SAFETY IN DESIGN, OPERATION, INSPECTION AND MAINTENANCE OF HYDROCARBON GAS COMPRESSOR STATIONS AND TERMINALS

First Edition September, 2001

OISD STANDARD

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
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SAFETY IN DESIGN, OPERATION, INSPECTION AND MAINTENANCE OF HYDROCARBON GAS COMPRESSOR STATIONS AND TERMINALS

Prepared by
FUNCTIONAL COMMITTEE

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
7th Floor, New Delhi House
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NOTE

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

Oil industry in India is more than 100 years old. Over the years a variety of practices have been in vogue because of collaboration / association with different foreign companies and governments. Standardisation in design, operating and maintenance practices was hardly in existence at a national level. This lack of uniformity, 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 & 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 the industry to draw up standards and guidelines on various subjects.

The present document on Safety in Design, Operation, Inspection and Maintenance of Hydrocarbon Gas Compressor Stations and Terminals was prepared by Functional Committee constituted amongst the members nominated by the industry. This document was prepared based on the accumulated knowledge and experience of industry members and the various national and international codes and practices.

This document will be reviewed periodically for improvements based on the new experiences and better understanding.

Suggestions from industry members may be addressed to:

The Coordinator
Committee on
SAFETY IN DESIGN, OPERATION,
INSPECTION & MAINTENANCE OF HYDROCARBON
GAS COMPRESSOR STATIONS AND TERMINALS
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ON

SAFETY IN DESIGN, OPERATION, INSPECTION & MAINTENANCE OF HYDROCARBON GAS COMPRESSOR STATIONS AND TERMINALS

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<td>Sh. M.K. Bandopadhyay</td>
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<td>2</td>
<td>Sh. V.S. Sadana</td>
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<td>OIL</td>
<td>Member</td>
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SAFETY IN DESIGN, OPERATION, INSPECTION AND MAINTENANCE OF HYDROCARBON GAS COMPRESSOR STATIONS & TERMINALS

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### INTRODUCTION

Safety in Hydrocarbon Gas Compressor Stations and Terminals can be ensured through sustained efforts and commitment at all levels and at all stages. Design, engineering, construction and commissioning need to be done as per the applicable safety standards and codes. Also operations, periodic inspections and maintenance activities as per the laid down procedures play an important role in...
ensuring safety throughout the life of the installation.

With Gas Industry coming up in a big way in India, need is felt for a separate specific standard on Gas installations, though OISD standards exist for Cross-country hydrocarbon pipelines. In order to provide a specific thrust on safety in Hydrocarbon Gas installations, this standard comes into being.

1.0 SCOPE

This standard covers the minimum requirement for Safety in Design, Operation, Inspection and Maintenance of Hydrocarbon Gas Compressor Stations, Gas metering and regulating stations (Terminals) of pipeline gas transportation systems. However, gas metering & regulating stations which are part of Process Plants and gas gathering stations are excluded.

3.0 DEFINITIONS

3.1 General Terms

3.1.1 Hydrocarbon Gas, as used in this code is any gas or mixture of gases suitable for industrial or domestic use and transmitted or distributed to the user through a piping system. The most common type is natural gas.

2.1 Valves

2.1.1 Shut Down Valve (SDV) is a valve installed for the purpose of stopping the flow of gas in pipeline.

2.1.2 Anti-surge Control Valve is a valve installed in a discharge to suction recirculation line of a centrifugal compressor to prevent surging by controlling the recirculation flow.

2.1.2 Pressure / flow control valve is a valve designed to regulate pressure / flow of gas in pipeline.

2.2 Design Related Terms

2.2.0 Pressure Terms

a Design pressure is the maximum pressure permitted by this code, as determined by the design procedures applicable to the materials and locations involved.

b Maximum allowable operating pressure is the maximum pressure at which a gas system may be operated in accordance with the provisions of this code.

c Maximum allowable test pressure is the maximum internal fluid pressure permitted by this code for a pressure test based upon the material and location involved.
4.0 DESIGN

4.1 Layout

Layout of gas compressor stations and terminals along with minimum safe inter-distances between blocks & facilities shall be as per latest revision of standard OISD-118.

4.2 Compressor Stations and Terminals building Design

The following safety criteria shall be applied in the design of compressor building/house and any other building in the installation inside of which hydrocarbons for industrial use are handled.

