Instt.), BPCL	Member
Girish K. Borah	Chief Manager (Instt.), BPCL, NRL	Member
Ravi Holiwale	AVP (Instt.), RIL	Member
Prakash N. Pathak	Jt. General Manager, EOL	Member
Sanjeev Thawani	Asst. Vice President (Instt.), BORL	Member
Praveen Kumar	Sr. Manager (E & C Instt.), BPCL, KR	Member
R Haridass	Sr. Manager (Maint. Instt.-II), CPCL	Member
Nirav D Shah	Sr. Manager (Instt.), Petronet	Member
Dharmvir	Jt. Director, OISD	Member Facilitator

In addition to the above several experts from industry contributed in the preparation, review and finalisation of the document.

FUNCTIONAL COMMITTEE (FIRST EDITION)
ON
PROCESS ISNTRUMENTATION, MAINTENANCE AND INSPECTION

LIST OF MEMBERS

Name	Designation / Organisation	Status
S/Shri		
A. Majumdar	DGM (Instt.), ONGC	Leader
V.K. Agarwal	DGM (Tech.) BPCL	Member
S. Raghuraman	AGM (Advance Control), EIL	Member
C.S. Ooman	Chief Manager (Instt.), MRL	Member
R.D. Shira	Chief Manager (Inst.. & Elect), BRPL	Member
P. Kajendran	Sr.Manager (M & I), IOC	Member
S. Rammohan	Sr.Manager (Instt.), GAIL	Member
V.M.Ranalkar	Dy. Director, OISD	Member Co-ordinator

In addition to the above several experts from industry contributed in the preparation, review and finalisation of the document.

MAINTENANCE AND INSPECTION OF SAFETY INSTRUMENTATION

CONTENTS

CONTENTS (Contd.)

MAINTENANCE AND INSPECTION OF SAFETY INSTRUMENTATION IN HYDROCARBON INDUSTRY

1.0 INTRODUCTION:

With the growth of oil & gas industry day by day, more and more complex process operations are required to be performed efficiently & economically. These factors add to it, an inbuilt potential hazard to safety. In the standard OISD-152 on "Safety Instrumentation for Process Systems in Hydrocarbon Industry, minimum required level of safety instrumentation for various equipment were dealt with in detail for the process operations in on shore production facilities, gas processing units, refineries and petrochemical process plants.
However marketing & pipeline installations, cross country pipelines, entire offshore facilities and on shore transportation facilities for gas & crude from oil fields and wellheads are excluded from the scope of OISD Std-152.

Once all necessary safety features are provided to meet the plant and personnel requirements during the plant design and detailed engineering through comprehensive automatic interlocks based on instrumentation, next important step is to keep them in proper working condition by continuous efforts which require periodic checks, maintenance & inspection. Particularly certain Trips and Alarms, though may not operate for years together, one has to take pain to keep them 'working' at every moment for any eventuality that may come even once in lifetime. Successful functioning of safety system can save lives & valuable assets.

Hence, this standard is prepared to spell out minimum requirement with respect to inspection & maintenance of safety instrumentation, which will keep it ready in proper working condition. This standard is not intended to apply to the process control instrumentation.

2.0 SCOPE:

This standard covers safety instrumentation with pneumatic, hydraulic, electrical & electronic / microprocessor system used in oil & gas installations and which are responsible for pre-trip alarm and plant trip.

The standard gives pre-commissioning checks to review the completion of erection / installation work in a project. It also covers the inspection checks & procedures with schedules to be followed for these instrumentations in an operating plant. For various Alarms and Trip system, it gives maintenance check lists with recommended frequencies for ensuring proper functioning. The standard specifies the test equipment used in workshops and fields, required for the calibration of these instruments.

At the end, general guidelines needed for imparting training to maintenance and operating staff and documentation requirements are also covered.

3.0 DEFINITIONS / BRIEF DESCRIPTION

3.1 SHOULD: Indicates that provision is recommendatory as per good engineering practices.

3.2 SHALL: Indicates provisions that are mandatory in nature.

3.3 ALARP: Risk reduced to a level that is "As Low As Reasonably Practicable".

3.4 BASIC PROCESS CONTROL SYSTEM (BPCS): Basic Process Control System provides normal operation functions. It generally includes basic control and monitoring of process operation through operator supervision.

3.5 CALIBRATION: Calibration is a comparison of measuring EQUIPMENT against a standard instrument of higher accuracy to detect, correlate, adjust, rectify and document the accuracy of the instrument being compared.

3.6 CONTROLLER LOADING: The percentage of time a sub-system spends in carrying out various activities in reference to the use of CPU time, memory and communication capacity in the worst case of sub-system activities out of the designed / designated cycle time of the sub-system.

3.7 EMERGENCY SHUTDOWN SYSTEM (ESD) : A system (confirming to a certain SIL level as per IEC 61508) of manual / automatic interventions depending on process criticality, when activated brings the equipment / facility to a safe and non-operating mode without following the predefined sequence /procedures. An Automatic Safety Shutdown System (ASSS) is a prevention safety layer, which takes automatic and independent action following predefined operating & safety logic to prevent a hazardous incident from occurring and to protect personnel, plant and equipment. An auto or manual trip system required under SIS should cater minimum requirement as under:

PHA study based identification of critical parameters for system trip. Independent Sensing element of each trip initiating parameter (preferably direct mounted).

Direct Type switch or Microprocessor based SMART Transmitters for Trip actuation.

Audio-visual alarms on trips.

Voting logic configuration for trip actuation on critical parameters to avert spurious shutdowns.

