ASME B19.3-1991

(REVISION OF ANSI/ASME B19.3-1986)

Safety Standard for Compressors for Process Industries

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

AN AMERICAN NATIONAL STANDARD

Safety Standard for Compressors for Process Industries

ASME B19.3-1991

(REVISION OF ANSI/ASME B19.3-1986)

The American Society of Mechanical Engineers

345 East 47th Street, New York, N.Y. 10017

Date of Issuance: July 31, 1991

The 1991 Edition of this Standard is being issued with an automatic addenda subscription service. The use of an addenda allows revisions made in response to public review comments or committee actions to be published on a regular yearly basis; revisions published in addenda will become effective 1 year after the Date of Issuance of the addenda. The next edition of this standard is scheduled for publication in 1996.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. The interpretations will be included with the above addenda service. Interpretations are not part of the addenda to the Standard.

FOREWORD

(This Foreword is not part of ASME B19.3-1991)

The use of compressed gases has a long history in the process industries. Experience has proven that the provision of certain basic safety features for compressor installations is essential to minimize the possibility of destructive mechanical failures or other serious accidents. Industry practices that have evolved from this experience provide a sound basis for safety requirements of gas compression facilities.

Information on industry practices, however, has not been readily available to all who design, install, or operate compressor installations. It was, therefore, decided that a need existed for a standard summarizing the basic safety requirements of compressor systems commonly used in the process industries. In developing this Standard, the Committee has consulted many sources and the resulting recommendations are believed to represent a summation of the best experience available.

In the case of practical difficulty or unnecessary hardship, the authority having jurisdiction is urged to grant exceptions from the literal requirements of this Standard and to permit the use of other devices or methods, but only when it is clearly evident that equivalent protection is thereby secured.

Safety codes and standards are intended to enhance public health and safety. Revisions result from committee consideration of factors such as technological advances, new data, and changing environmental and industry needs. Revisions do not imply that previous editions were inadequate.

This Standard, which was approved by the ASME B19 Committee and by the Sponsor, was approved and designated as an American National Standard by the American National Standards Institute on May 10, 1991.

CORRESPONDENCE WITH THE B19 COMMITTEE

(a) General. ASME codes and standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B19 Main Committee
The American Society of Mechanical Engineers
United Engineering Center
345 East 47th Street
New York, NY 10017

(b) Proposing Revisions. Revisions are made periodically to standards to incorporate changes which appear necessary or desirable, as demonstrated by the experience gained from the application of the standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s) and providing the proposed wording and a detailed description of the reasons for the proposal, including any pertinent documentation.

(c) Interpretations. On request, the B19 Committee will render an interpretation of any requirement of this Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the Main Committee.

The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his request in the following format.

Subject:	Cite the applicable paragraph number(s) and provide a concise description.
Edition:	Cite the applicable edition of the standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings which are necessary to explain the question; however, they should not contain proprietary names or information.

Requests which are not in this format will be rewritten in this format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information which might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

(d) Attending Committee Meetings. The B19 Main Committee regularly holds meetings which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the Main Committee.

ASME B19 COMMITTEE
Safety Standards for Compressors

(The following is a roster of the Committee at the time of approval of this Standard.)

OFFICERS

L. F. Rider, *Chairman*
P. E. Leonard, *Vice Chairman*
J. Pang, *Secretary*

COMMITTEE PERSONNEL

R. W. Abraham, Badger Engineers, Inc.
P. J. Beaty, E. I. DuPont de Nemours & Co.
W. F. Gallager, Air Products and Chemicals, Inc.
J. L. Hebb, U.S. Department of Energy
F. P. Jackson, Algonquin Gas Transmission
T. R. Kaye, *Alternate,* Maryland Casualty Co.
P. E. Leonard, Hartford Steam Boiler Inspection and Insurance Co.
D. C. Mbonu, General Services Administration
D. M. O'Dea, Exxon Research and Engineering Co.
H. P. Rhees, Champion Pneumatic Machinery Co.
L. F. Rider, York International Corp.
M. E. Schmidt, Industrial Risk Insurers

CONTENTS

Foreword iii
Correspondence With the B19 Committee v
Committee Roster vii

1 General 1
1.1 Purpose 1
1.2 Scope 1
1.3 Definitions 1
1.4 References 2
1.5 Format 2
1.6 SI (Metric) Units 2

2 General Safety Considerations for Design and Operation of Compressors 2
2.1 Design 2
2.2 Operating Practices 3

3 Safety Requirements 4
3.1 Excess Pressure Protection 4
3.2 Safety Devices 6
3.3 Fire and Explosion Protection 9
3.4 Prevention and Control of Leaks Involving Toxic or Flammable Material 13
3.5 Vibration Limits 13

SAFETY STANDARD FOR COMPRESSORS FOR PROCESS INDUSTRIES

1 GENERAL

1.1 Purpose

It is the purpose of this Standard to make available general information on safe practices and specific recommendations covering basic safety requirements for compressors used in the process industries. This information is intended to provide guidance to those who design, install, and operate compressors. Safety requirements described in this Standard for compressor auxiliary equipment, including drivers, shall not apply to such auxiliary equipment when used in applications other than compressor installations.

1.2 Scope

(a) The specific recommendations in this Standard cover the requirements for safety devices and protective facilities to prevent compressor accidents as a result of excessive pressure, destructive mechanical failures, internal fires or explosions, and leakage of toxic or flammable fluids. General safety practices and hazards unique to compressors are also covered. This Standard applies to the compressor and its auxiliaries, including drivers, intercoolers, surge chambers, disengaging drums or scrubbers, interconnecting piping and lubrication, seal oil, and jacket water systems. The requirements of this Standard apply to all types of compressors (centrifugal, axial, rotary, and reciprocating) which are an integral part of facilities for processing petroleum, petrochemicals, or chemicals, including air separation plants. They do not apply to gas transmission compressors, isolated petroleum production field compressors, or plant air compressors in manufacturing plants other than the process industries mentioned above.

(b) Although the provisions of this Standard will apply to the majority of typical compressors used in the process industries, exceptions to these recommendations with regard to certain facilities of unusual design or complexity may be necessary. In such cases, it is intended that designers capable of applying a complete and rigorous analysis to system requirements shall have latitude in the development of safety features. Provisions in this Standard are not intended to apply to (1) and (2) below:

(1) basic mechanical design of compressor components. This Standard is based on the requirement that the compressor components be designed by qualified engineers in accordance with the recognized standards and specifications. Further, it is essential that these engineers have a thorough knowledge of the basic concepts of the design of such equipment components as cylinders, pistons, crankshafts, flywheels, bearings, pressure vessels, and piping.