4.2.1 Location

Location of the compressor building/house or any other installation building handling hydrocarbon for industrial use shall be located at such clear distances from adjacent property not under control of the company as to minimize the hazard of communication of fire to these buildings from structures on adjacent property. Sufficient open space should be provided around the building to permit the free movement of fire-fighting equipment.

4.2.2 Building Construction

All these buildings which house gas piping in sizes larger than Nominal pipe size 2 inch. or equipment handling gas (except equipment for domestic purposes) shall be constructed of noncombustible or limited combustible materials as defined in ANSI/NFPA 220.

4.2.3 Exits

A minimum of two exits shall be provided for each operating floor of buildings, basements and any elevated walkway or platform 3.0 meter or more above ground or floor level. Individual engine catwalks shall not require two exits. Exits of each such building may be fixed ladders, stairways, etc. The maximum distance from any point on an operating floor to an exit shall not exceed 23 meter, measured along the centerline of aisles or walkways. Exits shall be unobstructed doorways located so as to provide a convenient possibility of escape and shall provide unobstructed passage to a place of safety. Door latches shall be of a type, which can be readily opened from the inside without a key. All swinging doors located in an exterior wall shall swing outward.

3.1.3 Fenced Areas

Any fence, which may hamper or prevent escape of persons from the vicinity of a compressor station or gas terminal in an emergency, shall be provided with a minimum of two gates. These gates shall be located so as to provide a convenient opportunity for escape to a place of safety. Any such gates located within 60 meter of any such building shall open outward and shall be unlocked (or capable of being opened from the inside without a key) when the area
within the enclosure is occupied. Alternatively, other facilities affording a similarly convenient exit from the area may be provided.

4.3 Electrical Facilities

All electrical equipment and wiring installed in gas transmission and distribution compressor stations and terminals shall conform to the requirements of ANSI/NFPA 70, insofar as the equipment commercially available permits. Electrical fittings, cables and hardwares will be as per Area classification as per API 500 and OISD-STD-149. Electrical installations in hazardous locations as defined in ANSI/NFPA 70 and which are to remain in operation during compressor station emergency shut-down as provided in para.4.4.3 shall be designed to conform to ANSI/NFPA 70 for Class I, Division I requirements.

1.0 Compressor Station and Terminal Equipment

1.0.0 Gas Treating Facilities

a Liquid Removal

When condensable vapors are present in the gas stream in sufficient quantity to liquify under the anticipated pressure and temperature conditions, the suction stream to each stage of compression (or to each unit of centrifugal compressor) shall be protected against the introduction of dangerous quantities of entrained liquids into the compressor. Every liquid separator used for this purpose shall be provided with manually operated facilities for removal of liquids therefrom. In addition, automatic liquid removal facilities or an automatic compressor shutdown device or a high liquid level alarm shall be used where sluge of liquid might be carried into the compressors.

b Liquid Removal Equipment

Liquid separators, unless constructed of pipe and fittings and no internal welding is used, shall be manufactured in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. Liquid separators when constructed of pipe and fittings without internal welding shall be in accordance with Location Class 4 requirements as per ASME B31.8

4.4.2 Fire Protection

Fire protection facilities should be provided in accordance with OISD-116 standard or Tariff Advisory Committee recommendations. If the fire pumps are a part of such facilities, their operation shall not be affected by emergency shutdown facilities.

4.4.3 Safety Devices

a. Emergency Shutdown Facilities

I. Each transmission compressor station shall be provided with an emergency shutdown system by means of which the gas can be blocked out of the station and the station gas piping blow down. Operation of the emergency
shutdown system also shall cause the shutdown of all gas compressing equipment and all gas fired equipment, and shall de-energize the electrical facilities located in the vicinity of gas headers and in the compressor room, except those that provide emergency lighting for personnel protection and those that are necessary for protection of equipment. The emergency shutdown system shall be operable from any one of at least two locations outside the gas area of the station, preferably near exit gates in the station fence, but not more than 150M from the limits of the stations. Blowdown piping shall extend to a location where the discharge of gas is not likely to create a hazard to the compressor station or surrounding area. Unattended field compressor stations of 1000 hp and less are excluded from the provisions of this paragraph.

Each compressor station supplying gas directly to a distribution system shall be provided with emergency shutdown facilities located outside the compressor station buildings by means of which all gas can be blocked out of the station provided there is another adequate source of gas for the distribution system. These shutdown facilities can be either automatic or manually operated as local conditions designate. When no other gas source is available, no shutdown facilities shall be installed that might function at the wrong time and cause an outage on the distribution system.

