SELECTION, OPERATION & MAINTENANCE OF COMPRESSORS

OISD-STD-120
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Prepared by

FUNCTIONAL COMMITTEE FOR REVISION OF STANDARDS ON ROTARY EQUIPMENT

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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 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 “Selection, Operation & Maintenance Of Compressors” has been thoroughly revised by the “Committee for Revision of Standards on Rotary Equipment”. This document was originally prepared in January 1990 & amended in August 1999. 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:

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These documents are intended to supplement rather than replace the prevailing statutory requirements & best engineering practices in vogue.
# Functional Committee for Revision of Standards on Rotary Equipment

*(Complete Revision: August, 2007)*

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<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>
# SELECTION, OPERATION & MAINTENANCE
OF
COMPRESSIONERS

## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Scope</td>
<td>1</td>
</tr>
<tr>
<td>3.0</td>
<td>Definitions</td>
<td>1</td>
</tr>
<tr>
<td>4.0</td>
<td>Selection of Compressors</td>
<td>2</td>
</tr>
<tr>
<td>5.0</td>
<td>Auxiliary Assemblies</td>
<td>3</td>
</tr>
<tr>
<td>6.0</td>
<td>Seals and Sealing System</td>
<td>3</td>
</tr>
<tr>
<td>7.0</td>
<td>Lubrication System</td>
<td>4</td>
</tr>
<tr>
<td>8.0</td>
<td>Process Control and Protection System</td>
<td>4</td>
</tr>
<tr>
<td>9.0</td>
<td>Equipment Monitoring and Protection System</td>
<td>5</td>
</tr>
<tr>
<td>10.0</td>
<td>Inspection and Testing</td>
<td>5</td>
</tr>
<tr>
<td>11.0</td>
<td>Erection and Commissioning</td>
<td>5</td>
</tr>
<tr>
<td>12.0</td>
<td>Operation</td>
<td>6</td>
</tr>
<tr>
<td>13.0</td>
<td>Maintenance</td>
<td>7</td>
</tr>
<tr>
<td>14.0</td>
<td>Change Management</td>
<td>8</td>
</tr>
<tr>
<td>15.0</td>
<td>Documentation</td>
<td>8</td>
</tr>
<tr>
<td>16.0</td>
<td>References</td>
<td>9</td>
</tr>
</tbody>
</table>

### Annexures

1. Guidelines for Compressor Design and Manufacture
2. A Typical Seals and Sealing System Design, Alarm and Trips
3. Guidelines for Machine Condition Monitoring System
4. A Typical Installation and Test Procedure (ITP) For Compressors
5. Typical Preventive Maintenance Schedule
SELECTION, OPERATION AND MAINTENANCE OF COMPRESSORS

1.0 INTRODUCTION

Compressors are used to increase the pressure of a wide variety of gases and vapors for a multitude of purposes. The pressure of the fluid is increased by reducing the fluid specific volume during passage of the fluid through the compressor.

Compressors can be classified as reciprocating, rotary, jet, centrifugal, or axial-flow, depending on the mechanical means used to produce compression of the fluid, or as positive-displacement or dynamic-type, depending on how the mechanical elements act on the fluid to be compressed. Positive-displacement compressors confine successive volumes of fluid within a closed space in which the pressure of the fluid is increased as the volume of the closed space is decreased. Dynamic-type compressors use rotating vanes or impellers to impart velocity and pressure to the fluid.

Compressors in Hydrocarbon Industry are vital equipment and hence their proper selection, operation & maintenance are critical for safety and environment. This standard has been developed considering the importance of Compressors in the overall safety of the Hydrocarbon Industry.

2.0 SCOPE

This document covers the safety aspects in selection, installation & commissioning and operation & maintenance of compressors and their associated systems in hydrocarbon industry.

3.0 DEFINITIONS

3.1 SETTLING OUT PRESSURE

The pressure of the compressor system when the compressor is shut down.

3.2 SURGE

The volume flow capacity below which a centrifugal compressor becomes aerodynamically unstable.

3.3 AXIALLY SPLIT

A joint that is parallel to the shaft center line.

3.4 RADIALLLY SPLIT

A joint that is perpendicular to the shaft center line.

3.5 SHAFT END SEALS

The process gas seal on the end of the shaft which restricts leakage of process gas.

3.6 HYDRODYNAMIC BEARINGS

Bearings that use the principles of hydrodynamic lubrication. Here, the bearing surfaces are oriented so that relative motion forms an oil wedge, or wedges, to support the load without shaft-to-bearing contact.

3.7 SHALL

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Indicates mandatory requirement

3.8 SHOULD
Indicates recommendation which is advisory but not mandatory

3.9 NORMAL OPERATING POINT
The point at which usual operation is expected and optimum efficiency is desired.

4.0 SELECTION OF COMPRESSORS
The following factors shall be considered for selection of compressors:
   a. Service
   b. Temperature
   c. Pressure
The compressor shall comply with the applicable equipment and OISD standards.

Motors, electrical components and electrical installations shall be suitable for the area classification as per OISD STD-113 and approved by Chief Controller of Explosives, wherever necessary.