(2) design and operation of connected process facilities.

(c) The principles promoting safe operation of compressors used for process industries are not restricted to new compressor systems. It is recommended that all compressor systems be reviewed to consider possible changes due to revision of this Standard.

1.3 Definitions

maximum allowable temperature — the maximum temperature for which the manufacturer has designed the compressor (or any part to which the term is referred) when handling the specified gas at the specified pressure

maximum allowable working pressure — the maximum pressure for which the manufacturer has designed the compressor (or any part to which the term is referred, such as an individual cylinder or casing) when handling the specified gas at the specified temperature

maximum continuous speed — the highest speed at which the manufacturer's design will permit continuous operation with overspeed and governor mechanisms installed and operating *surge point* – the capacity below which operation becomes unstable at the operating speed of a centrifugal or axial compressor

1.4 References

The latest edition of the following standards, codes, or specifications shall, to the extent specified herein, form a part of this Standard. The edition bearing the latest date of publication shall be used.

API – AMERICAN PETROLEUM INSTITUTE
API RP 500A, Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries
API RP 520, Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries
API 618, Reciprocating Compressors for General Refinery Services

ASME – THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ASME Boiler and Pressure Vessel Code (hereafter referred to as "the ASME Code"), Section VIII, Division I
ASME A13.1, Scheme for Identification of Piping Systems
ASME B15.1, Safety Standard for Mechanical Power Transmission Apparatus
ANSI/ASME B31.3, Chemical Plant and Petroleum Refinery Piping
ASME Guide SI-1, Orientation and Guide for Use of SI (Metric) Units
ASTM E 380, Metric Practice Guide

CHLORINE INSTITUTE
The Chlorine Manual

COMPRESSED GAS ASSOCIATION
Acetylene Transmission for Chemical Synthesis

FEDERAL REGISTER 40 CFR PART 60

ISO – INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ISO R508, Identification Colours for Pipes Conveying Fluids in Liquid or Gaseous Condition in Land Installations and on Board Ships

NEMA – NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
ICS-1, General Standards for Industrial Control and Systems
ICS-2, Industrial Control Devices, Controllers, and Assemblies
MG1, Motors and Generators
MG2, Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

NFPA – NATIONAL FIRE PROTECTION ASSOCIATION
ANSI/NFPA 37, Installation and Use of Stationary Combustion Engines and Gas Turbines
ANSI/NFPA 70, National Electrical Code

OSHA – OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
Part 1910, Occupational Safety and Health Standards

1.5 Format

The mandatory rules of this Standard are characterized by use of the word *shall.* If a statement is of an advisory nature, it is indicated by use of the word *should*, or is stated as a recommendation.

1.6 SI (Metric) Units

This Standard contains SI (metric) units as well as customary units. The SI units in the text have been directly (soft) converted from the customary units. Further information on the use of SI units is contained in ASTM E 380, Metric Practice Guide, and ASME Guide SI-1, Orientation and Guide for Use of SI (Metric) Units.

Current committee policy is to neither encourage nor discourage steps toward metrication, but to have standards published with information in the form which will best serve the needs of those who use the Standard. It is not the intent of the Standard to favor a design in SI units over one made in customary units, or conversely. In converting to SI units, an effort has been made to maintain the precision of the original values so that the accuracy of the converted values is neither exaggerated nor understated. Therefore, if there is a difference in the dimensions or the results of calculations between the two systems of units, the customary units govern.

2 GENERAL SAFETY CONSIDERATIONS FOR DESIGN AND OPERATION OF COMPRESSORS

The operation of a compressor and its auxiliary components may involve certain hazards which are unique to this type of equipment. Industry experience has indicated that these risks will be minimized through application of the design criteria and operating practices outlined below.

2.1 Design

2.1.1 Compressor piping shall comply with the provisions of ANSI/ASME B31.3. The use of cast iron valves and fittings in the process stream shall be avoided where piping is subjected to shock loading or vibratory stresses. Cast iron valves and fittings shall also be avoided in systems handling flammable, combustible, or toxic fluids.

2.1.2 The arrangement of compressor and driver piping shall facilitate drainage. In addition, accessible separation and/or drainage facilities shall be provided in piping upstream of compressors or drivers at low points or other locations susceptible to collection of liquid.

2.1.3 Facilities for emergency shutdown or isolation shall be provided for single compressor/multiple unit compressor systems when failure or operational upset could create a serious hazard in adjacent areas. Whether such facilities should operate automatically or from a remote manual station will depend on the dangers involved. Valves for isolating each compressor and driver shall be provided.

2.1.4 Compressor accessories such as water jackets and tubular heat exchangers shall be provided with drainage facilities to prevent freezing during idle periods.

2.1.5 Screens should be installed in compressor suction during initial startup and break-in periods for protection against damage from foreign materials. The screens may be removed after the piping system has been cleaned. Pressure drop indication is recommended.

2.1.6 Reciprocating compressor cylinders handling saturated vapors should be furnished with discharge nozzles on the bottom or downward side to facilitate drainage when the unit is idle.

2.1.7 External surfaces subject to temperatures in excess of 175°F (80°C) with which personnel may have contact shall be guarded or insulated.

2.1.8 Protection against the effects of noise exposure shall be provided in accordance with OSHA 1910.95. Compressor manufacturers should be consulted regarding expected noise levels. Other system components such as valves, inlet piping, and separators can generate noise, and the manufacturers of these components should be consulted also. Manufacturers are able to offer system components that have been specifically designed or treated to reduce their noise levels. Should a system not meet OSHA requirements, the affected area shall be clearly identified and warning signs posted at all entrances.

2.1.9 Emission limits, testing, reporting, etc., are covered in the Federal Register 40 CFR Part 60 Subpart GG.

2.1.10 All exposed moving parts shall be provided with personnel protection guards. These guards shall be designed and constructed so as to avoid risk of injury to personnel. Moving parts are defined as those having movement that is not hand powered and which move during normal operation. Guards shall comply with ANSI/ASME B15.1.

Guards shall be made of solid materials, with or without a liner, when necessary to meet the area classification (NFPA 70 and/or similar governing document).

Guards shall be securely fastened to the machine supporting structure or to the machines themselves.