3.8 EQUALISING VALVE: The normally close valve connecting high pressure and low pressure side of a differential pressure instrument used for checking zero reading of instrument.

3.9 **FACTORY ACCEPTANCE TEST**: Testing of system performance at vendor works as per approved procedure duly witnessed by the owner or his representative.

3.10 **FAIL SAFE POSITION**: The position of final control element in case of pneumatic or hydraulic or electric supply failure.

3.11 **FIRE, GAS & SMOKE DETECTION (FGSD) SYSTEM:**

A system that detects following at an early stage:

- Presence of flammable and toxic gases;
- Presence of a fire;
- Presence of smoke from smouldering or incipient fires.

FGSD system generates alarms, warnings and / or initiates shutdown functions and / or actuates fire fighting system. Also, based on pre-defined criticality on identified scenarios, it may be configured to initiate evacuation process, reports generation, historisation of data & events at predetermined level of concentrations. Associated electrical or electronics circuits connecting with the field devices of detection system require high availability and reliability in conformance to SIL level as per IEC 61508 or equivalent international standards. Initiating devices like gas/fire detectors should be in line with applicable standards such as NFPA-72, EN-54 or equivalent.

3.12 **FLUSHING**: Process of blowing the system with a fluid usually steam, gas or air of specified pressure for a specified time to remove foreign material, rust, dust, grease, moisture etc. from the system.

3.13 **HAZARD:** Potential Source of harm / accident

3.14 **HYDROSTATIC / PRESSURE TESTS**: Test for leakage by filling the system with liquid, usually water, up to specified pressure and observing loss of pressure for specified time.

3.15 **IMPULSE PIPING**: Piping and / or tubing from take off valves up to the instrument including drain/vent valves for the instrument.

3.16 **IMMERSION LENGTH**: The length of thermowell after the flange face/pipe connection thread/socket which is inserted inside the pipe.

3.17 **LOGIC SOLVER**: The instrumentation system used for execution of logic required for achieving the functional safety (like PLC, Solid State Devices, programmable devices, relay based interlocks etc.)

3.18 **LOOP CHECKING**: Process of checking the loop performance by giving pneumatic/electric signal at field for observing readings/response at control system for sensors and by giving signal from control system for observing the response of final control element.

3.19 **MACHINE SAFETY FEATURES:** These are in-built safety provisions or those additionally advised by the OEM (Original Equipment Manufacturer)/vendor for protection of the process equipment in emergencies. It includes alarms and trip signals required to be integrated with the trip logic system of the equipment and the process system. For example an automatically operated shutdown valve (SDV) used for the protection of process equipment is suitably configured for identified emergency scenarios.

Maintenance Override Switch: The switch operated to bypass the trip while the instrument is taken for maintenance.

3.20 **PARTIAL STROKE TESTING (PST)**: Online testing by partially operating the final control element without upsetting the process.

3.21 **PLANNED SHUTDOWN**: Planned plant outage for checking healthiness and overhauling of the equipment (not normally possible when plant is operational), to bring it back to the original condition as close as practicably possible.

3.22 **PNEUMATIC TESTS**: Test for leakage by filling the system with air specified pressure and observing the leaks with soap solution and bubbler unit.

3.23 **PRE - COMMISSIONING CHECKS**: Activities performed prior to operation stage for ensuring safe and smooth start up such as cold alignment checks, loop checking, etc.

3.24 **PROOF TEST**: Test performed to reveal undetected faults in a Safety Instrumented System (that includes valve, actuator, actuator / valve coupling, solenoid valve, quick exhaust valve, logic solver and measure instruments) so that, if necessary, the system can be restored to its designed functionality. The total proof test is also necessary to verify the full functionality of the safety loop for the required SIL level, where ever SIL levels are assigned.

3.25 **RISK:** It is the combination of the likelihood of an accident with the severity of potential consequences. It is possible to make quantitative risk assessment to judge whether the risk involved in a situation is acceptable or not.

3.26 **REDUNDANCY**: The system component takes over automatically in the event of the failure of the main component without causing any interruption in the system and upsetting the process.

3.27 **SAFETY DEVICE:** An instrument of control or mechanism used for the safety of the system.

3.28 SAFETY INSTRUMENTATION: Instrumentation responsible / utilised for achieving functional safety. Functional safety is part of overall safety which depends upon correct functioning of the safety related systems. Particularly for this standard Safety Instrumentation is considered as the instrumentation responsible to achieve Safety Instrumented System functions, pre alarms related to Safety Instrumented System and Fire & Gas detectors.

3.29 SAFETY INSTRUMENTATION FUNCTION (SIF): Safety instrumentation function is set of associated sensor(s), logic solver(s) and final control element(s), with a specified safety integrity level, provided to achieve functional safety and which can be either a safety instrumented protection function or control function.

3.30 SAFETY INSTRUMENTED SYSTEM (SIS): Safety Instrumented System (SIS) is composed of software & hardware which takes the process to a safe state when predetermined conditions, as set on control parameters like pressure, temperature, levels, flow etc, are violated. So, SIS protects against the possibility of a process excursion developing into an incident and limits the excursion potential.

3.31 SAFETY INTEGRITY LEVEL (SIL): Safety Integrity Level (SIL) is a measure of reliability /integrity of safety instrumented system when a process demand occurs. The level of reliability is defined in the scale of 1 to 4 as SIL-1, SIL-2, SIL-3 & SIL-4; wherein SIL-4 designates highest reliability level of safety instrumented system.

3.32 SENSOR: A device that measures the process condition.

3.33 TAKE-OFF VALVES: The valve mounted directly on equipment/ pipe/ standpipe and is operated to isolate instrument and connected impulse pipe.