4.1 SERVICE
i) Consideration shall be given to the characteristics of process gas which have high potential to cause compressor failures, such as flow/pressure fluctuations, reactivity, particulate size and contaminant levels etc.

ii) The basic compressor design and materials shall be selected considering the fluid factors such as gas composition, toxicity and flammability.

iii) In case of centrifugal compressors, radial split (barrel) type design should be considered for Hydrogen/Hydrogen-rich service, while axial split for other services.

iv) Rotational speeds of reciprocating compressors in Hydrogen service should be limited to a maximum of 350 RPM.

v) Compressor shall be designed for the extreme temperature limits specified for gases that polymerize, like cracked gas.

vi) Where the process fluid contains contaminants like H$_2$S, manufacturing process shall require materials and special heat treatment in conformity with NACE MR-103 Standard.

4.2 TEMPERATURE
i) The basic compressor design, materials, seals and sealing arrangements shall be suitable for the lowest and highest operating temperatures in the system.
ii) In case of reciprocating compressor in utility services, the discharge temperature should not exceed 170 degree centigrade.

4.3 PRESSURE

i) The basic compressor design and materials, seals and sealing system shall be suitable for the lowest and highest operating pressures in the system.

ii) In the case of centrifugal compressors, radial split design (barrel) and forged construction should be used for pressures above 20 bar.

5.0 AUXILIARY ASSEMBLIES

i) All process gas connections to the casing shall be suitable for maximum allowable working pressure of the casing.

ii) Connections welded to the casing shall meet the material requirements of the casing, including impact values, rather than the requirements of the connected piping. All connection welding shall be completed before the casing is hydrostatically tested.

iii) In case of reciprocating compressor, crank case explosion relief device shall be provided in process gas service.

iv) Pulsation suppressor connections shall be flanged in positive displacement compressors.

v) All connections shall be suitable for the hydrostatic test pressure of the region of the casing to which they are attached.

vi) Vents and drains shall be routed to safe location, and double block valves shall be provided for compressors in Hydrocarbon service.

The general guidelines for consideration of above parameters in compressor design are placed at Annexure-1.

6.0 SEALS AND SEALING SYSTEM

i) The seals & sealing systems shall meet relevant equipment standard requirements and OISD-STD-125.

ii) The sealing system shall be able to seal process gas during operation and idle (non running) condition of the compressor.

iii) Leaked gases from sealing system shall be routed to flare systems or safe locations as applicable.

iv) Level of fugitive emissions through seals shall comply with environmental and safety regulation as applicable. (Refer to OISD GDN 224m on “Monitoring & Control of Volatile Organic Compounds Emission”)

v) Sealing system should have protection against backup pressure from the flare / vent system.
vi) All centrifugal and rotary compressors handling flammable and hazardous gases shall be provided with seals having enhanced safety features such as tandem / double dry gas seals, liquid film seals and mechanical (contact) shaft seals.

vii) For Reciprocating Compressors handling flammable gases, stuffing boxes and sealing systems shall be designed to ensure that there is no leakage to the atmosphere or crankcase. Systems, like individual Non-return-valves, shall be in place to ensure that there is no leakage of process gas into the purge gas / instrument air circuits.

viii) The sealing system shall have provisions like flow-meters, pressure switches / transmitters in supply and leak off lines for indication / monitoring of seal condition. It shall also have alarms and trips, as applicable, to detect seal failures so as to prevent catastrophic situations.

The requirements and examples of a typical seals and sealing system design, alarm and trips based on seal condition for different types of compressors is placed at Annexure-2.

7.0 LUBRICATION SYSTEM

i) To guard against unsafe situations due to failure of lubrication systems, provisions for alarm or safe shutdown of the machine should be built into the system. This system shall typically be for low lube oil pressure and high lube temperature.

ii) Rundown tanks for the safe coast-down shall be provided for large high-speed turbine driven compressors.

8.0 PROCESS CONTROL & PROTECTION SYSTEM

The safety of equipment from abnormal process conditions shall be ensured by incorporating system that provides adequate protection to the equipment.

Following considerations shall be given:

i) For centrifugal / axial compressors, to prevent failures due to surge or minimum flow conditions, systems shall be equipped either with surge control systems, discharge vent or with minimum opening inlet valves in case of closed loop operations as applicable.

ii) The lower and upper limits for critical process parameters like suction & discharge pressures and suction & discharge temperatures shall be identified and necessary alarms and trips to detect failures, as applicable shall be provided.

iii) For rotary and centrifugal compressors, systems shall have necessary provisions like NRVs to prevent the reverse rotation of the equipment. NRVs should be suitably located to prevent reverse rotation incase of abrupt stoppage or tripping of the machine.

iv) Monitoring devices shall be provided for differential pressure measurement and monitoring across compressor inlet strainer with provision for alarm and trip, as applicable.

v) Provision for protections due to Lubrication system failures shall be in place.

vi) Provisions and safe operating procedures shall be in place to prevent and protect the equipment against liquid carry over from the process.

vii) Process systems shall have adequate relief and safety devices, wherever required.
9.0 EQUIPMENT MONITORING & PROTECTION SYSTEM

For safe operation the compressors shall have suitable continuous monitoring and protection systems as per provisions of OISD-RP-124 and OISD-RP-126.

In addition, the following monitoring and protection systems shall have the following:-

a) Provision to monitor the various machine conditions like vibrations, bearing metal temperatures, axial displacement, rod-drop, stuffing box temperature, oil/cooling water pressures & temperatures, etc. as applicable for different type of machines.

b) Acceptable limits defined for all machine condition parameters.

c) Generation of alarms when any machine parameter reaches the pre-set values in order to facilitate evaluation and suitable action.

d) Provision to trip the machine either manually or automatically.

The general guidelines and typical examples for continuous equipment monitoring and protection system are placed at Annexure-3.