Guard construction shall be such that heat buildup or concentration of corrosive materials will not adversely affect the parts being guarded or personnel.

2.2 Operating Practices

2.2.1 Rotating equipment shall not be placed in regular operation unless all safety features required by this Standard are in place.

2.2.2 A check of emergency or safety trip devices on compressor equipment shall be included as part of regularly scheduled maintenance.

Any safety device required by this Standard shall not be jumpered, bypassed, or defeated by any person. In the event that shutdown of the system would impose a more hazardous condition, the owner shall install a backup system drive train to maintain safe operation of the overall plant.

2.2.3 Inlet piping to compressors or drivers, surge chambers, disengaging drums or scrubbers, and cylinders or casings shall be drained prior to startup.

2.2.4 The flywheel or crankshaft of a reciprocating compressor shall be locked in place prior to maintenance work. After mechanical work of any kind has been completed on a compressor, it shall be barred over sufficiently (at least one revolution) to ensure that there are no mechanical interferences within the compressor or driver.

2.2.5 Compressors handling toxic or flammable gases shall be isolated from the process piping by means of blinds or double valves and bleeder when major maintenance is required. Before opening such compressors, the equipment should be purged or evacuated. Minor adjustments to compressor and driver, such as rod packing and valve inspection (on an individual basis), may be performed without blinding, provided adequate precautions, such as depressuring, are taken to protect personnel. Check valves shall not be relied upon for isolating compressors.

2.2.6 When maintenance is being performed on compressors, precautions shall be taken to ensure isolation of all energy sources to the driver. These precautions shall include the use of blinds or double valves and bleeder on steam and fuel gas supplies to drivers, or in the case of motor driven compressors, either:

(a) electrical load centers shall have a switching arrangement that must be locked in the open position, tagged, and tried; or

(b) other positive means of current interruption shall be employed.

In all cases, all connected equipment shall be depressured to prevent rotation of the drive shaft.

2.2.7 When fire resistant or other synthetic lubricants are used, the following shall be considered:

(a) effect of lubricant on painted surfaces, gaskets, and seals;

(b) effects of process gas on lubricant in the cylinder;

(c) toxicity rating of lubricant;

(d) effects of lubricant carry-over into process equipment.

2.2.8 The startup, shutdown, and emergency procedures for all operations involving compressors shall be reviewed periodically with the operators.

Good maintenance and repair procedures can contribute to the safety of the maintenance crew as well as operating personnel. Therefore, supervisors should establish comprehensive maintenance and operating procedures with periodic reviews with affected personnel and instruction for new hires. These procedures should cover startup, break-in period, routine operation, routine maintenance, preventive maintenance, trouble-shooting, and overhaul, with the manufacturer's instructions as a basis.

Competent observation of compressor performance is one of the best methods of determining need for maintenance which, in turn, can be the best safety precaution available. Any damage observed or suspected should be reported to supervisors. If the condition impairs safe operation, the machine shall be taken out of service for repair in the prescribed safe manner. Safeguards that have been altered or damaged should be reported so appropriate action can be taken to ensure against worker injury.

Records showing the history of operation, maintenance, inspections, and testing should be kept and reviewed regularly. These records should be a part of normal operation and maintenance. Such records form an important diagnostic tool. This tool can result in a safe working place, optimum operation, and minimum maintenance expense, and aid predictive maintenance. The compressor or system supplier is normally able to assist the owner and supervisors in establishing the type of records to be kept.

2.2.9 A nondestructive examination and inspection program for highly stressed compressor parts shall be established and implemented on a predetermined schedule based on manufacturer's recommendation, which should be predicated on type, age, severity of service, and past industry performance and experience of equipment.

2.2.10 Color coding or other marking of piping systems is recommended. Piping system markings shall comply with OSHA Section 1910.144 and 1910.145. Coding to ANSI/ASME A13.1, ISO R508, or labels identifying line contents are preferred.

2.2.11 Electric motors, their controls, and wiring shall be designed and installed in accordance with NFPA 70 and NEMA MG1, MG2, ICS-1, and ICS-2. Motors should be maintained in accordance with the manufacturer's instructions and NFPA 70B. Should a conflict exist, the manufacturer's instructions should be given preference. Safety requirements shall be in accordance with NFPA 70E.

3 SAFETY REQUIREMENTS

3.1 Excess Pressure Protection

3.1.1 General Requirements

(a) Gas compressors, drivers, and their auxiliaries shall be protected by a pressure relieving device or devices as required to prevent the pressure in any element of the gas compressors, drivers, and their auxiliaries from exceeding 110% of its maximum allowable working pressure. A value of 116% of maximum allowable pressure is permitted when two or more pressure relief devices are used [see the ASME Code, Section VIII, Division 1, UG-125 and UG-134(a)]. Exceptions to this requirement may be made in systems in which the only possibility for pressure to exceed 110% of the maximum allowable working

pressure relates to accidental closure of block valves, provided such valves are intended only for isolating equipment that is shut down. Special precautions shall be taken to ensure that such valves are open when equipment is placed in operation. Positive displacement compressors shall be protected with pressure relieving devices between compressor discharge and block valves, without exception.

(b) Pressure relieving devices should preferably be spring-loaded valves of the type described in the ASME Code, Section VIII, Division 1, UG-126. Design and installation of such valves shall adhere to the provisions of UG-126.

(c) Rupture disks may be used in lieu of or in conjunction with relief valves provided they are designed and installed in accordance with the ASME Code, Section VIII, Division 1, UG-127. Rupture disks may have application in corrosive service, or where required relief capacity is in excess of that which can be handled by a reasonable number of relief valves. When rupture disks are used, the disk rupture pressure, and consequently the maximum allowable working pressure, should be sufficiently above the intended operating pressure to prevent premature failure due to fatigue or creep. In addition, rupture disks should be inspected periodically for fatigue cracks during unit shutdowns.

(d) Pressure relieving devices shall be constructed of materials suitable for the pressure, temperature, and other conditions of the service intended.

(e) Pressure relieving devices may not be required in systems using centrifugal or axial compressors where the maximum pressure that may occur in any element cannot exceed 110% of its maximum allowable working pressure. To determine if relief facilities may be omitted, the maximum pressure which may occur within the system shall be evaluated for the various combinations of inlet pressure, flow, speed, and gas composition which could occur simultaneously.

3.1.2 Determination of Relief Requirements

(a) The system shall be analyzed to determine what circumstances or combinations thereof will cause the pressure on any compressor element to exceed 110% of its maximum allowable working pressure. For the most severe conditions, the flow at this pressure shall govern the capacity of relief facilities.