4.0 PRE-COMMISSIONING CHECKS:

Pre-commissioning checks are intended to review the status of the completion of erection work as per relevant standards, specified documents and drawings, inspection of workmanship and preparation of checklist to take corrective action, wherever necessary, prior to commissioning of the new facility.

These activities are the non-operating tests, cold alignment checks, loop checking & interlock checking that are generally carried under the supervision of the owner or his representative. All the pre-commissioning checks shall be properly documented.

4.1 IMPULSE PIPING:

4.1.1 Temporary supports for the impulse piping, cable trays, ducts etc. shall be avoided. Permanent supporting shall be ensured before mechanical completion. Any temporary supports, if found, shall be removed and repair of damage sustained, if any, shall be done.

4.1.2 During fabrication of manifolds proper alignment of impulse piping shall be ensured so as to make sure that no undue strain is imparted to the instrument.

4.1.3 Hydrostatic or pneumatic tests shall be conducted on all impulse piping as per the codes, standards and specifications followed for the main piping.

4.1.4 Impulse pipes shall be flushed and drained / vented with water / dry air. Take-off valves shall be isolated, caps/plugs shall be put in place and the equalising valves, wherever provided, shall be opened.

4.1.5 Painting, Thermal tracing and insulation of the impulse pipes wherever necessary shall be ensured.

4.2 PNEUMATIC PIPING AND TUBING:

4.2.1 Air quality should be checked for Suspended Particulate Matter, Dew Points etc. before charging the instrument air.

4.2.2 All supply headers and tubing shall be cleaned by blowing with instrument air.

4.2.3 Checks for leaks and tightness of headers & tubing shall be conducted.

4.3 INSTRUMENT JUNCTION BOXES, CABLE GLANDS, CABLES AND CABLE TRAYS:

4.3.1 All electrical wiring shall be checked for insulation, continuity, termination (including ferrule checking, lugging, etc.), correct source of power and polarity.

4.3.2 All thermocouples, RTDs etc. shall be checked for proper immersion length and type of elements, proper polarity and continuity upto the receiving instruments.

4.3.3 Proper grounding of the instruments and sub-systems as recommended by the manufacturers / as required, shall be checked.

4.3.4 Checks shall be conducted for proper glanding, plugging and sealing of unused entries and termination / insulation of unused wires.

4.3.5 Checks shall be conducted for proper positioning of cover gasket and tightness of bolts.

4.3.6 Fuses of proper rating as per fuse coordination shall be used in the electrical wiring and power control circuits.

4.4 ORIFICE PLATES, THERMOWELLS, CONTROL VALVES, SHUTDOWN VALVES, REMOTE OPERATED VALVES (ROVs), IN-LINE METERS AND DIAPHRAGM SEAL TYPE METERS:

4.4.1 Orifice plates shall be checked for correct direction before installation after completion of flushing operations. Ensure unused tapping points on orifice flanges are plugged & seal welded in high pressures (600# & above), all hydrocarbon and toxic services. (modification details for this to be furnished by Mr. Atish Chakrabarty)

4.4.2 Control valves, thermowells, mass flow meters, ultrasonic flow meters, vortex flow meters, turbine meters and any other inline meters shall be isolated / removed for pressure testing/flushing of the pipeline. Shutdown valves and ROVs shall also be removed if they are not welded. These will be reinstalled after pressure testing / flushing of the pipelines.

4.4.3 Diaphragm seal type meters shall be installed after completion of pressure testing / flushing of the pipelines.

4.4.4 Control valves and shutdown valves shall be lubricated and gland packed, wherever required.

4.4.5 Ensure that vent ports (wherever applicable) are provided with sintered plugs and are not dirty.

4.5 CALIBRATION, LOOP CHECKING & INTERLOCK CHECKING:

4.5.1 Shop or field calibration of the instruments with standard test equipment having valid traceability and adjustments shall be done as required and report to be prepared & maintained.

4.5.2 Final control elements like control valves / shutdown valves shall be made mechanically free. Adjustment of stroke and field calibration of the final control element shall be done. Fail safe position of final control elements shall be checked as per P&ID.

4.5.3 Loop checking shall be done by giving pneumatic/electric signal at field instruments and by observing readings / response at control system. Similarly the response of final control element shall be observed by giving signal from control system.

4.5.4 All safety interlock circuit and control loops related to safety shall be simulated from field instruments and their correct functioning shall be ensured upto the final control element. It shall be witnessed by operations group. Report of the same shall be prepared & maintained.

4.6 LOGIC SOLVER / CONTROL SYSTEM :

4.6.1 Installation of Logic Solver / Control system shall be as per manufacturer's recommendations / installation instructions/ manuals including earthing scheme. Ensure that an additional earth pit is provided for periodical checking by isolation. There shall be separate earthing Grid for Instrumentation and Electrical systems. All earth pits shall be tagged and test records shall be maintained.

4.6.2 Ensure that Factory Acceptance Test (FAT) has covered all checks as per design specifications & approved procedure.

4.6.3 Ensure checking of all safety loops configuration (including additions done after factory acceptance tests) from input to output for correct functioning of safety logic / control scheme including trip set point, control action, input and output action, proper alarm description, operator interface, ranges, logic / control scheme; system checks like redundancy of controller/ communication/ inputs/ outputs, controller loading, load sharing of power supplies, alarm / event log, Maintenance Override Switch (MOS) operation, logging, trending after system installation at site & after connecting inputs and outputs. System backup restoration shall also be checked. Above shall enable Site Acceptance Test (SAT) after completion of remaining activities as per approved procedure.

