

WARNING—Misuse of this product may cause explosion and personal injury. Do not use without first reading and understanding these instructions and the apparatus installation and operating instructions.

AMETEK

U.S. GAUGE DIVISION
HUNTER SPRING PRODUCTS
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USE AND INSTALLATION OF PRESSURE GAUGES

The following information on installation and use has been excerpted from ASME B40.1-1991. The complete ASME B40.1-1991 standard which contains additional information may be obtained from the American Society of Mechanical Engineers, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300

3.3.4 Pressure Connection

- 3.3.4.1 Location of Connection
- stem mounted - bottom or back
 - surface mounted - bottom or back
 - flush mounted - back

3.3.4.2 Type of Connection. Taper pipe connections for pressures up through 20,000 psi (160,000 kPa) are usually 1/8-27, 1/4-18, or 1/2-14NPT American Standard external or internal taper pipe threads per ANSI/ASME B1.20.1, as required. Above this pressure, 1/4 high pressure tubing connections, or equal, may be used. Other appropriately sized connections, employing sealing means other than tapered threads, are acceptable.

In applications of stem mounted gauges, especially with liquid filled cases and where vibration is severe, consideration should be given to the possibility of failure of the stem or associated piping caused by the vibrating mass of the gauge. A large connection (e.g., 1/2NPT instead of 1/4NPT) or a stronger stem material (e.g., stainless steel instead of brass), or both, should be considered.

3.4.1.10 Mounting a pressure gauge in a position other than that at which it was calibrated can affect its accuracy. Normal calibrating position is upright and vertical. For applications requiring mounting in other than this position, notify the supplier.

3.4.1.12 Caution to Users.

Pressure gauges can be rendered inaccurate during shipment despite care taken in packaging. To ensure conformance to the standard grade to which the pressure gauge was manufactured, it should be checked before use.

4 SAFETY

4.1 Scope

This Section of the Standard presents certain information to guide users, suppliers, and manufacturers toward minimizing the hazards that could result from misuse or misapplication of pressure gauges with elastic elements. The user should become familiar with all sections of this Standard, as all aspects of safety cannot be covered in this Section. Consult the manufacturer or supplier for advice whenever there is uncertainty about the safe application of a pressure gauge.

4.2 General Discussion

4.2.1 Adequate safety results from intelligent planning and careful selection and installation of gauges into a pressure system. The user should inform the supplier of all conditions pertinent to the application and environment so that the supplier can recommend the most suitable gauge for the application.

4.2.2 The history of safety with respect to the use of pressure gauges has been excellent. Injury to personnel and damage to property have been minimal. In most instances, the cause of failure has been misuse or misapplication.

4.2.3 The pressure sensing element in most gauges is subjected to high internal stresses, and applications exist where the possibility of catastrophic failure is present. Pressure regulators,

chemical (diaphragm) seals, pulsation dampers or snubbers, syphons, and other similar items, are available for use in these potentially hazardous systems. The hazard potential increases at higher operating pressure.

4.2.4 The following systems are considered potentially hazardous and must be carefully evaluated:

- compressed gas systems
- oxygen systems
- systems containing hydrogen or free hydrogen atoms
- corrosive fluid systems (gas and liquid)
- pressure systems containing any explosive or flammable mixture or medium
- steam systems
- nonsteady pressure systems
- systems where high overpressure could be accidentally applied
- systems wherein interchangeability of gauges could result in hazardous internal contamination or where lower pressure gauges could be installed in higher pressure systems
- systems containing radioactive or toxic fluids (liquids or gases)
- systems installed in a hazardous environment

4.2.5 When gauges are to be used in contact with media having known or uncertain corrosive effects or known to be radioactive, random or unique destructive phenomena can occur. In such cases the user should always furnish the supplier or manufacturer with information relative to the application and solicit his advice prior to installation of the gauge.