(b) The most frequent causes of overpressure on compressors are:

(1) blocked outlets or other restrictions to flow;
(2) failure of automatic controls;
(3) loss of cooling water;
(4) change in composition of gas or vapor;
(5) increase in suction or inlet pressure;
(6) excessive speed;
(7) flow reversal;
(8) the malfunction of reciprocating compressor valves.

(c) Overpressure on equipment resulting from various combinations of the causes listed in (b) shall not be considered as controlling if such an occurrence is only possible in the event of two or more unrelated causes occurring simultaneously.

3.1.3 Pressure Setting and Sizing of Relief Devices

(a) The maximum pressure setting of relief devices shall adhere to the requirements of the ASME Code, Section VIII, Division 1, UG-134.

(b) To minimize leakage from pressure relief valves, the set pressure of valves (pressure at which relief valve starts to open) should be a minimum of 10% or 15 psi (103 kPa), whichever is greater, above the intended operating pressure at the valve inlet. On reciprocating compressors, the minimum should be 10% or 25 psi (172 kPa), whichever is greater.

(c) Capacity of relief valves shall be in accordance with the formula given in the ASME Code, Section VIII, Division 1, UG-131 and UG-133. Where the set pressure of the relief valves is below the maximum allowable working pressure of the protected equipment, the maximum allowable working pressure may be substituted in the formula for set pressure.

3.1.4 Location of Pressure Relief Devices

(a) Relief devices should be installed as close as practicable to the system being protected. Pressure relief devices should be installed on the discharge side and upstream of any check valves in the system.

(b) Relief devices shall be connected to the vapor space of lines or vessels.

(c) For most compressor installations, overpressure protection for the compressor and its auxiliaries requires only a pressure relieving device or devices on the discharge of each compressor stage. Such an arrangement will usually suffice, provided the system pressure gradient under relieving conditions is such that the pressure on the weakest element will not exceed its maximum allowable working pressure by more than 10%.

(d) Pressure relief requirements for steam turbines, steam engines, and their accessories are normally governed by the pressure rating of the exhaust section of the driver case or of downstream components. Thus, the required set pressure of the relief device will generally be lower than the inlet pressure;

and the relief device, if required [see exception in para. 3.1.1(a)], shall be located in the exhaust portion of the system. The relief devices should be sized to pass the maximum steam which the turbine is capable of passing at the specified operating conditions. Sentinel valves are warning devices and shall not be used as overpressure protection.

3.1.5 Installation of Pressure Relieving Facilities

(a) The inlet line to a relief device, including all valves and fittings, shall have an opening at least equal in area to the area of the inlet to the relief device.

(b) When two or more pressure relieving devices are required to operate simultaneously through one connection, the cross-sectional area of this connection shall be at least equal to the combined inlet areas of the relief devices.

(c) The maximum pressure drop through inlet lines to pressure relief devices should not exceed 3% of the set pressure under conditions of maximum flow.

(d) When block valves are provided in the inlet line to relief devices, they shall be installed and maintained in accordance with provisions in the ASME Code, Section VIII, Division 1, Appendix M, M-5.

NOTE: Information on design and installation of relief devices is available in API RP 520, Parts I and II.

3.1.6 Disposal of Relief Stream

(a) Atmospheric discharge pipes shall terminate at a location which will not create a hazard to personnel. Where feasible, direct relief to the outside atmosphere is recommended.

(b) Discharge from relief devices for equipment located in a building shall terminate outside the building, preferably above the highest point of the roof, for relief of gases other than air.

(c) Atmospheric discharge lines shall be designed to facilitate drainage of water or other liquids which may accumulate in the outlets of the relief devices on the discharge riser.

(d) When compressors are installed in a closed loop, relief streams off the discharge may be routed to the suction portion of the system, provided this will not cause an excessive temperature rise in the system. In such cases, relief valves must be either of balanced design or of a type designed for superimposed back pressure.

(e) Where disposal of relief stream, either to atmosphere or to a lower pressure portion of the system, is considered impractical or unsafe, relief streams should be discharged to a closed gathering system. For toxic or hazardous materials, a dual relief with a three-way valve is recommended.

(f) When discharge lines of closed systems are long, or where outlets of two or more valves having set pressures within a comparable range utilize a common header, the effect of back pressure on reducing capacity of relief devices shall be considered. Use of specially designed valves for use on high or variable back-pressure service may be required.

(g) Discharge lines of closed systems shall be designed to facilitate drainage of liquid which may accumulate in outlet piping from relief valves.

(h) Where block valves are provided in the discharge lines from pressure relief devices, they shall be installed and maintained in accordance with the ASME Code, Section VIII, Division 1, Appendix M, M-6.

(i) The sudden loss of pressure on highly volatile fluids can cause a refrigeration effect resulting in very low temperatures. The harmful effects of reduced material ductility due to such low temperatures shall be taken into account in the design of the relief system. Refer to ANSI/ASME B31.3, para. 301.9.

3.2 Safety Devices

The following safety devices are required for protection against mechanical failure of compressors which might result in fire, explosion, or hazards to personnel. Exceptions may be taken to the utilization of any of the devices, other than overspeed protection, if stopping the compressor creates a process condition more dangerous than the hazard due to the anticipated mechanical failure.

3.2.1 Centrifugal and Axial Compressors

(a) A check valve shall be installed in each compressor discharge system where there is the possibility of reverse rotation resulting from back flow of gases through the compressor.

(b) The lubrication system (and seal oil system, if it is combined with the lubrication system) shall be equipped with an automatic shutdown device which stops the compressor driver at a preset lubricant pressure, flow, or differential pressure as recommended by the compressor manufacturer. The shutdown system shall be designed and installed in such a manner that a simulated low lubricant pressure, flow, or differential pressure test may be safely made while the compressor is in operation. An alarm, set

at a pressure or flow higher than the shutdown setting, should be included.

(c) A high discharge temperature alarm set above the specified operating temperature, but at least 25°F (14°C) below the maximum allowable temperature of the compressor, and a shutdown device set to stop the compressor driver at the maximum allowable compressor temperature may be installed at the compressor discharge from each stage of compression.

(d) If compressor suction or interstage disengaging drums or scrubbers are provided, a drain and a high-liquid-level alarm shall be installed to protect against liquid entering the compressor. Provision should be made for the high-liquid-level alarm to be safely tested with the unit in operation. A high-liquid-level compressor shutdown device set to operate above the alarm level should be included. Pulsation dampeners or bottles that can collect liquid shall be provided with drains.