Gas terminals shall also be provided with Emergency shutdown system by means of which gas can be blocked out of terminals and blow down system.

b. Engine Overspeed Stops

Every compressor prime mover, except electrical induction or synchronous motors, shall be provided with an automatic device which is designed to shut down the unit before the speed of the prime mover or of the driven unit exceeds the maximum safe speed of either as established by the respective manufacturers.

4.4.4 Pressure Limiting Requirements in Gas Compressor Stations and Terminals

a. Pressure relief or other suitable protective devices of sufficient capacity and sensitivity shall be installed and maintained to assure that the maximum allowable operating pressure of the station piping and equipment is not exceeded by more than 10%.

b. A pressure relief valve or pressure limiting device, such as a pressure switch or unloading device, shall be installed in the discharge line of each positive displacement transmission compressor between the gas compressor and the first discharge block valve. If a pressure relief valve is the primary overprotection device, then the relieving capacity shall be equal to or greater than the capacity of the compressor. If the relief valves on the compressor do not prevent the possibility of over-
pressuring the pipeline as specified in para 845 of ASME B 31.8, a relieving or pressure limiting device shall be installed on the pipeline to prevent it from being overpressurised beyond the limits prescribed by the Code.

c. Vent lines provided to exhaust the gas from the pressure relief valves to atmosphere should be extended to a location where the gas may be discharged without undue hazard. Vent lines shall have sufficient capacity so that they will not inhibit the performance of the relief valve. The fire services should remain alert/standby during the time of major venting.

3.3.4 Fuel Gas Control

An automatic device designed to shut off the fuel gas when the engine stops shall be provided on each gas engine/turbine operating with pressure gas injection. The engine/ turbine distribution manifold shall be automatically vented simultaneously.

3.3.4 Cooling and Lubrication Failures

All gas compressor units shall be equipped with shutdown & alarm devices to operate in the event of inadequate cooling or lubrication of the units.

3.3.4 Seal Failure

All gas compressor units shall be provided with shut down and depressurisation in the event of failure of seals.

4.4.8 Anti Surge Protection

All centrifugal compressor units shall be provided with suitable anti surge control and protection device in line with the vendor recommendation.

4.4.9 Acoustic levels

Acoustic levels shall be as per OISD –166.

4.5 EXPLOSION PREVENTION

3.4.0 Flame Detection

Suitable devices for detection of flame inside the enclosure of gas turbine/engine shall be provided to ensure fuel shut off as well as tripping of unit.

3.4.0 Building Ventilation

Ventilation shall be adequate to ensure that employees are not endangered under normal operating conditions (or such abnormal conditions as a blown gasket, packing gland, etc.) by accumulations of hazardous concentrations of flammable or noxious vapors or gases in rooms, sumps, pits, or similarly enclosed places, or in any portion thereof.

3.4.0 Hydrocarbon Gas / thermal / UV / Smoke Detectors

All gas compressor stations and terminals should be provided with suitable gas and smoke detectors at all strategic locations as per good engineering standards & practices. In case of gas turbines /compressors with enclosures, suitable gas/thermal and UV detectors shall be provided. Also,
auto-actuation of fire fighting system may be interconnected with actuation of UV/thermal detectors.

2.0 Control Room Safety
Control room safety including blast proofing, if any, shall be as per OISD-163.

3.0 Emergency stop
An emergency mechanical tripping device shall be provided in addition to normal tripping system to stop the machine in the event of emergency.

4.8 Safety Instrumentation

Minimum safety instrumentation to be provided in an installation shall be as per OISD-152.

All other parameters and safety aspects of compressor station and terminal design including piping will be as per ASME B 31.8 and all other applicable standards and codes.

5.0 OPERATING PROCEDURES

5.1 BASIC REQUIREMENTS

Each gas installation within the scope of this standard shall:

b) have written operating and maintenance manuals covering process description, details of main control / logic / interlocks, start up and shut down procedures, details of equipment, description of alarm and trip set points as a minimum. Operating instructions should also take care of unsafe conditions arising out of failure of utilities and off sites;

c) have a disaster management plan to take care of emergencies in the installation. This plan will cover chain of commands, responsibilities and authorities, available and required resources as a minimum;

a) operate and maintain its facilities in conformity with these manuals and plans;

a) modify the manuals/plans from time to time as experience dictates and changes in operating conditions;

a) Provide training for employees in procedures established for their operating and maintenance functions. The training shall be comprehensive and shall be designed to prepare employees for service in their area of responsibility;

a) Keep records to administer the plans and training properly.