10.0 INSPECTION & TESTING

i) Stage inspections and tests at various manufacturing stages shall be selected such that the integrity of the rotating components and the compressors is ensured. Typical tests that shall be carried out includes Material Testing, Dimensional Checks, Impeller Over Speed, Dynamic Balancing, Testing of Rotor, Mechanical Test Run of Compressors, Hydro-Testing & Dynamic Pressure Testing for Dry Gas Seals.

ii) If specified, performance / Complete Unit test shall be carried out.

iii) Records of such tests shall be evaluated and maintained for future reference.

11.0 ERECTION AND COMMISSIONING

11.1 ERECTION

i) Equipment erection shall be done in accordance with the approved procedures laid down based on OEM recommendations and national / international standards.

ii) Erection quality shall be ensured with the use of Installation & Test Procedure (ITP), Stage-wise inspection and Hold points. A sample Installation and Test Procedure is attached in Annexure-4.

iii) Integrity of foundation shall be verified through quality control checks.

iv) Usage of proper grout and application method shall be ensured.

v) Equipment erection shall be done with approved lifting plans and deploying of competent & skilled rigging personnel.

vi) Only periodically inspected, calibrated and certified as ‘fit for use’ (by the competent person) tools, tackles and lifting equipment shall be used.

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vii) Erection of equipment, connected piping and piping supports shall be such that strain on the equipment nozzles due to piping loads is within acceptable limits.

11.2 COMMISSIONING

Commissioning of equipment shall be carried out with the following activities as the minimum:-

11.2.1 PRE-COMMISSIONING ACTIVITIES

i) Ensuring completeness of the system including connections and sub systems.

ii) Ensuring cleanliness of all process, oil and steam piping, including sub systems.

iii) Verification of inlet strainer for bypassing of debris across seating frame.

iv) Verification of erection checklists.

v) Ensuring readiness of instrumentation and completion of loop checks.

vi) Verification / Certification of correct functioning of alarms & trips/ protections.

vii) Provision of fine start up strainers with proper differential pressure measurement.

11.2.2 PREPARATION & COMPLIANCE WITH FOLLOWING PROCEDURES

i) Equipment Start-up

ii) Normal Operation

iii) Normal and Emergency Shutdown

11.2.3 Deployment of Qualified, Trained and Competent personnel.

11.2.4 Readiness & functional verification of auxiliary systems like Lubrication & Sealing system.

11.2.5 Equipment shall be commissioned as per startup procedures and all operating and machine parameters shall be verified for conformance with design values at various steps. Deviations, if any, from design values shall be recorded and corrective measures taken after evaluation.

12.0 OPERATION

The safe and reliable operation of compressors shall be ensured through:-

i) Use of Standard Operating Procedure (SOP). Standard Operating Procedures shall address start-up, normal operation and normal & emergency shutdown of the compressor.

ii) Deployment of trained, qualified & skilled operators.

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iii) Periodic training of operations personnel.
iv) Operation of the equipment within the specified operating window.
v) Monitoring and protection systems shall be in place and functioning. No protection shall be bypassed without approval from authorized personnel in line with OISD-RP-126.
vi) ‘Normal, Minimum and Maximum’ values of operating parameters shall be defined in the procedures or log sheets.
vii) Continuous monitoring of process, equipment parameters and condition of auxiliary systems like, lubricating oil, etc. as defined in OISD-RP-124.
viii) There shall be no leaks from oil and process systems.
ix) Properties of toxic or hazardous process fluids (MSDS) being handled and the precautions to be taken, shall be prominently displayed near the equipment.

13.0 MAINTENANCE

13.1 Maintenance systems in line with OISD standards shall be in place to ensure the health and integrity of compressors. Following shall be considered in finalization the maintenance program;
a) Condition of the Machine
b) Type of Machine,
c) Criticality and Standby Availability
d) Running Hours
e) OEM recommendations
f) Opportunity

13.2. The maintenance systems shall comprise of :-
a) Standard Maintenance Procedure (SMP)
b) Compliance to requirements like, Work Permit System, etc.
c) Deployment of competent and skilled personnel validated through training.
d) Use of tools, tackles and lifting equipment which are periodically inspected, calibrated and certified ‘fit for use’ by competent person.
e) Procedure shall be established to carry out monitoring of the equipment and process parameters in line with OISD-RP-124.
f) Procedures shall also detail the type and scope of the Predictive and Preventive activities being done based on standard practices and OISD-RP-124. Typical preventive maintenance schedules for centrifugal and reciprocating compressors are attached at Annexure-5.
g) Overhauling of compressors shall be based on Condition of the equipment, OEM recommendations or available opportunities due to plant shutdowns (turnarounds).

h) Procedure with regard to spare parts to be maintained in the inventory considering the criticality of the compressor shall be in place.

i) Review and approvals shall be done for refurbishment of critical components.

14.0 CHANGE MANAGEMENT

i) Change management systems should be in place as per OISD-RP-126.

ii) Changes in the Process and Equipment related Parameters or any related System shall be properly reviewed by all concerned and approved by designated authority.