(e) An antisurge device shall be utilized if system requirements indicate that the compressor may operate in surge for extended periods.

(f) Vibration and shaft movement alarms and shutdown should be utilized to avoid destructive failures.

3.2.2 Reciprocating and Rotary Compressors

(a) A check valve shall be installed in each rotary compressor discharge system where there is the possibility of reverse rotation resulting from back flow of gases through the compressor.

(b) The lubrication system (and seal oil system, if it is combined with the lubrication system) shall be equipped with an automatic shutdown device which stops the compressor driver at a preset lubricant pressure, flow, or differential pressure as recommended by the compressor manufacturer. The shutdown system shall be designed and installed in such a manner that a simulated low lubricant pressure, flow, or differential pressure test may be safely made while the compressor is in operation. An alarm, set at a pressure or flow higher than the shutdown setting, should be included.

(c) If compressor suction or interstage disengaging drums or scrubbers are provided, a drain and a high-liquid-level alarm shall be installed to protect against liquid entering the compressor. Provision should be made for the inclusion of the high-liquid-level compressor shutdown devices set to operate above the alarm level. Pulsation dampeners or bottles that can collect liquid shall be provided with drains.

(d) Pulsation-induced vibration shall not cause a cyclic stress level in excess of the endurance limit of the material used. The peak-to-peak (double amplitude) pulsation level, expressed as a percentage of the average absolute line pressure at the compressor flange, shall not exceed the value determined by use of the appropriate Design Approach specified in API Standard 618, Section 3.9.

Due to the pulsating nature of the flow through positive displacement compressors, it is possible that piping systems, where acoustic frequencies are close to the exciting frequency of the compressor, can experience excessive pressure pulsations. Such pulsations can cause:

(a) compressor driver to be severely overloaded;

(b) piping to vibrate with overstress occurring at fittings, valves, and structural supports;

(c) noise;

(d) vibrations in surrounding structures;

(e) damage to compressor valves;

(f) reduced capacity and performance.

Methods commonly used to correct pulsations include but are not limited to:

(a) commercial pulsation damping devices;

(b) strategically located orifices and/or choke tubes;

(c) volume bottles;

(d) a change in pipe length to avoid acoustic resonance.

Improved performance can be obtained by minimizing pressure pulsation levels in the compressor and associated piping systems.

If the frequency of the pulsations is in resonance with the natural frequency of the piping or foundation, fatigue failures of pipe nipples, anchor bolts, and other parts may result. If required, properly designed pulsation dampeners, orifices, or choke tubes shall be installed in the piping adjacent to the compressor cylinders to minimize the pressure pulses and their effect on other parts of the system. Pipe nipples supporting valves or fittings from the compressor cylinders or piping should be $\frac{3}{4}$ in. Schedule 160 minimum, and should be gusseted to avoid vibration which may produce fatigue failure. Piping systems should include supports, as required, to minimize vibration and stress at fittings and valves. Vibration alarms and shutdowns should be utilized to avoid destructive failures.

3.2.3 Steam Turbines and Steam Engines

(a) Steam drivers shall be equipped with an overspeed trip set to stop the turbine or engine at a speed of 110% of the maximum continuous speed of the compressor or driver, whichever is lower. The overspeed shutdown shall stop all steam flow and shall

be readily accessible and capable of being manually tripped and reset.

(b) For manual shutdown, a block valve shall be provided at a readily accessible location in the main steam supply line to the driver.

(c) The lubrication system (and seal oil system, if it is combined with the lubrication system) shall be equipped with an automatic shutdown device which stops the compressor driver at a preset lubricant pressure, flow, or differential pressure as recommended by the compressor manufacturer. The shutdown system shall be designed and installed in such a manner that a simulated low lubricant pressure, flow, or differential pressure test may be safely made while the compressor is in operation. An alarm, set at a pressure or flow higher than the shutdown setting, should be included.

(d) Shutdown devices shall be designed to actuate a quick-closing trip valve. Governor valves should also be closed by the shutdown device.

3.2.4 Internal Combustion Engines

(a) The lubrication system (and seal oil system, if it is combined with the lubrication system) shall be equipped with an automatic shutdown device which stops the compressor driver at a preset lubricant pressure, flow, or differential pressure as recommended by the compressor manufacturer. The shutdown system shall be designed and installed in such a manner that a simulated low lubricant pressure, flow, or differential pressure test may be safely made while the compressor is in operation. An alarm, set at a pressure or flow higher than the shutdown setting, should be included.

(b) Engines shall be equipped with an overspeed trip set to stop the engine at a speed of 110% of the maximum continuous speed of the compressor or engine, whichever is lower. The overspeed shutdown shall be easily accessible and capable of being manually tripped and reset.

(c) The engine jacket water system shall be provided with an alarm and/or shutdown device to stop the engine if jacket water temperature exceeds limits recommended by the manufacturer.

(d) Shutdown devices shall be designed to perform the following applicable functions:

(1) shut off the fuel;

(2) vent the gaseous fuel from the engine (some designs may not require this protection);

(3) deenergize the ignition system;

(4) relieve diesel compression, if practicable.

(e) For manual shutdown, a block valve shall be provided at a readily accessible location in the main fuel supply line to the engine.

3.2.5 Gas Turbines

(a) The lubrication system (and seal oil system, if it is combined with the lubrication system) shall be equipped with an automatic shutdown device which stops the compressor driver at a preset lubricant pressure, flow, or differential pressure as recommended by the compressor manufacturer. The shutdown system shall be designed and installed in such a manner that a simulated low lubricant pressure, flow, or differential pressure test may be safely made while the compressor is in operation. An alarm, set at a pressure or flow higher than the shutdown setting, should be included.

(b) Turbines shall be equipped with an overspeed trip set to stop the turbine at a speed of 105% of the maximum continuous speed of the compressor or turbine, whichever is lower. Split-shaft turbines shall have separate overspeed trips on each shaft.

(c) Gas turbine high temperature alarm and shutdown shall be provided and set to the manufacturer's recommended values.

(d) For manual shutdown, a block valve shall be provided at a readily accessible location in the main fuel supply line to the turbine.

Isolating fuel source valves shall provide tight shutoff and shall be arranged to close automatically on shutdown of the driver. Fuel lines between the isolating valve and gas turbine shall be vented or drained automatically on shutdown.