5.2 Personal Protective Equipment

Necessary personal protective equipment such as Hand gloves, Safety Shoes, Helmets, Safety belts, Safety goggles etc. shall be used (Refer OISD Standard – 155).

4.2 Work Permit System

No Maintenance/inspection work shall be carried out without following the OISD Standard OISD-105 on “Work Permit System” and Section 4 of OISD-137 for electrical maintenance purpose.
**4.2 Safety Audits.**

Regular safety audits shall be carried out in line with OISD –145.

**4.2 Hydrocarbon Gas In**

Hydrocarbon gas should be allowed in the installation only after safety system namely Fire detection / Fire suppression system, Gas smoke detectors, Communication system, Flare System (if provided), etc. are made available.

**5.6 Accident Investigation.**

All accidents & near misses shall be thoroughly investigated & action plan required to prevent recurrence shall be drawn, implemented & records of such plans should be maintained.

**5.7 Safety Index.**

Each installation shall device & maintain a safety index covering status of safety interlock, safety valves, Fire & gas detection system etc.

**6.0 Inspection & Maintenance Procedures**

**6.1 Serviceability of Installation**

The serviceability and safety of the gas installation equipment, especially in the long term, are affected by the standard of maintenance and inspection carried out. It is, therefore, very essential to detail out an inspection and maintenance philosophy. It should spell out the requirements of preventive, predictive and breakdown maintenance along with the Policy of spare parts and Inventory management, keeping in view the specific nature of gas industry in which any breakdown of on-line equipment has consequential losses to the tune of several times its own cost.

**6.2 Preventive Maintenance Schedules**

To facilitate maintenance to be done in a planned manner, a preventive maintenance schedule covering the necessary work to be done, mentioning the periodicity (i.e. daily, weekly, monthly, quarterly, half yearly and yearly schedules) must be worked out. The basic recommendations given by the manufacturers should be considered and modified bearing in mind the local conditions and the experience gained on the equipment. The periodicity of maintenance can also be defined in terms of running hours especially in case of rotating equipment. To streamline the maintenance activities necessary checklist may be prepared which will serve as an effective tool for covering all aspects of maintenance.

**6.3 Predictive Maintenance Programmes**

Predictive maintenance programmes form the back-bone of Quality maintenance and also play a very significant role in ensuring the safety of the installation by giving a forewarning about the possible trouble or breakdown, which can then be controlled and losses minimized.

The predictive maintenance programs, therefore, must form part of the maintenance planning function of any gas installation. All the important rotating equipments must be covered by Vibration monitoring and analysis...
though their frequencies can vary depending upon the severity and criticality of the service. Lube oil analysis can also become one of the crucial parameter to monitor the health of the equipment. Monitoring of transients during startups and shutdowns and monitoring of bearing temperatures for critical rotating equipment may also form part of Predictive maintenance planning.

5.3 Break downs

All breakdowns must be recorded and all important/critical breakdowns must be analysed for their reasons and suitable corrective and preventive actions must form part of the breakdown analysis report.

6.5 Inspection & Maintenance of Static Equipment

6.5.1 Pressure Vessels And Storage Facilities

Standard OISD-128 on “Inspection of Unfired Pressure Vessels” and OISD-129 on “Inspection of Storage Tanks” shall be referred.

6.5.2 Shut-Off Valves, Control Valves, Non-Return Valves, Pipes, Valves and Fittings

OISD Standard OISD-130 on “Inspection of Pipes and Valves and Fittings” shall be referred.

6.5.3 Strainers And Filters

Shall be inspected and cleaned/replaced as per the frequency determined by designer in Operation & Maintenance manual or based on the parameters monitoring its condition.

6.5.4 Safety Relief Valves/Pressure Safety Valves

OISD Standard OISD-132 on “Inspection of Pressure Relieving Devices” shall be referred.