15.0 DOCUMENTATION

Following documents should be maintained for compressors:-

i) Installation & Test Plan

ii) Standard Maintenance Procedure and Standard Operating Procedure

iii) Equipment Maintenance History & Records

iv) Equipment Failure History

v) Failure Analysis Report

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16.0 REFERENCES

i) API-617 (Centrifugal compressors for general refinery services)

ii) API-618 (Reciprocating compressors for general refinery services)

iii) API-619 (Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries)


v) OISD-STD-105 (Work Permit System)

vi) OISD-RP-124 (Predictive Maintenance Practices)

vii) OISD-RP-126 (Specific maintenance practices for rotating equipment)
Annexure - 1

GUIDELINES FOR COMPRESSOR DESIGN AND MANUFACTURE

A) GENERAL

1) Overall Sound level, around complete package, at one meter distance should preferably be less than or equal to 90 dBA. Provision of noise enclosures should be considered above 90 dBA.

2) Process Gas connections shall be flanged or machined and studded. Threaded flange holes are not accepted.

3) External lube oil coolers shall be supplied. For Shell and Tube type coolers, lube oil pressure shall be higher than water pressure.

4) All repairs on compressor parts shall be approved by purchaser. Repairs on Journal areas are not acceptable.

5) Coupling guards shall be of Non-Sparking metallic and of rigid construction. Coupling guard should be designed to withstand 900 N static point load in any direction without the guard contacting moving parts.

B) CENTRIFUGAL COMPRESSORS

1) For services where partial pressure of hydrogen exceeds 13.8 barg (200 psig), Radial Split (barrel) type casing design shall be provided.

2) Torsional analysis is advised be included for the complex trains.

3) For the application in which process gas is used as seal gas in Dry Gas Seals, provision for clean external gas shall be provided for settle out conditions.

4) Wherever variable speed drivers have been used, Separation margin to critical speeds shall be maintained for the complete operating range.

C) RECIPROCATING COMPRESSORS

1) Piston Speed shall be preferably below 4 m/s for the reciprocating compressors. Wherever higher speeds are offered, references with successful applications shall be made available.

2) The maximum predicted discharge temperature shall not exceed 135°C for hydrogen rich (MW less than 12) service and 150°C for other services for all specified operating and load conditions.

3) Bolting on reciprocating or rotating parts shall be positively locked mechanically (lock washers, tab washers and anaerobic adhesives are not acceptable).

4) Cylinder coolant inlet temperature must be higher by 6 °C than suction temperature.

5) Valve unloaders shall be designed not to mix process hydrocarbon gas with Instrument Air. Tubing for leak off vent lines and air supply lines shall be sized & painted differently to avoid interconnection.

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Annexure – 2

A TYPICAL SEALS AND SEALING SYSTEM DESIGN, ALARM AND TRIPS

The sealing system shall be suitably designed to ensure the safe and reliable operation of the machine. Suitable control, monitoring and protective devices shall be in place to prevent failure / unsafe situations.

Typical seal control systems are shown along with protective features.
Figure 4A-2—Tandem Dry Gas Seal Schematic With Intermediate Labyrinth Seal

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Figure 4A.3—Tandem Dry Gas Seal Schematic

Test valve.
Check valve supplied by purchaser.
If secondary vent is sent to flare, a customer-supplied check valve will be required.

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1. **DIFFERENTIAL PRESSURE CONTROL SYSTEM**

i) **Primary seal gas supply line should be provided with:**

- Duplex Filter (coalescing type) to clean the gas.
- Differential pressure measurement across reference line and seal gas supply line. Alarm should be provided on low differential pressure

ii) **Primary Leak-off line should be connected to flare and should be provided with:**

- Leak-off pressure measurement. Alarm and Trip on high leak-off pressure with 2oo3 logic.
- Leak-off flow indication

iii) **Buffer gas supply line should be provided with:**

- Duplex Filter (coalescing type) to clean the gas
- Low pressure alarm.
- Flow indication.

iv) **Secondary seal gas leak-off should be vent to atmosphere and should be provided with:**

- High pressure alarm.
- Leak-off flow indication.

v) **Separation gas supply should be provided with:**

- Low pressure alarm

2. **Flow Control System**

i) **Primary seal gas supply line should be provided with:**

- Duplex Filter (coalescing type) to clean the gas.
- Flow measurement.

ii) **Primary Leak-off line should be connected to flare and should be provided with**

- Leak-off pressure measurement. Alarm and Trip on high leak-off pressure with 2oo3 logic.
- Leak-off flow indication.
iii) Buffer gas supply line should be provided with:

- Duplex Filter (coalescing type) to clean the gas.
- Low pressure alarm
- Flow indication.

iv) Secondary seal gas leak-off should be vent to atmosphere and should be provided with:

- High pressure alarm.
- Leak-off flow indication

v) Separation gas supply should be provided with:

- Low pressure alarm
Annexure - 3

GUIDELINES FOR MACHINE CONDITION MONITORING SYSTEM

The guidelines given below are to be applied for online monitoring of compressors in critical services. Deviations may be considered based on capacity, size and criticality of the machine.

A) RECIROCATING COMPRESSORS

- Following is to be included on Compressor:
  - Key phasor
  - Rod drop per each cylinder
  - 2 Accelerometers / velocity meter for compressor frame vibration
  - 2 Simplex RTDs per main bearing; one in line, one spare
  - Stuffing box temperature measurement

- Following is to be included on motor:
  - Two accelerometers / velocity meters on each bearing
  - 2 simplex RTDs for each bearing; one in line, one spare
  - Motor winding temperature measurement 2 per winding (total 6)

B) CENTRIFUGAL COMPRESSORS

i) Compressor

- Temperature measurement:
  - Radial bearings: 2 pads – 2 RTD on each, (Simplex RTDs one in line, one spare)
  - Axial Bearings: Active = 3 pads- 2 RTD on each, (Simplex RTDs one in line, one spare)
  - Inactive = 2 pads - 2 RTD on each, (Simplex RTDs one in line, one spare)

- Vibration measurement:
  - Radial bearings: 2 proximity probes (X & Y) per bearing.