(e) The Federal Register 40 CFR Part 60 is the Clean Air Act. Consult this section and its subparts since it can affect design, operation, maintenance, testing and reporting of leaks, and disposal of the volatile organic compounds.

3.2.6 Electric Motors

(a) The lubrication system (and seal oil system, if it is combined with the lubrication system) shall be equipped with an automatic shutdown device which stops the compressor driver at a preset lubricant pressure, flow, or differential pressure as recommended by the compressor manufacturer. The shutdown system shall be designed and installed in such a manner that a simulated low lubricant pressure, flow, or differential pressure test may be safely made while the compressor is in operation. An alarm, set at a pressure or flow higher than the shutdown setting, should be included.

(b) For manual shutdown, a stop button shall be provided at a readily accessible location to interrupt power to the motor.

3.3 Fire and Explosion Protection

(a) This section covers fires and explosions (detonations or deflagrations) which initiate inside the compressor, driver, or its auxiliaries. Precautions to avoid internal explosions are required only where there are features inherent in the design or operation of the system which provide an opportunity for either formation of a flammable atmosphere inside equipment or for uncontrollable chemical reactions. A hazard exists where the compressor handles hydrocarbons, air, oxygen, or reactive compounds such as acetylene. When compressors are operated with air for running-in and commissioning periods, the precautions of para. 3.3.2(b) shall be followed. Closed-loop compressor operation with air shall be avoided.

(b) Although these criteria would exclude from consideration the majority of compressors handling flammable materials, the risk of explosions cannot always be considered negligible in such installations. Under certain conditions, explosive atmospheres may occur where flammable gases are involved, especially if the material has a wide explosive range (e.g., hydrogen) and there is a possibility of air leakage into the compressor. Prevention of explosions in this or similar situations is primarily a matter of preventing air entry, which may be accomplished through proper design of equipment and strict adherence to prescribed operating procedures.

3.3.1 Hydrocarbon Compressors

(a) Consideration should be given to the following possibilities for accidental entry of air into hydrocarbon compressors:

(1) air leakage through packing and flanges during startup when cylinder or casing pressure might be lower than atmospheric pressure;

(2) valves left open in suction line vents;

(3) insufficient purging after compressor has been opened for maintenance.

(b) Prevention of explosions is more complex with regard to the various types of facilities discussed below since materials which may provide one or more of the ingredients of an explosion are inherent in the operation of the equipment or are necessary to the process.

3.3.2 Air Compressors. Fires or explosions involving air compressors can be classified into two general categories: those in which compressor lubricating oil is in contact with airstream and those involving closed-loop operation.

(a) Lubricating Oil in Contact With Airstream. The majority of fires or explosions in air compressor systems have involved reciprocating machines. The fuel for air compressor fires is the cylinder lubricating oil itself or the carbonaceous products formed by oxidation of the lubricating oil. The formation of carbonaceous deposits in air compressor systems depends on the amount and type of the lubricating oil used and the temperature of the metal surface on which the oil is deposited. These effects appear to be interrelated, i.e., an operating temperature which is satisfactory with the correct amount of oil may cause carbon deposition if excess oil is used. The mechanism by which the fuel in air compressor fires is ignited is not definitely known; however, a factor common to all theories of ignition is excessive temperature, which may involve either the gas itself or a localized condition resulting from mechanical friction. High temperature is also important because it promotes deposition of carbon in the compressor system. Excessive temperatures are generally caused by valve or cooling water failures or by operation at unusually high compression ratios. High operating speeds combined with ineffective jacket design also promote high cylinder temperatures. To minimize the risk of fires and explosions in positive displacement air compressors, the following precautions are recommended.

(1) Use nonlubricated compressors.

(2) Provide high temperature alarms and cutouts in compressor discharge.

(3) Use the minimum amount of lubricating oil that will lubricate the cylinder satisfactorily and train operators to detect significant increases in lubricating oil consumption. Use the least viscous oil that will satisfy operating conditions.

(4) Train operators to detect faulty compression cylinder valves and have repairs made promptly.

(5) Take inlet air from a cool, clean location. Provide air filters (preferably of a dry type) and service at regular intervals.

(6) Provide intercoolers to maintain interstage suction temperatures at lowest practicable level. Keep intercoolers and cylinder jackets free of deposits.

(7) Inspect reservoirs, cylinder, pulsation dampener, discharge pipe, afterfilters, etc., regularly. Remove deposits and oil accumulations. Provide access for inspection and cleaning.

(b) Closed-Loop Compressor Operation. Leakage of lubricating oil from seals or bearings into a closed loop can create a flammable mixture, and if coincident with such a condition an element in the machine becomes overheated, a serious explosion may result. To prevent disasters of this type, bearings and oil seals of centrifugal or axial compressors for closed-

loop air systems should be designed to prevent lubricant carry-over into the compressor. If there is any possibility of oil carrying into the compressor, closed-loop air systems shall not be used.

3.3.3 Oxygen Compressors

(a) The principal hazard in handling oxygen is its reactivity with any combustible material. Combustible materials for oxygen systems are defined as oxidizable organic or inorganic materials. Combustible organic materials are lubricating oil, joint compounds, and gasket and valve packing. Combustible inorganic materials are carbon steel, rust, or iron scale that may be further oxidized and finely divided metal particles eroded from oxygen piping or equipment.

(b) To minimize the risk of fires or explosions in oxygen compressors, the following precautions are essential.

(1) For safe operation, all equipment and piping shall be completely free of hydrocarbons and foreign material described in (a). Prior to initial operation or operation following any contamination, thorough cleaning is essential.

(2) Reciprocating compressor cylinders should be nonlubricated. If lubrication is required, lubricants compatible with oxygen shall be used.

(3) Piping or equipment of cast iron or carbon steel shall not be used for handling oxygen over 350°F (177°C).

(4) Under certain conditions, high velocities in compressor piping will create a hazard. The maximum safe velocity is dependent on several variables including temperature, pipe metallurgy, bore finishes, and whether oxygen is wet or dry. For example, for dry oxygen at 150 psi (1035 kPa) and 250°F (120°C), a safe velocity is 100 ft/sec (30 m/s) for carbon steel pipe and 200 ft/sec (61 m/s) for stainless steel pipe. With higher operating temperatures or pressures, the maximum safe velocities would be lower.

(5) Where high fluid velocities occur, blowdown vent and sample connections shall be made of low reactive materials such as brass, bronze, stainless steel, or monel.