4.6.4 Redundant power feeders shall be ensured for 'energized to trip' circuits. Line monitoring shall be checked where ever applicable. Availability of UPS common diagnostics alarm to operator shall be ensured.

4.6.5 In case of programmable logic solver / control system, backup shall be taken after every change and just before commissioning. In case a backup needs to be restored, correct revision of backup shall be ensured.

4.6.6 Checks shall be made to ensure that the logic solver / control system is designed fail safe i.e. there is no failure mode (total power failure, all processor failures, all communication failure etc.) that result into dangerous situation.

4.6.7 Checks shall be made to ensure that SIS functionalities are independent of Maintenance / Engineering interface.

4.6.8 The changes in configuration of logic solver / Control System (Safety Instrumented System) shall be made through proper change management process. Record shall be maintained for all the changes done.

4.6.9 It should be reviewed that interlocks to achieve functional safety are segregated from other interlocks. It is recommended to implement safety interlock in separate logic solver. The non-safety interlocks should be implemented in DCS and /or other separate logic solvers.

(Note: Above will optimise the size of safety logic solver system and will enable higher focus on maintaining availability of logic solver system. This will also optimise the time required for checks on logic solver system before restart in case of trip and will help reduce the down time. The possibility of system going to degraded mode and subsequent trip will also decrease).

4.7 SPECIAL INSTRUMENTS (like Analysers, Vibration Monitoring System, Antisurge Control System, Nucleonic Instruments & Gas Detectors, etc.):

4.7.1 Pre-commissioning checks for installations, testing, calibration checking etc. shall be carried out as recommended by the manufacturer/as per code, in addition to the applicable requirements stated by this standard.

4.8 OTHER MANDATORY CHECKS:

4.8.1 Checks shall be made for Electrical/Electronic equipment including accessories like cable glands, junction boxes, etc. for their suitability with respect to area classification.

4.8.2 Checks for proper filling of recommended sealing liquid, wherever required, shall be carried out.

4.8.3 Checks for the proper lubrication of the valves used in the instrumentation line shall be done and their free operation ensured.

4.8.4 Proper identification tag on cables, junction boxes and instruments shall be ensured.

4.8.5 All instrument vents and drains shall be provided with caps / plugs.

4.8.6 Checks shall be made for ensuring availability of uninterrupted power supply to all components of safety instrumented system.

4.8.7 Covers of junction boxes/ field instruments/ field mounted panels should be fixed after proper sealing and greasing.

5.0 ON STREAM INSPECTION AND MAINTENANCE CHECKS:

Inspection and Maintenance checks and procedures to be followed for instruments are covered here with prescribed frequency. In case, the instrument is a part of SIL verified safety instrumented function, then the ‘test interval’ considered during the SIL verification shall replace the prescribed frequency. This checking shall be followed by necessary overhauling, lubrication, calibration and setting etc., if required. All inspection and maintenance checks shall be properly documented.

5.1 IMPULSE LINES & PIPE FITTINGS:

The impulse lines and fittings are practically exposed to the actual operating conditions, hence require thorough inspection to ensure plant and personnel safety. The following checks shall be carried out, as specified below.

5.1.1 Condition of the impulse lines and fittings shall be checked for external corrosion & erosion. Corrosion under insulation shall also be checked. Replacement, hydro-testing and painting shall be done as required.

FREQUENCY: The impulse lines & fittings used for severe services like High Pressure (600# rating & above), High Temperature (500^0 C & above), corrosive & erosive services, H_2 service and LPG service shall be checked in every shut down and for all other services at least once in six years.

5.1.2 Physical inspection of instrument supports and painting (if required) of the same, at least once in a year.

5.1.3 Checks shall be made for undue vibrations and mechanical damage to impulse piping and fittings, at least once in a year. Corrective measures are to be taken as required.

5.2 INSTRUMENT JUNCTION BOXES, CABLE GLANDS, CABLES AND CABLE TRAYS:

These equipment need utmost care due to the fact that they carry power to the instruments and are potential hazards in case of poor maintenance. It is worthwhile to note that these items are handled frequently and hence need closer monitoring. The following checks shall be carried out after taking necessary precautions.

5.2.1 Inspection for proper glanding of the cables as regard to their size, installation, tagging and suitability to the area classification.

5.2.2 Inspection of all unused cable entries. Shall be plugged if observed.

5.2.3 Inspection of cover(s) for presence of all bolts & their tightening.

5.2.4 Inspection of general condition of the junction boxes, junction box stencilling/ tagging along with supports and to paint them as required. Undue vibration of Junction boxed shall be arrested.

5.2.5 Junction box earthing connectivity shall be checked.

FREQUENCY: For all above, once in a year

5.2.6 Opening the junction boxes and inspecting the condition of gaskets, grease on bolts/ cover threads and terminal strips including termination/proper sealing of unused wire.

FREQUENCY : Every planned shutdown.

5.2.7 Inspection of cable route including cable tray / cable duct shall be carried out. Exposure to hostile environment shall also be corrected, if required.

FREQUENCY: Once in three years.

5.3 FIELD TRANSMITTERS (LEVEL, FLOW, PRESSURE & TEMPERATURE etc.):

The following checks shall be carried out periodically:

5.3.1 Inspection of the external chamber type level instruments for any external pitting, corrosion & erosion after removing insulation wherever required, at least once in six years. Replacement, hydrotesting and painting shall be done as required.

5.3.2 Inspection of the cooling system, radiation shields provided for Nucleonic Detectors shall be done at least once in a year and corrected as required.