- Axial position measurement: 3 probes per bearing.

- Keyphason

ii) Drive Steam Turbine for Compressor

- Temperature measurement:
  - Radial bearings: 2 pads – 2 RTD on each, (Simplex RTDs one in line, one spare)
  - Axial Bearings: Active = 3 pads- 2 RTD on each, (Simplex RTDs one in line, one spare)
  - Inactive = 2 pads - 2 RTD on each, (Simplex RTDs one in line, one spare)
Vibration measurement:
Radial bearings: 2 probes (X & Y) per bearing.
Axial position measurement: 3 probes per bearing.
Keyphasor

iii) Gear Box for Compressor
Temperature measurement:
Radial bearings: 2 pads – 2 RTD on each, (Simplex RTDs one in line, one spare)
Axial Bearings: Active = 3 pads, 2 RTD on each, (Simplex RTDs one in line, one spare)
Inactive = 2 pads - 2 RTD on each, (Simplex RTDs one in line, one spare)
Vibration measurement:
Radial bearings: 2 proximity probes (X & Y) per bearing.
Axial position measurement: 3 probes per bearing.
Key Phasors – one per each speed shaft

iv) Drive Motor:
Two proximity probes (X & Y) on each motor radial bearing.
Two simplex RTDs for each bearing; one in line, one spare.
Motor winding temperature measurement 2 per winding (total 6)

C) SCREW COMPRESSORS
i) Compressor
Temperature measurement:
Radial bearings: 2 pads – 2 RTD on each, (Simplex RTDs one in line, one spare)
Axial Bearings: Active = 3 pads- 2 RTD on each, (Simplex RTDs one in line, one spare)
Inactive = 2 pads - 2 RTD on each, (Simplex RTDs one in line, one spare)
Vibration measurement:
Radial bearings: 2 Proximity probes (X & Y) per bearing, or Accelerometers for casing vibration based on the vendor recommendation
Axial position measurement: 3 probes per bearing.
ii) Drive Steam Turbine for Compressor

- Temperature measurement:
  - Radial bearings: 2 pads – 2 RTD on each, (Simplex RTDs one in line, one spare)
  - Axial Bearings: Active = 3 pads- 2 RTD on each, (Simplex RTDs one in line, one spare)
    Inactive = 2 pads - 2 RTD on each, (Simplex RTDs one in line, one spare)

- Vibration measurement:
  - Radial bearings: 2 proximity probes (X & Y) per bearing.

- Axial position measurement: 3 probes per bearing.

- Keyphasor

iii) Gear Box for Compressor

- Temperature measurement:
  - Radial bearings: 2 pads – 2 RTD on each, (Simplex RTDs one in line, one spare)
  - Axial Bearings: Active = 3 pads- 2 RTD on each, (Simplex RTDs one in line, one spare)
    Inactive = 2 pads - 2 RTD on each, (Simplex RTDs one in line, one spare)

- Vibration measurement:
  - Radial bearings: 2 Proximity probes (X & Y) per bearing, or Accelerometers for casing vibration based on the vendor recommendation

- Axial position measurement: 3 probes per bearing.

- Key Phasors – one per each speed shaft, if applicable

iv) Drive Motor

- Two proximity probes (X & Y) on each motor radial bearing.

- Two simplex RTDs for each bearing; one in line, one spare.

- Motor winding temperature measurement 2 per winding (total 6)
### Annexure – 4

**A TYPICAL INSTALLATION AND TEST PROCEDURE (ITP) FOR COMPRESSORS**

**A. Installation & Test Procedure : Centrifugal Compressor**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Activity Description</th>
<th>Controlling Documents</th>
<th>Acceptance Criteria</th>
<th>Contractor</th>
<th>Executing Engineer</th>
<th>Quality / Audit Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Handling during transport, erection and replace of damaged items if any</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>S</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>2</td>
<td>Foundation released for equipment erection</td>
<td>Civil Drawing</td>
<td></td>
<td>H</td>
<td>W</td>
<td>DR</td>
</tr>
<tr>
<td>3</td>
<td>Centre line and elevation mark on foundation (including co-ordinates)</td>
<td>G A Drawing / Civil Drawing</td>
<td></td>
<td>W</td>
<td>W</td>
<td>W%</td>
</tr>
<tr>
<td>4</td>
<td>Check pocket centre to centre distance, depth size and cleanliness</td>
<td>G A Drawing / Civil Drawing</td>
<td>Visual</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>5</td>
<td>Check foundation top surface micro chipping and anchor / jack bolt size and clearance in base plate holes as per requirement</td>
<td>G A Drawing / Civil Drawing</td>
<td>Visual</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>6</td>
<td>Check sole plates / packer plates / shim condition under base plate</td>
<td>Visual</td>
<td></td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>7</td>
<td>Removal of shipping preservatives and removal of transportation fixtures</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>8</td>
<td>Equipment erected, leveled and base plate foundation bolts tightened</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>9</td>
<td>Measure DBSE and record reading</td>
<td>PO &amp; Datasheet / P&amp;ID</td>
<td>Visual</td>
<td>W</td>
<td>S</td>
<td>H</td>
</tr>
<tr>
<td>10</td>
<td>Verify driver installation correct</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>11</td>
<td>Check axial float of compressor / motor / turbine</td>
<td></td>
<td></td>
<td>H</td>
<td>W</td>
<td>W%</td>
</tr>
<tr>
<td>12</td>
<td>Nozzles and all openings covered / blinded</td>
<td>As Per Requirement</td>
<td></td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>13</td>
<td>Pocket is cleaned, dried prior to grouting (1st Phase)</td>
<td></td>
<td></td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>14</td>
<td>Check the clearance provided for vertical expansion at holding down bolts of compressor / motor / turbine</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>W</td>
<td>H</td>
</tr>
<tr>
<td>15</td>
<td>Check clearance provided on centering keys at the bottom of compressor (suction and discharge) for axial movement</td>
<td>Vendor Manual</td>
<td></td>
<td>H</td>
<td>W%</td>
<td>H</td>
</tr>
</tbody>
</table>

*OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.*
<table>
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<tr>
<th></th>
<th>Description</th>
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<th>Requirement</th>
<th>W</th>
<th>W%</th>
<th>S</th>
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</thead>
<tbody>
<tr>
<td>16</td>
<td>Check the centering and gap provided beneath front bearing pedestal key to ensure free axial expansion of casing</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>17</td>
<td>As per requirement checks of installed compressor prior to final alignment</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>18</td>
<td>Grouting (1st phase) - jack screws removed</td>
<td>Visual</td>
<td>W%</td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>19</td>
<td>Check availability of shim (2-3 mm) under driver &amp; compressor, tighten anchor bolts and check soft foot</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>H%</td>
<td>W</td>
</tr>
<tr>
<td>20</td>
<td>Final alignment with nozzle pipe work disconnected</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>21</td>
<td>Connection of pipe work to equipment nozzles and check alignment</td>
<td>Vendor Manual</td>
<td>Flange Parallelism</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>22</td>
<td>Compressor / turbine / motor shaft deflection due to pipe stress and parallelism of suction, discharge piping with compressor nozzle checked</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>H%</td>
<td>S</td>
</tr>
<tr>
<td>23</td>
<td>Equipment base plate grouting (2nd phase) complete</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>24</td>
<td>Compressor and driver dowelled (when specified)</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>S</td>
<td>S%</td>
<td>S</td>
</tr>
<tr>
<td>25</td>
<td>Check the magnetic axis of the motor</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>26</td>
<td>Auxiliary equipment like seal piping, cooling water piping, safety valves, coolers, filters / strainers flow glass, breather and constant oil leveler installed correctly</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>27</td>
<td>Check fit up of coupling and coupling guard</td>
<td>Visual</td>
<td>W%</td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>28</td>
<td>Vents, drains and accessory piping installed</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>29</td>
<td>Check installation of seal support system</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>W</td>
<td>W%</td>
<td>S</td>
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<tr>
<td>30</td>
<td>Lube oil tank clean before flushing</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>31</td>
<td>Lube and seal oil systems installed and flushing complete</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>W%</td>
<td>S</td>
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<tr>
<td>32</td>
<td>Lube and seal oil systems filled with correct lubricant</td>
<td>Vendor Manual</td>
<td>As Per Requirement</td>
<td>H</td>
<td>W%</td>
<td>S</td>
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<tr>
<td>SI No.</td>
<td>Activity Description</td>
<td>Controlling Documents</td>
<td>Acceptance Criteria</td>
<td>Contractor</td>
<td>Executing Engineer</td>
<td>Quality / Audit Engineer</td>
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<td>--------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Handling during transport, erection and replace of damaged items if any</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>S</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>2</td>
<td>Foundation released for equipment erection</td>
<td>Civil Drawing</td>
<td>H</td>
<td>W</td>
<td>W</td>
<td>DR</td>
</tr>
<tr>
<td>3</td>
<td>Centre line and elevation mark on foundation (including co ordinates)</td>
<td>G A Drawing / Civil Drawing</td>
<td>As per relevant specification</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>4</td>
<td>Check pocket centre to centre distance, depth size and cleanliness</td>
<td>G A Drawing / Civil Drawing</td>
<td>As per relevant specification</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>5</td>
<td>Check foundation top surface micro chipping and anchor / jack bolt size and clearance in base plate holes as per requirement</td>
<td>G A Drawing / Civil Drawing</td>
<td>As per approved drawing</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>6</td>
<td>Check sole plates / packer plates / shim condition under base plate</td>
<td>As per approved drawing</td>
<td>W</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>7</td>
<td>Removal of shipping preservatives and removal of transportation fixtures</td>
<td>Vendor Manual</td>
<td>H</td>
<td>W%</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>8</td>
<td>Equipment erected, leveled and base plate foundation bolts tightened</td>
<td>Vendor Manual</td>
<td>As per approved drawing</td>
<td>H</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>9</td>
<td>Nozzles and all openings covered / blinded</td>
<td></td>
<td>W</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>10</td>
<td>Pocket is cleaned, dried prior to grouting (1st Phase). Jack screws removed (if applicable)</td>
<td>Grouting Procedure</td>
<td>As per approved drawing</td>
<td>W</td>
<td>W</td>
<td>W%</td>
</tr>
<tr>
<td>11</td>
<td>Check Web Deflection</td>
<td>Vendor Manual</td>
<td>Within 0.05 mm</td>
<td>H</td>
<td>W</td>
<td>W</td>
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<tr>
<td>12</td>
<td>Check assembly of distance piece and cylinders</td>
<td>Vendor Manual</td>
<td>H</td>
<td>W%</td>
<td>H</td>
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<tr>
<td>13</td>
<td>Check leveling of cylinders and grout supports</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>H</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>14</td>
<td>Equipment base plate grouting (2nd Phase) complete and base plate bolts torque tightened after curing of grout</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>H</td>
<td>W</td>
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<th>H</th>
<th>W%</th>
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<td>15</td>
<td>Checking piston rod run out and check bumping clearance</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>H</td>
<td>W%</td>
<td>H</td>
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<tr>
<td>16</td>
<td>Check position of fly wheel and check web deflection</td>
<td>Vendor Manual</td>
<td>W</td>
<td>W</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Check leveling and positioning of motor and provide doweling legs, side jack bolts for alignment</td>
<td>Vendor Manual</td>
<td>H</td>
<td>W</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Check availability of shim (2-3 mm) under driver, tighten anchor bolts and check soft foot</td>
<td>Visual</td>
<td>H</td>
<td>W</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Measure DBSE and record reading</td>
<td>PO &amp; Datasheet / P&amp;ID</td>
<td>As per relevant specification</td>
<td>W</td>
<td>S</td>
<td>W</td>
</tr>
<tr>
<td>20</td>
<td>Intermediate alignment and pocket grouting for motor</td>
<td>Vendor Manual</td>
<td>W</td>
<td>S</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Check alignment between compressor and motor. Check web deflection</td>