(6) Compressor lubrication of oil systems shall be completely isolated from the gas being handled by the compressor by:

(a) positive sealing systems on centrifugal and rotary compressors;

(b) extended, two compartment distance pieces for reciprocating compressors.

3.3.4 Acetylene Compressors

(a) The principal hazard in compressing acetylene is that it may spontaneously decompose under certain conditions of pressure and temperature. The decomposition may occur relatively slowly, resulting in a deflagration with pressures about 11 times the initial pressure, or it can detonate and develop pressures up to 350 times the initial pressure. Decomposition is promoted by the presence of small amounts of oxygen or catalytic agents, such as iron rust and various other materials.

(b) It is recommended that equipment and piping for acetylene compression be as small as practicable. The small piping decreases the likelihood of a decomposition accelerating to a detonation and is more easily constructed to withstand decomposition pressures. All piping should be designed to withstand the pressures which may be encountered when decomposition occurs.

(c) With proper precautions, acetylene may be compressed to 400 psia [2760 kPa (absolute)] but as pressure increases, the temperature at which decomposition will occur decreases. The tabulation below gives a pressure–temperature correlation for spontaneous decomposition without the presence of oxygen or catalytic agents. The measured temperature at any point in the compressor system shall not exceed the limits given.

300°F (149°C)	at	400 psia (2760 kPa)
390°F (199°C)	at	300 psia (2070 kPa)
480°F (249°C)	at	200 psia (1380 kPa)
610°F (321°C)	at	100 psia (690 kPa)
680°F (360°C)	at	50 psia (345 kPa)
750°F (399°C)	at	14.7 psia (100 kPa)

If there is a possibility of hot spots forming due to factors such as friction, valve failure, or external heat source, the normal operating temperatures should be further reduced.

(d) Maximum precautions should be taken to avoid the presence of catalytic agents such as pipe scale, iron rust, or other foreign materials in the system. Likewise, precautions should be taken to prevent contamination of the acetylene with air or other oxidizing agents because these can initiate decomposition under conditions where the values for temperature and pressure are much lower than those tabulated above.

(e) One of the most common precautions used in handling acetylene is the use of a flash arrester. This device stops the progress of decomposition. Flash arresters specifically designed for acetylene service

should be considered for installation at the outlet of the compressor system.

(f) Copper, mercury, silver, and their alloys shall not be used with acetylene, as these materials may form acetylides which are fulminators and will decompose violently with flame generation.

(g) For further information, refer to Acetylene Transmission for Chemical Synthesis.

3.3.5 Chlorine Compressors. Chlorine is a very toxic and reactive gas. Because of its poisonous nature, precautions shall be taken to prevent leakage into the atmosphere.

(a) Corrosion is not a serious problem with chlorine if it is dry and at a temperature below 250°F (121°C). Under these conditions it can be handled with most common ferrous materials of construction. Accelerated corrosion of carbon steel, stainless steel, and cast iron can be expected above this temperature or if the chlorine is wet. Since carbon steel ignites at 482°F (250°C) in the presence of chlorine, the discharge temperature must be monitored and maintained below 302°F (150°C).

(b) Chlorine containing more than 150 ppm of moisture attacks all ferrous materials, including the stainless steels, Hastelloy, and NiResist. To avoid the use of exotic alloys, gas should be thoroughly dry before compression, and precautions should be taken to prevent accidental contact with water. Any air or other gases mixed with chlorine for process purposes should be dried to a dew point of −40°F (−40°C) or lower. Materials that are known to withstand wet chlorine are glass, ceramics, tantalum, and fiber reinforced plastic. Titanium may be used for wet chlorine gas, but shall not be used for dry chlorine gas because of the combustion hazard.

(c) Chlorine reacts with all common lubricants, and the use of nonlubricated compressors is recommended. Where a lubricant is essential, the fluorinated lubricants may be used. Sealant/coolant fluid for rotary compressors with 98% sulfuric acid has also proven successful with dry chlorine.

(d) For further information, refer to the Chlorine Manual.

3.3.6 Starting Air Systems

(a) Causes of Explosions. Numerous fires and explosions which have occurred in starting air systems while starting large internal combustion engines have been traced to accumulations of lubricating oil in the starting air line, coincident with faulty air check valves. When these conditions exist concurrently, the following sequence of events is possible.

(1) Leakage of fuel gas through a check valve that is stuck or leaking creates a flammable mixture in the starting air line.

(2) The mixture can be ignited from the power cylinder.

(3) Flame propagates through the air check valve and starting air line.

(4) Depending on pressure, temperature, and quantity of lubrication oil or gas in the starting air line, a fire or explosion may follow. Detonations in starting air lines are particularly destructive because they travel at a very high speed, and they produce very high localized pressures due to shock waves. For these reasons, relief valves or rupture disks have not prevented rupture of starting air lines when conditions were favorable to detonation.

(b) Prevention of Explosions. To minimize the risk of explosions in starting air systems, the following precautions are recommended.

(1) Thermometers, thermocouples, or other temperature sensing devices installed in discharge piping should be monitored to detect fouled or defective valves.

(2) Any increase in compressor oil consumption should be investigated.

(3) Intake air filters should be kept clean.

(4) Discharge temperature of any stage of starting air compressor shall not exceed 350°F (177°C).

(5) Starting air header on engine should be vented during normal operation.

(6) Receivers and low spots in air piping should be blown down on a regular schedule. Low spots in piping should be fitted with drains.

(7) Air receiver and interconnected piping should be inspected on a regular schedule. Oil or dirt accumulation should be removed.

(8) Starting air check valves and air pilot valves on engines should be included as part of regularly scheduled maintenance.

3.3.7 Engine Explosions. Explosions in crankcases of reciprocating engines can be disastrous, and operators of such equipment should be familiar with the causes of these accidents and the measures which may be helpful in minimizing the risk of an explosion.

(a) Causes of Explosions. Crankcase explosions result from ignition of a combustible mixture of lubricating oil or gas and air. Combustion pressure which develops following ignition within the confined space frequently exceeds the strength of the crankcase housing, and destructive failure occurs. The ignition source may be gas blowby or an overheated engine part.

(b) Prevention of Explosions. Prevention of crankcase explosions requires either elimination of the ignition source or prevention of flammable atmospheres.