4.2.6 Fire and explosions within a pressure system can cause pressure element failure with very violent effects, even to the point of completely disintegrating or melting the pressure gauge. Violent effects are also produced when failure occurs due to:

- hydrogen embrittlement;
- contamination of a compressed gas;
- formation of acetylides;
- weakening of soft solder joints by steam or other heat sources;
- weakening of soft soldered or silver brazed joints caused by heat sources such as fires;
- corrosion;
- fatigue;
- mechanical shock;
- excessive vibration.

Failure in a compressed gas system can be expected to produce violent effects.

4.2.7 Modes of Pressure Gauge Failure

4.2.7.1 Fatigue Failure. Fatigue failure caused by pressure induced stress generally occurs from the inside to the outside along a highly stressed edge radius, appearing as a small crack that propagates along the edge radius. Such failures are usually more critical with compressed gas media than with liquid media.

Fatigue cracks usually release the media fluid slowly so case pressure buildup can be averted by providing pressure relief openings in the gauge case. However, in high pressure elastic elements where the yield strength approaches the ultimate strength of the element material, fatigue failure may

resemble explosive failure.

A restrictor placed in the gauge pressure inlet will reduce pressure surges and restrict fluid flow into the partially open Bourdon tube.

4.2.7.2 Overpressure Failure. Overpressure failure is caused by the application of internal pressure greater than the rated limits of the elastic element and can occur when a low pressure gauge is installed in a high pressure port or system. The effects of overpressure failure, usually more critical in compressed gas systems than in liquid filled systems, are unpredictable and may cause parts to be propelled in any direction. Cases with pressure relief openings will not always retain expelled parts.

Placing a restrictor in the pressure gauge inlet will not reduce the immediate effect of failure, but will help control flow of escaping fluid following rupture and reduce potential of secondary effects.

It is generally accepted that solid front cases with pressure relief back will reduce the possibility of parts being projected forward in the event of failure.

The window alone will not provide adequate protection against internal case pressure buildup, and can be the most hazardous component.

Short duration pressure impulses (pressure spikes) may occur in hydraulic or pneumatic systems, especially when valves open or close. The magnitude of the spikes may be many times the normal operating pressure, and may not be indicated by the gauge. The result could be immediate failure, or a large upscale error. A restrictor (snubber) may reduce the magnitude of the pressure transmitted to the elastic element.

4.2.7.3 Corrosion Failure. Corrosion failure occurs when the elastic element has been weakened through attack by corrosive chemicals present in either the media inside or the environment outside it. Failure may occur as pinhole leakage through the element walls or early fatigue failure due to stress cracking brought about by chemical deterioration or embrittlement of the material.

A chemical (diaphragm) seal should be considered for use with pressure media that may have a corrosive effect on the elastic element.

4.2.7.4 Explosive Failure. Explosive failure is caused by the release of explosive energy generated by a chemical reaction such as can result when adiabatic compression of oxygen occurs in the presence of hydrocarbons. It is generally accepted that there is no known means of predicting the magnitude or effects of this type of failure. For this mode of failure, a solid wall or partition between the elastic element and the window will not necessarily prevent parts being projected forward.

4.2.7.5 Vibration Failure. The most common mode of vibration failure is that where the movement parts wear because of high cyclic loading caused by vibration, resulting in gradual loss of accuracy, and, ultimately failure of the pointer to indicate any pressure

change.

4.2.7.6 Vibration-Induced Fatigue Failure. In addition to its effect on the gauge movement and linkage (see para. 4.2.7.5) vibration may, in some instances, result in high loading of various parts of the pressure element assembly. This loading could cause cracks in the element itself, or in joints. Case pressure buildup may be slow, but it is possible that a large hole may suddenly develop, with a high rate of case pressure rise, which could result in a failure similar to an explosive failure.

4.2.8 Pressure Connection. See recommendations in para. 3.3.4.

4.3 Safety Recommendations

4.3.1 Operating Pressure. The pressure gauge selected should have a full scale pressure such that the operating pressure occurs in the middle half (25 to 75%) of the scale. The full scale pressure of the gauge selected should be approximately two times the intended operating pressure.

Should it be necessary for the operating pressure to exceed 75% of full scale, contact the supplier for recommendations. This does not apply to test, retarded, or suppressed scale gauges.