<td></td>
<td>As per relevant specification</td>
<td>W</td>
<td>W%</td>
<td>H</td>
</tr>
<tr>
<td>22</td>
<td>Check alignment of rotor and stator, and check for uniform air gap</td>
<td></td>
<td>As per relevant specification</td>
<td>H</td>
<td>W</td>
<td>H</td>
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<tr>
<td>23</td>
<td>Final grouting of motor base plate</td>
<td>As per specification</td>
<td>W</td>
<td>W</td>
<td>W</td>
<td></td>
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<tr>
<td>24</td>
<td>Check axial float of compressor / motor &amp; for free rotation of the machine</td>
<td></td>
<td>As per relevant specification</td>
<td>W</td>
<td>W%</td>
<td>W</td>
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<tr>
<td>25</td>
<td>Compressor and driver dowelled (when specified)</td>
<td>Vendor Manual</td>
<td>As per relevant specification</td>
<td>H</td>
<td>W</td>
<td>W%</td>
</tr>
<tr>
<td>26</td>
<td>Vents, drains and accessory piping installed</td>
<td>Vendor Manual &amp; Drawing</td>
<td>As per approved drawing</td>
<td>H</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>27</td>
<td>Auxiliary equipment like seal piping, cooling water piping, safety valves, coolers, filters / strainers flow glass, breather and constant oil leveler installed correctly</td>
<td>Vendor Manual &amp; Drawing</td>
<td>As per requirement</td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>28</td>
<td>Check fit up of coupling and coupling guard</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Lube oil tank clean before flushing</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>H</td>
<td>W%</td>
<td>H</td>
</tr>
<tr>
<td>30</td>
<td>Lube and seal oil systems installed and flushing complete</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>H</td>
<td>W%</td>
<td>H</td>
</tr>
<tr>
<td>31</td>
<td>Lube and seal oil systems filled with correct lubricant</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>H</td>
<td>W%</td>
<td>H</td>
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<td>SL No.</td>
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<td>Quality / Audit Engineer</td>
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</tr>
<tr>
<td>1</td>
<td>Centre line and elevation mark on foundation (including co-ordinates)</td>
<td>G A Drawing / Civil Drawing</td>
<td>H</td>
<td>W</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check pocket centre to centre distance, depth size and cleanliness</td>
<td>G A Drawing / Civil Drawing</td>
<td>W</td>
<td>W%</td>
<td>W%</td>
<td>W%</td>
</tr>
<tr>
<td>3</td>
<td>Check foundation top surface micro chipping</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>W</td>
<td>W%</td>
</tr>
<tr>
<td>4</td>
<td>Check jack bolts</td>
<td>Vendor Manual</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>5</td>
<td>Removal of shipping preservatives and removal of transportation fixtures</td>
<td>Vendor Manual</td>
<td>As per requirement</td>
<td>W</td>
<td>W%</td>
<td>W%</td>
</tr>
<tr>
<td>6</td>
<td>Check Packer plates / shims condition under base plate</td>
<td>Visual</td>
<td>W</td>
<td>S</td>
<td>S</td>
<td>W%</td>
</tr>
<tr>
<td>7</td>
<td>Equipment erected along with driver and aligned with foundation centre line</td>
<td>G A Drawing</td>
<td>W</td>
<td>W</td>
<td>W%</td>
<td>S</td>
</tr>
<tr>
<td>8</td>
<td>Equipment leveled properly and foundation bolts tightened</td>
<td>G A Drawing</td>
<td>Level and shim within specification</td>
<td>H</td>
<td>W</td>
<td>H</td>
</tr>
<tr>
<td>9</td>
<td>Equipment nozzle elevations and coordinates checked</td>
<td>G A Drawing</td>
<td>H</td>
<td>W%</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Preliminary alignment of compressor with driver</td>
<td>W</td>
<td>W</td>
<td>W%</td>
<td>S</td>
<td></td>
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<tr>
<td>11</td>
<td>No loose items (tubing, pressure switches, slide valve level glass etc) mounted on the equipment</td>
<td>G A Drawing</td>
<td>Visual</td>
<td>W</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>12</td>
<td>Nozzles and all openings covered / blinded</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Pocket is cleaned, dried prior to grouting (1st Phase).</td>
<td>Visual</td>
<td>W</td>
<td>S</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Check that specified grouting material is used (Remove jack screws after grouting has cured)</td>
<td>Visual</td>
<td>H</td>
<td>W</td>
<td>W%</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
<table>
<thead>
<tr>
<th>No.</th>
<th>Task Description</th>
<th>Source</th>
<th>Visual</th>
<th>W</th>
<th>W%</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Check motor / drive base plate bolts for proper size and tightness</td>
<td>Visual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Check availability of shim (2-3 mm) under driver, tighten anchor bolts and check soft foot</td>
<td>Visual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Measure DBSE and record reading</td>
<td>Vendor Manual</td>
<td>W</td>
<td>S</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>19</td>
<td>Check leveling and alignment (without piping) &amp; record reading. Weld side jack bolts for alignment</td>
<td>Vendor Manual</td>
<td>H</td>
<td>W</td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>20</td>
<td>Doweling of legs</td>
<td>Vendor Manual</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>21</td>
<td>Full grouting of base plate complete, cured and base plate bolts were tightened</td>
<td>Vendor Manual</td>
<td>Visual</td>
<td>H</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>22</td>
<td>Auxiliary equipment like seal piping, cooling water piping, safety valves, coolers, filters / strainers flow glass, breather and constant oil leveler installed correctly</td>
<td>Vendor Manual &amp; Drawing</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>23</td>
<td>Check erection of all instruments</td>
<td>P&amp;ID</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>24</td>
<td>Check parallelism of suction and discharge piping with compressor nozzles and check, piping strain is not imposed on compressor. Do final alignment with piping, and remove side jack bolts.</td>
<td>Vendor Manual</td>
<td></td>
<td>H</td>
<td>W</td>
<td>H</td>
</tr>
<tr>
<td>25</td>
<td>Check fit up of coupling and coupling guard</td>
<td>Visual</td>
<td></td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>26</td>
<td>Lube oil system installed, lube oil tank / bearing housing cleaned and filled with proper lubricant</td>
<td>Vendor Manual</td>
<td>Visual</td>
<td>W</td>
<td>W%</td>
<td>W</td>
</tr>
<tr>
<td>27</td>
<td>Adjustment of alarm and trip setting</td>
<td>Vendor Manual</td>
<td>Visual</td>
<td>H</td>
<td>W%</td>
<td>H</td>
</tr>
<tr>
<td>28</td>
<td>Check equipments name plate secured and directional arrows on pump, motor, control valves and NRVs for correctness. Base plate to be provided with lifting lugs for a four point lift, centre line supports are provided with horizontal jack screws</td>
<td>Datasheet and P&amp;ID, G A Drawing</td>
<td>Visual</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>29</td>
<td>Equipment painting / touch up</td>
<td>As per specification</td>
<td>Visual</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
</tbody>
</table>
## LEGEND OF INSPECTION REQUIREMENT