5.4 THERMOCOUPLES & THERMOWELLS:

Thermocouples and Thermowells are instruments which are directly mounted on the process lines without isolation valves and hence need closer checks. The following checks shall be carried out periodically:

5.4.1 Visual check of thermowells, flanges and conduits for external pitting and corrosion.

FREQUENCY: Once in six years in planned shutdown

5.4.2 Thermowells used for severe services like high velocity (above 10 m/s) & high temperature (above 500 Deg C), higher pressure (600# & above), 2-phase flow, corrosive and/ or erosive service, hydrogen service, IBR steam services shall undergo hydro-test at 150% of operating pressure or test pressure as per code, externally & internally and/or other non-destructive tests.

FREQUENCY: Once in six years in planned shutdown

5.4.3 Inspection of skin thermocouples for surface cracks, mounting clamps, breakages and welding cracks, if applicable.

FREQUENCY: Every planned shutdown

5.4.4 Inspection of sealing elements for special design temperature elements. FREQUENCY: Every planned Shut down.

5.5 FINAL CONTROL ELEMENTS:

The final control element, being the actual device that regulates the various process parameters, needs to be checked periodically to avoid any unsafe conditions. The following checks shall be carried out for all the final control elements used in the safety shutdown system.

5.5.1 Hydrotest at 1.5 times of the maximum operating pressure shall be done. Seat leak test shall also be done, by removal if they are not welded.

5.5.2 If tests as mentioned above fails, valve internals for pitting and erosion shall be checked. In case of body damage, non-destructive test to be carried out and suitability for reuse to be ascertained, if required.

(FREQUENCY: For all above, at least once in six years or during planned shutdown).

5.5.3 Visual inspection for all final control elements including accessories like air filter regulators, valve positioners, I/P convertors, limit switches, solenoid valves, sintered plugs at vent ports shall be carried out at least once in six months.

5.5.4 Physical inspection of instrument headers in the plant should be done for detecting leakages/ corrosion. Checking of leakage in instrument air piping & tubing for all the joints shall be done with soap solution and leakages, if any, to be arrested.

FREQUENCY: Once every year

5.5.5 Air quality should be checked for Suspended Particulate Matter, Dew Points etc.

FREQUENCY: Once in six months

5.6 LOGIC SOLVER/ CONTROL SYSTEM:

5.6.1 Inspection & Maintenance of Logic solver / Control system shall be as per manufacturer’s recommendations / maintenance manuals including earthing scheme and records shall be maintained.

5.6.2 Following maintenance / checks should be done at prescribed frequency as given below:

a	System status and Fault Diagnosis including loop faults	Daily
b	Earth leakage detector	Daily
c	Interlock Bypass information	Daily
d	Monitoring temperature levels	Monthly
e	Monitoring environmental conditions (corrosion/humidity/dust) levels	Quarterly
f	Checking of various level voltages	Shutdown
g	Checking of power supplies including load testing	Shutdown
h	Proper grounding	Shutdown
I	Cleaning of modules	Shutdown
j	Redundancy checks	Shutdown

5.6.3 In case of programmable Logic Solver / control system, backup shall be taken after every change. In case a backup needs to be restored, correct revision of backup shall be ensured.

5.6.4 The changes in configuration of Logic Solver / Control System (Safety Instrumented System) shall be made through proper change management process. Record shall be maintained for all the changes done.

5.6.5 Alarm Management System:
Functionality and maintenance requirement as detailed in OISD 152 clause number 6.6 shall be followed.

5.6.6 Instrument Asset Management System (IAMS):

Instrument Asset Management System, if provided, should be used as a software tool to establish a computerised maintenance management system. It communicates directly to field instruments over control system communication network to access instrument information. Periodic review of the diagnostic information from instruments along with the database available in the system should be used to conduct regular predictive and preventive maintenance activities.

6.0 FUNCTIONAL CHECKS:

All instruments generating pre-alarms & trips, associated logic solvers and final control elements need to undergo functional checking at prescribed frequency. Same are mentioned in following sub sections. In case, the instrument is a part of SIL verified Safety Instrumented Function, then the ‘test interval’ considered during the SIL verification shall replace the prescribed frequency. This checking shall be followed by necessary overhauling, lubrication, calibration and setting etc., if required.

6.1 HARDWIRED ANNUNCIATOR

Press test button and see that all alarm lamps are flashing and audio system works.

FREQUENCY: Once in shift (8 hrs.)

6.2 LEVEL ALARMS:

6.2.1 Level Switch/Transmitters (external):

Create high or low level condition (depending on whether it is high or low level alarm) by moving the float from the bottom or by filling or draining the float chamber with process liquid or water.

FREQUENCY – During planned shutdown

6.2.2 Level Switches/Transmitters (internal):

Create actual high level or low level in the vessel and check the alarm wherever possible. Alternate method should be followed where ever it is not possible.

Special level instruments like RADAR, SERVO, ULTRASONIC, NUCLEONIC, etc. should be checked as per OEM recommendations.

FREQUENCY – During planned shutdown.

Servo Level Instruments when used in safety service, must be inspected and calibrated on regular basis (at least once in three months).

To ensure proper functioning of Radar Level instruments Still pipe shall be considered for floating roof tanks, LPG sphere bullets and vessels with agitators.

To ensure proper functioning of Ultrasonic Level Transmitter it should be mounted in such a way that the upper level limit doesn't fall within its dead band. For highly turbulent fluids, the transmitter should have dampening adjustment features. If chances of high dust, vapour formation or acid fumes are envisaged, beam guide shall be provided or an alternate method of level measurement should be used.

6.2.3 Level Transmitter (Differential Pressure Type):

Create high or low level condition from the transmitter and check alarm.

FREQUENCY : During planned shutdown.