5.5 Inspection and Maintenance of Rotating Equipment of Gas Installation

a) Inspection of Rotating Equipment shall be carried out as per the following:

  ) Inspection of Pumps : Refer OISD-119
  ) Inspection of Compressors : Refer OISD-120
  ) Inspection of prime movers (excluding motors) : Refer OISD-121
  ) Inspection of Fans, Blowers & Gear Boxes : Refer OISD-122
  ) Recommended practice for inspection and maintenance of Rotating Equipment Components: Refer OISD-123
  ) Recommended Practice – inspection and Maintenance of Mechanical Seals : Refer OISD-125

a) In addition, the maintenance shall also be carried out keeping in view the recommendation of equipment manufacture in its maintenance manual. However, based on experience generated in plant over the years and taking into account the climate/environment of the location of the plant, the maintenance requirements / frequencies can be modified which shall be properly documented.
5.5.0 Inspection of Gas turbines

Gas Turbines which normally act as prime movers in gas installations are to be inspected and maintained as per the recommendations of the equipment manufacturer. In addition, the boroscopic inspection should be used to detect and trend thermal wear and damage of the hot section of the Gas Turbine. Trending the condition of internal gas turbine components helps in the orderly planning of overhauls allowing them to be done when needed rather than too soon or too late. Among the problem that can be detected by Boroscopic Inspection are hot section thermal damage and wear, clogged or damaged fuel injectors, contamination in the compressor stages etc. which cause degradation in the turbine performance. The time intervals for such inspections normally depends on the type of turbine and vendors’ recommendations and the type of duty & fuel used. A typical schedule for boroscopic inspection program for a gas turbine is shown at Annexure-I.

6.7 Inspection of Safety Instrumentation

OISD Standard OISD-153 on “Maintenance & Inspection of Safety Instrumentation” shall be referred.

6.8 Inspection of Electrical Equipment

OISD Standard OISD-137 on “Inspection of Electrical Equipment” shall be referred.

6.9 Inspection of Fire Fighting Equipment

OISD Standard OISD-142 on “Inspection of Fire Fighting Equipment” shall be referred.

5.9 Inspection of Load Lifting Devices / Equipment

All load lifting equipment, cranes, wire ropes, chain pulley blocks, tackles, etc. shall be inspected once in a year. Factory’s Act shall be referred for guidance.

5.9 Inspection of Telecommunication System / Equipment

( ) System Functional tests shall be carried out at specified frequencies.

( ) Telecommunication equipment shall be inspected as per manufacture’s recommendations.

6.12 Inspection of Telemetry System / Equipment

(i) System Functional tests shall be carried out at specified frequencies.
(ii) Telemetry equipment shall be inspected as per manufacture’s recommendations.
7.0 DOCUMENTATION

Formats for recording inspection findings shall be designed specifically for the equipment/instrument/system used in the installations and the following records shall be maintained by each installation

(a) Maintenance and inspection formats.

(b) History sheets as per OISD-127.

(c) Safety index reports.

(d) Accidents and near misses and their remedial measures.

8.0 REFERENCES

This standard shall be read in conjunction with the following standards, codes and publications

i  API RP 500 - Area Classification.

ii  API STD-1104 - Welding Of Pipelines and Related Facilities

iii  ASME - Boiler and Pressure Vessel Code, Section VIII Division-1 Pressure Vessels and Section VII – Division –2 Alternative Rules for Pressure Vessels and Section –IX, Welding Qualifications.

iv  ANSI 118 – Layouts.

v  ANSI B 31.8 - Gas Transmission and Distribution Piping System

vi  OISD 105 – Work Permit System

vii  OISD 118 – Layout for Oil & Gas Installations

viii  OISD 119 – Inspection of Pumps

ix  OISD 120 – Inspection of Compressors

x  OISD 121 – Inspection of Turbines and Diesel Engines.

xi  OISD 122 – Inspection of Fans, Blowers, Gear Boxes & Agitators.

xii  OISD 123 – Inspection of Rotating Equipment Components

xiii  OISD 125 – Inspection and Maintenance of Mechanical Seals

xiv  OISD 127 – History recording of Rotating Equipment.

xv  OISD 128 – Inspection of Unfired Pressure Vessels

xvi  OISD 129 – Inspection of Storage Tanks.

xvii  OISD 130 – Inspection of Pipes, Valves & Fittings.

xviii  OISD 132 – Inspection of Pressure Relieving Devices.
## Typical Scheduled Inspection Categories and Frequencies

For Gas Turbines

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<th>Type of inspection</th>
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<tr>
<td>Combustion components Inspection</td>
<td>8,000 to 10,000 hours</td>
</tr>
<tr>
<td>Hot Gas Path Inspection</td>
<td>15,000 to 20,000 hours</td>
</tr>
<tr>
<td>Major Overhaul</td>
<td>30,000 to 45,000 hours</td>
</tr>
</tbody>
</table>