<table>
<thead>
<tr>
<th>SL No</th>
<th>Legends</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H (Hold Point)</td>
<td>Mandatory inspection point and work shall not proceed without the presence of a representative of the cognizant organization</td>
</tr>
<tr>
<td>2</td>
<td>W (Witness Point)</td>
<td>Designated witness points for the involved personnel, which are required to signed off by witnessing personnel. All activities, which have a W point, will require a written notification to Quality / Auditing Engineer, in the event that the quality / auditing engineer does not attend within agreed period the work may proceed. In such cases, the executing engineer / contractor personnel will record in the appropriate signature space on the forms &quot;NotWitnessed&quot;, and shall sign and date such spaces</td>
</tr>
<tr>
<td>3</td>
<td>W% (%Witness Inspection Point)</td>
<td>Designated percentage witness point assigned by the quality engineer, which will require written notification. In the event quality engineer does not attend within the agreed period, the work may proceed. The percentage shall mean a minimum of 10% inspection, if not otherwise agreed in the contract, however this may be increased as discretion of the quality inspector.</td>
</tr>
<tr>
<td>4</td>
<td>S (Surveillance)</td>
<td>Random observation of the controls of process activities however, such activities are not required to be signed off By the quality engineer</td>
</tr>
<tr>
<td></td>
<td>DR (Document Review)</td>
<td>This entails review of appropriate documentation</td>
</tr>
</tbody>
</table>
Annexure-V

TYPICAL PREVENTIVE MAINTENANCE SCHEDULES

1.0 CENTRIFUGAL COMPRESSORS

1.1 Once in 3 month or After 1000 Hours of operation which ever is early

i) Lube oil for the following:
   a) Flash point
   b) Water content
   c) Impurities and wear particles
   d) Viscosity and Viscosity index
   e) 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

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)
1.3 **After 24000 Hours**
Complete overhauling of the compressor shall be carried out.

2.0 **RECIROCATING COMPRESSORS**

2.1 **PREVENTIVE MAINTENANCE INSPECTION SCHEDULE FOR THE FIRST 1000 HOURS FROM COMMISSIONING**

**After 60 Hours**

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

**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.

**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)

2.2 PREVENTIVE MAINTENANCE INSPECTION SCHEDULE AFTER FIRST 1000 HOURS OF COMMISSIONING

**After 2000 Hours**

i) Condition of compressor suction and discharge valve

ii) Oil filters (whether cleaned or not).

**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.

**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 un-loader 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 after-cooler, 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.

**After 16000 Hours**

Complete overhauling of the compressor shall be carried out.