6.3 TEMPERATURE ALARMS:

6.3.1 Thermocouple or Resistance Temperature Detector (RTD): Disconnect at the Thermocouple or RTD head and feed millivolts or connect variable resistance box from the head and check alarm. The thermocouple / RTDs response shall be checked, where ever possible, in temperature bath with standard thermometers.

FREQUENCY : During planned shutdown.

6.3.2 Filled system type temperature switches (rigid stem or capillary type): Remove switches and test them in temperature bath with standard thermometers. The switch contact shall be opened / closed and alarm verified.

FREQUENCY : During planned shutdown

6.4 FLOW ALARMS:

Create low or high flow condition from the transmitter and verify alarm.

FREQUENCY : During planned shutdown

6.5 PRESSURE ALARM:

Create high or low pressure condition with any standard equipment from the instrument and check the alarm.

FREQUENCY : During planned shutdown .

6.6 GAS ALARMS (HC GAS DETECTORS & TOXIC GAS DETECTORS LIKE H2S, BENZENE, CL2 ETC.):

The gas alarms / detectors shall be calibrated with the help of standard gases.

FREQUENCY : Once in 6 months

6.7 MISCELLANEOUS ALARMS:

Alarm for PH/ conductivity/ flame/ speed/ Vibration etc. as applicable shall be checked and calibrated as recommended by OEM.

FREQUENCY: During planned shutdown.

6.8 TRIP SYSTEM:

Trip system (complete system including power supply system, transmitters, switches, relays, logic system of DCS/PLC, solenoid valves, lamps, interconnecting cables, final control elements) shall be checked for the proper functioning. The method of checking the sensors shall be as per clause # 6.2 to 6.7 as applicable.

Ensure checking of all safety loops (including additions/ modifications during shutdown) from input to output for correct functioning of safety logic / control scheme including trip set point, control action, input and output action, system checks like redundancy of controller/ communication/ inputs/ outputs, controller loading, load sharing of power supplies, alarm / event log, Maintenance Override Switch Operation logging. System backup restoration and antivirus functioning as per requirement shall also be checked.

Any change shall be made only after due authentication by competent authority through proper change management process.

FREQUENCY: During every planned shutdown or as per Test Intervals specified for SIL certified loops.

6.9 FINAL CONTROL ELEMENT:

The operation of all final control elements along with SOVs, ROVs Excess Flow Check Valves, volume booster, quick exhaust valve etc. shall be verified by changing system output as per safety function, as a minimum and properly documented.

Full stroke time of the valve wherever specified shall be verified and noted.

FREQUENCY: Every planned shutdown

Shutdown valves always remain in one position. To increase the probability of the valve to respond on demand, Partial Stroke Test (PST) should be carried out, wherever PST facility is provided.

FREQUENCY: Every six months

7.0 TEST EQUIPMENT:

Scope of this standard includes two types of test equipment:

1. Workshop Testing Equipment

2. Field Testing Equipment.

Test equipment, whether it is for workshop or field use, should be of accuracy better than the instruments being calibrated. All test equipment should have the traceability to the National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited test lab.

The test equipment listed is the minimum required for testing / calibration of safety instrumentation.

The accuracy of the test equipment should be as per **Annexure- I.**

7.1 WORKSHOP EQUIPMENT:

The workshop equipment can be put under following categories:

7.1.1 Universal Test bench for calibrating all type of instruments and / or the test equipment for:

(a) Pressure Instruments

(b) Temperature Instruments.

(c) Control Valves

(d) Electronic Instruments

7.1.2 Testing Equipment for Pressure Instruments:

(i) Dead weight Tester

Range :
(1) 0-10 Kg/Sq. Cm
(2) 0-100 Kg/Sq. Cm
(3) As per requirement.

(ii) Air dead weight Tester for dry calibration.
Range : 0-7 Kg/Sq. Cm

(iii) Vacuum Pumps
Range : 0- 760 mm of Hg.

(iv) Vacuum Gauge Tester
Range : 0-760 mm Hg.

(v) Portable Pneumatic Calibrator with precision gauge of min. 200 mm dial size having Range - 10000 mm to + 20000 mm WC (Water Column) with precision regulator and a pneumatic switch block.

(vi) Comparator with Standard Pressure Gauges of various ranges

(vii) Hand actuated pressure and vacuum pumps.
Range : 700 mm Hg. Vac. to 5.0 Kg/Sq. Cm

(viii) Mercury Manometers
Range : 0-2.0 Kg/Sq. Cm

(ix) Inclined Manometer
Range : 0-200 mm WC

(x) Work bench equipped with precision regulator, air supply, gauges for seeing the input/output, electrical power supply etc.

(xi) Precision Pressure Regulators of various ranges.

7.1.3 Testing Equipment for Temperature Instrument:

(i) Reference sensor for applicable type thermocouple:

ii) Temperature Indicator/Calibrator (Digital) for measurement and simulating Thermocouples, RTDs, Millivolts etc.

iii) Resistance Temperature Simulator (Decade Box):

Range 0.01 Ohms to 1111.110 Ohms

iv) Precision Thermometer sets ASTM auxiliary quality, NBS certification, Ice point scales

Scale			Divisions
-38	to	2 Deg.C	1/10 Deg.C
- 8	to	32 Deg.C	1/10 Deg.C
25	to	55 Deg.C	1/10 Deg.C
50	to	80 Deg.C	1/10 Deg.C
75	to	105 Deg.C	1/10 Deg.C
95	to	155 Deg.C	1/5 Deg.C
145	to	205 Deg.C	1/5 Deg.C
195	to	305 Deg.C	1/2 Deg.C
295	to	405 Deg.C	1/2 Deg.C

(v) Temperature Calibration Test Bath

Range: -40 Deg.C to 600 Deg.C.