(1) Elimination of Ignition Sources. Elimination of ignition sources is not feasible, as the possibility of some form of mechanical seizure is always present. Technical difficulties inherent in measuring temperatures of all moving parts preclude as impractical any attempt to prevent potential ignition sources through early detection of overheated parts. However, proper maintenance and operation are recommended as a means of minimizing mechanical failure. If an engine is shut down due to mechanical trouble which might involve an overheated part in the crankcase, inspection doors on crankcase should not be opened for at least 15 min. This is to allow the heated part to cool before air is permitted to enter the crankcase, and thereby to minimize the possibility of an explosion.

(2) Crankcase Ventilation. Approaches sometimes recommended to prevent flammable mixtures include forced ventilation of the crankcase or operating the crankcase below atmospheric pressure. When such methods are employed, it should be recognized that under certain conditions, crankcase ventilation may dilute a rich mixture into the flammable or explosive range.

As an alternative to ventilation, crankcases may be continuously purged with inert gas. However, the volume of gas required to effectively purge a large engine will usually cause this approach to be impractical.

(c) Explosion Relief. Because it is difficult to eliminate the causes of explosions, relief devices are sometimes installed to prevent pressures exceeding the strength of the crankcase housing. Relief devices may range from simple spring-loaded cover plates to specially designed valves fitted with flame traps. Rupture disks are not recommended since the inrush of air to fill the partial vacuum created by an explosion may lead to a second explosion, sometimes more violent than the first. As to sizing relief devices, investigations, including full-scale tests, have shown it would not be practical to provide sufficient relief area to maintain a safe pressure level when conditions are favorable to an explosion developing maximum intensity. As a result, the majority of engine manufacturers do not provide crankcase relief devices as standard equipment. However, experience has shown that many typical crankcase explosions can be safely relieved with conventional crankcase explosion relief devices.

(d) For further information, refer to ANSI/NFPA 37.

3.3.8 Combustion Gas Turbine Explosion. The normal safe operation of combustion gas turbines requires that the combustion be confined to the specially designed combustion chambers. Abnormal fires and explosions have resulted from fuel accumulations within the compressor or turbine casing, or the exhaust duct-work.

(a) The principal causes of these accidents are as follows:

(1) leakage of the fuel past the isolating block valves or governing valve during idle periods;

(2) improper governor valve setting on starting controls;

(3) maloperation of devices protecting against lack of combustion and/or loss of flame during starting;

(4) presence of liquid fuel in the gas fuel system;

(5) inadequate purge of turbine and duct systems prior to startup.

(b) The following precautions are recommended to minimize the risk of fires in gas turbines.

(1) Fuel isolating valves and governing valves shall provide tight shutoff and should automatically close on shutdown of the turbine. Facilities should be available for depressuring the fuel system on the turbine side of the isolating and governing valves during idle periods.

(2) Monitoring equipment shall be provided to scan turbine temperature on starting or to establish the presence of normal combustion in the combustion chambers within a 15 sec period after fuel is admitted to the turbine. Upon failure to establish normal combustion, the turbine shall automatically shut down and the fuel shall be vented and drained.

(3) The starting cycle for the turbine shall include a purge period to provide purge air to sweep the internal passages and duct-work free of combustible materials. Purge periods should be sufficiently long to ensure that at least 5–10 volumes of air have swept through the internal turbine and duct volume.

(4) Prior to starting, the fuel starting valve should be checked to make certain that it is in working order. Upon initial firing, a governor valve action should be checked to determine if it is operating correctly.

(5) The starting cycle for the turbine, as a minimum, should be semiautomatic with start, purge, run, and off positions. A system of monitoring lights or messages shall be provided to indicate that the turbine cycle is proceeding satisfactorily.

(6) Regarding explosions in turbine exhaust ducts, it is not considered practical to provide explosion doors or hatches to relieve the rapid burning of excessive combustibles passing through the turbine exhaust system.

(c) For further information, refer to ANSI/NFPA 37.

3.4 Prevention and Control of Leaks Involving Toxic or Flammable Material

Means for the prevention and control of compressor leakage shall be provided if the compressor is handling a toxic or flammable gas.

3.4.1 Venting shall be provided to carry away any leakage which is inherent with certain seals or which may result if the seals become defective.

(a) Centrifugal, axial, and rotary compressors shall require vents from the shaft seals to carry away leakage past the seal faces or labyrinths.

(b) Reciprocating compressors shall require vents from the piston rod packing. Where closed distance pieces are used, they shall be similarly vented.

(c) The vents described above shall be piped to a gas collection system or, where permissible, to the atmosphere at a safe distance from process equipment and operating personnel.

3.4.2 Where seal oil systems are used to prevent gas leakage, the seal oil systems shall be provided with an alarm indicating a low seal oil pressure or level and an automatic shutdown device which stops the compressor driver at a preset low seal oil pressure or level, as recommended by the compressor manufacturer.

3.4.3 Ventilation of areas and buildings containing compressors handling hazardous gas shall be designed to prevent recirculation or concentration of gas leakage. For example, where the hazardous gas is heavier than air, unventilated pits or trenches should be avoided. Vented flammable or toxic gas shall be located so as not to be drawn into intakes of adjacent air compressors.

3.4.4. Motor drivers for compressors handling flammable gas shall conform with applicable sections of ANSI/NFPA 70, Article 500. In addition, API RP 500A is recommended as a guide to classifying hazardous areas.

3.4.5 In addition to the electrical ignition hazards described in the above references, consideration should be given to preventing contact of flammable mixtures with other sources of possible ignition. Devices that may spark or become hot enough to ignite a flammable mixture shall be recognized as ignition hazards. Examples are:

(a) engine spark ignition systems. It is not practical to make engine spark ignition systems explosion proof. However, proper design and maintenance of these systems will minimize the hazard.

(b) engine exhaust components;

(c) furnaces or other ignition sources in a process unit. The location of the compressor shall take into consideration the distance to furnaces or other sources of external ignition in addition to any large fire risk areas attendant with the overall process layout.

3.5 Vibration Limits

Many factors influence the maximum vibration severity level to which compressor equipment, drivers, and transmission devices may be exposed. The manufacturer should be consulted for values related to specific equipment. Vibration and shaft movement alarms and shutdowns should be used to avoid destructive failures.

This document is printed
on 50% recycled paper.

50% RECOVERED PAPER MATERIAL means paper waste generated after the completion of the papermaking process, such as postconsumer materials, text books, envelopes, bindery waste, printing waste, cutting and converting waste, butt rolls, obsolete inventories, and rejected unused stock.

ISBN # 0-7918-2099-8

J07091