(vi) Liquid Temperature Bath System

Range: 22 to 250 Deg.C

(vii) Portable hand held temperature indicator with different probes.

(a) For Thermocouples (b) For RTDs.

7.1.4 Testing Equipment & facilities for Control Valves / Shut off Valves:

(a) Hydraulic system for pressure testing of control valves.

(b) Lapping Arrangement.

(c) Leakage Testing Facility.

7.1.5 Test Equipment for Electronic Equipment

(1) Digital Multimeters, $3^1/_2$ Digit

(2) Function Generator

(3) Frequency Counter

(4) Oscilloscope

(5) Variable D.C. Power Supply

(6) Work Bench for Electronic Instruments

(7) DC Current source.

7.1.6 Testing & calibration facilities for Gas Detectors:

7.2 FIELD EQUIPMENT:

The following facilities should be provided at plant site(s).

7.2.1 Portable Calibration Kit.

7.2.2 Multimeters

7.2.3 Intrinsically safe RTD Calibrator/Simulator

7.2.4 Intrinsically safe Thermocouple Calibrator/Simulator.

7.2.5 4-20 MA current source plus Transmitter Simulator.

7.2.6 Squeeze Bulb for small signal generation.

7.2.7 Megger & Earth testing device.

7.2.8 Configuration / Field communication device for Programing /configuring field instrument such as RADAR/ Servo/ Ultrasonic meters, Vibration Monitoring System, PLCs, etc.

7.2.9 Universal field Calibrator

7.2.10 Fibre Optic Testing Equipment

7.2.11 Network Testing Equipment/ Software

7.2.12 Radiation Survey Meter for Nucleonic Instrument

7.2.13 Field Bus Tester

8.0 TRAINING:

GENERAL GUIDE LINE

The training plays a very important part in safe operation and maintenance of the plant. The training is required for Maintenance staff and the Operation personnel who handle the instruments.

8.1 TRAINING OF MAINTENANCE STAFF:

In addition to the Basic / Advanced Instrumentation training as required to handle field instruments, DCS/PLC, Analysers etc. the following training as a minimum shall be imparted.

8.1.1 Training on Process and its safety instrumentation:

Whenever a new plant is constructed or whenever an instrument personnel joins new plant, training shall be given on process and its safety instrumentation.

8.1.2 Training on new instrument / equipment:

Whenever a new instrument/system are procured, training of instrument staff on maintenance aspects shall be given either at vendors' works or in-house by qualified trainer on the actual equipment.

8.1.3 Training on SIS as per IEC61508/61511

Training should be imparted for the maintenance of Safety Instrument System in line with IEC61508/61511.

8.1.3 Refresher Course:

Refresher course should be given to maintenance staff at regular intervals about calibration/ maintenance procedures for vital equipment including special instruments and safety interlocks.

8.2 TRAINING OF OPERATION STAFF:

8.2.1 Training on Safety Instrumentation:

(i) Whenever a new plant is constructed or operation personnel join a new plant, they shall be given training on safety instrumentation.

(ii) Whenever a new instrument / system are installed, training to Operation staff shall be given on the actual equipment wherever necessary.

8.2.2 Refresher Course:

Suitable orientation / refresher courses shall be organised for Operating personnel at regular intervals.

9.0 Documentation:

The following documents shall be maintained till their prescribed retention period as decided by respective organisations to ensure that necessary information is available when required for continuous operation of safety instrumentation. The list of such documents/ manuals shall be readily available with the instrumentation staff.

9.1 Instrumentation Specifications and Data Sheets.

9.2 Description of safety instrumented function (could be in the form of cause & effect charts, ladder logic diagrams, logic write-up, sequence charts, logic diagrams etc.)

9.3 Alarms & Trip Settings, Timer & Counter Settings.

9.4 Installation manuals, Operating Manuals, Maintenance Manuals.

9.5 Interlock test / proof test procedures

9.6 Maintenance & Calibration Schedule

9.7 FAT / SAT reports

9.8 Documentation / records required by this standard, as detailed in **Annexure - II**.

General Guidelines for Accuracy of calibrators

ANNEXURE – I

No.	Type of Parameter	Parameter Range	Function	Accuracy	Equipment
1	Electrical parameters	VOLTAGE – 1000V AC/DC	Measure	±0.05%	Digital Multimeter (3 ½ digit)
		DC Current	Measure	±0.2%	
		AC Current	Measure	±1%	
		Resistance up to 50MΩ	Measure	±1%	
		0-24mA Source / Measure	Source/Measure	± 0.015%	Loop Calibrator
		0-50V Measure	Measure	± 0.015%	
2	Pressure parameter	Pressure Tester – Hydraulic -700 bar	Sourece	± 0.015%	Dead Weight Tester
		DP.Guage (0 - 140 bar)	Measure	± 0.02% FS	Digital Pressure Guage, Pressure/Vacuum Pumps
		Digital Manometer ((-1) – 7bar)	Measure	± 0.2% FS	
3	Electrical / Pressure	Press (-)1 - 21 BAR	Source	± 0.025%FS	Multifunction calibrator
		Simulation 0-10 VDC	Source	± 0.03%	
		Simulation 0-25 mA	Source	± 0.03%	
		Measure 30 VDC	Measure	± 0.03%	
		Measure 25 mA DC	Measure	± 0.03%	
		Resistance 0 - 3900Ω	Source/Measure	± 0.03%	
		Frequency up to 20kHz	Source/Measure	± 0.05%	
4	Temperature	PRT PT-100 ((-)150 – 650 °C)	Measure	± 0.2%	Special type Sensors (RTD/Thermocouple)
		Thermocouple- R/S TYPE (Up to 1200°C)	Measure	± 0.4%	
		Temperature Bath (0-300 Deg C)	Source	± 0.5 degC	Temp. Bath
		Temperature Bath (300 - 1200 Deg C)	Source	± 5.0 degC	Temp. Bath
		Resistance Box (0.1 to 1111.2 ohms)	Source	± 0.01 Ohm	Decade Box
5	Wave forms	Frequency	Source	NA	Function Generator
		Oscilloscope	Measure	NA	Oscilloscope
6	Control Valve Maint.	Hydraulic system for pressure testing of CV	Valve Body leakage testing	NA	Pressure Pump with hydrotest assembly
		Lapping arrangement	Plug/seat lapping	NA	Lapping compound (course/fine), tool for plug holding/rotation
		Leakage testing Facility	Plug/seat leakage testing	NA	Air pressure set up with rotameter (as per leakage class)
7	Smoke/Gas Detectors	Testing/calibration facility of Smoke/Gas detectors	Source	NA	Gas cylinder / Canister
8	Work Bench	Bench with precision regulaor, air supply, pressure guages, electrical power supplies	Infrastructure	NA	Bench with Power supply (240v AC, 110v AC/DC, 24 V DC), Air supply with Pressure guages

<u>General Guidelines for Accuracy of calibrators</u>

Elecrtical parameters	4 times the accuracy of equipment under test (except pressure)
Pressure parameters	3 times the accuracy of equipment under test
Temperature parameters	As per available 'special sensors'

List of Documents to be maintained as per OISD-STD-153 ANNEXURE- II

PRE COMMISSIONING CHECKS

Sl. No:	Document	Ref Clause in STD 153	
1	Pre commissioning check of Impulse piping	4.1	
2	Impulse piping hydrotest / pneumatic test report	4.1.3	
3	Pre commissioning check of Pneumatic piping & tubing	4.2	
4	Pre commissioning check of JB, cable gland, cabling & trays	4.3	
5	Fuse coordination report	4.3.6	
6	Pre commissioning check of thermowell, orifice, valves, ROV & In line meters	4.4	
7	Calibration report of instruments	4.5.1	
8	Loop checking reports	4.5.3	
9	Interlock checking reports	4.5.4	
10	Earth pit test records	4.6.1	
11	FAT reports	4.6.2	
12	SAT reports	4.6.3	
13	Latest Software back ups	4.6.5	
14	ESD logic change management records	4.6.8	
	REGULAR INSPECTION & MAINTENANCE CHECKS		Minimum Frequency
1	Inspection reports of Impulse lines & Fittings	5.1	once in 6 years
2	Hydro test reports of Impulse lines	5.1.1	as mentioned in clause 4.1.1.
3	Inspection report of supports, undue vibration & mechanical damage	5.1.3	once in a year
4	Inspection report of JB, cable glands, cable & cable trays	5.2	once in a year
5	Inspection report of JB internals	5.2.6	Every planned shutdown
6	Inspection report of cable route including cable tray / duct conditions	5.2.7	once in 3 years
7	Inspection report of external chamber level instrument	5.3.1	once in 6 years
8	Inspection report of cooling system / radiation shields of Nucleonic detectors	5.3.3	once in a year
9	Inspection report on visual check of thermowells, flanges and conduits & Skin T/C	5.4.1 , 5.4.3	once in 6 years in planned shutdown
10	Hydrotest reports of thermowells in severe service	5.4.2	once in 6 years in planned shutdown

11	Inspection report of sealing element for special design temperature element	5.4.4	once in 6 years and once in planned S/D for severe service
12	Hydraulic / Seat leak test report of final control elements (valves)	5.5.1	once in 6 years in planned shutdown
13	Inspection report on visual check of final control elements and accessories	5.5.3	once in 6 months
14	Inspection report of instrument air header & air tubing for leakage and corrosion	5.5.4	once in a year
15	Test report of instrument air quality monitoring (dew point , SPM)	5.5.5	once in 6 months
16	Reports of the following checks on Logic solver / control system :	5.6.2	
	System status and Fault Diagnosis including loop faults		Daily
	Earth leakage detector		Daily
	Interlock Bypass information		Daily
	Monitoring temperature levels		Monthly
	Monitoring environmental conditions (corrosion/humidity/dust) levels		Quarterly
	Checking of various level voltages		Quarterly
	Checking of power supplies including load testing		Shutdown
	Proper grounding		Shutdown
	Cleaning of modules		Shutdown
	Redundancy checks		Shutdown
	Record of back ups taken with revision	5.6.3	after each change
	ESD logic change management records	5.6.4	for each change
	FUNCTIONAL CHECKS		Frequency shall be as per SIL verification, wherever applicable.
1	Test report of Hardwired annunciator	6.1	once in a shift
2	Functional check report of Level alarms	6.2	Every planned shutdown
3	Functional check report of Temperature alarms	6.3	Every planned shutdown
4	Functional check report of Flow alarms	6.4	Every planned shutdown
5	Functional check report of Pressure alarms	6.5	Every planned shutdown
6	Functional check report of HC & Toxic gas detectors	6.6	once in 6 months
7	Functional check report of misc. alarms	6.7	Every planned shutdown
8	Functional check reports of complete trip system	6.8	Every planned shutdown
9	Functional check report of Final control elements	6.9	Every planned shutdown
10	Partial stroke checking of final control elements	6.9	once in 6 months