4.3.2 Use of Gauges Near Zero Pressure.

The use of gauges near zero pressure is not recommended because the accuracy tolerance may be a large percentage of the applied pressure. If for example, a 0/100 psi Grade B gauge is used to measure 6 psi, the accuracy of measurement will be +/- 3 psi, or +/- 50% of the applied pressure. In addition, the scale of a gauge is often laid out with takeup, which can result in further inaccuracies when measuring pressures that are a small percentage of the gauge span.

For the same reasons, gauges should not be used for the purpose of indicating that the pressure in a tank, autoclave, or other similar unit has been completely exhausted to atmospheric pressure. Depending on the accuracy and the span of the gauge and the possibility that takeup is incorporated at the beginning of the scale, hazardous pressure may remain in the tank even though the gauge is indicating zero pressure. A venting device must be used to completely reduce the pressure before unlocking covers, removing fittings, or performing other similar activities.

4.3.3 Compatibility With the Pressure Medium

The elastic element is generally a thin walled member, which of necessity operates under high stress conditions and must; therefore, be carefully selected for compatibility with the pressure medium being measured. None of the common element materials is impervious to every type of chemical attack. The potential for corrosive attack is established by many factors, including the concentration, temperature, and contamination of the medium. The user should inform the gauge supplier of the installation conditions so that the appropriate element materials

IMPORTANT - Read other side for additional instructions and warnings.

(Excerpts from ASME B40.1-1991 continue on back)

can be selected.

4.3.4 In addition to the factors discussed above, the capability of a pressure element is influenced by the design, materials, and fabrication of the joints between its parts.

Common methods of joining are soft soldering, silver brazing, and welding. Joints can be affected by temperature, stress, and corrosive media. Where application questions arise, these factors should be considered and discussed by the user and manufacturer.

4.3.5 Some special applications require that the pressure element assembly have a high degree of leakage integrity. Special arrangement should be made between manufacturer and user to assure that the allowable leakage rate is not exceeded.

4.3.6 Cases

4.3.6.1 Case, Solid Front. It is generally accepted that a solid front case per para. 3.3.1 will reduce the possibility of parts being projected forward in the event of elastic element assembly failure. An exception is explosive failure of the elastic element assembly.

4.3.6.2 Cases, Liquid Filled. It has been general practice to use glycerine or silicone filling liquids. However, these fluids may not be suitable for all applications. They should be avoided where strong oxidizing agents including, but not limited to, oxygen, chlorine, nitric acid, and hydrogen peroxide are involved. In the presence of oxidizing agents, potential hazard can result from chemical reaction, ignition, or explosion. Completely fluorinated or chlorinated fluids or both, may be more suitable for such applications.

The user shall furnish detailed information relative to the application of gauges having liquid filled cases and solicit the advice of the gauge supplier prior to installation.

Consideration should also be given to the instantaneous hydraulic effect that may be created by one of the modes of failure outlined in para 4.2.7. The hydraulic effect due to pressure element failure could cause the window to be projected forward even when a case having a solid front is employed.

4.3.7 Restrictor. Placing a restrictor between the pressure connection and the elastic element will not reduce the immediate effect of failure, but will help control flow of escaping fluid following rupture and reduce the potential of secondary effects.

4.3.8 Specific Service Conditions

4.3.8.1 Specific applications for pressure gauges exist where hazards are known. In many instances, requirements for design, construction, and use of gauges for these applications are specified by state or federal agencies or Underwriters

Laboratories, Inc. Some of these specific service gauges are listed below. The list is not intended to include all types, and the user should always advise the supplier of all application details.

4.3.8.2 Acetylene Gauge. A gauge designed to indicate acetylene pressure. It shall be constructed using materials that are compatible with commercially available acetylene. The gauge may bear the inscription ACETYLENE on the dial.

4.3.8.3 Ammonia Gauge. A gauge designed to indicate ammonia pressure and to withstand the corrosive effects of ammonia. The gauge may bear the inscription AMMONIA on the dial. It may also include the equivalent saturation temperature scale markings on the dial.

4.3.8.4 Chemical Gauge. A gauge designed to indicate the pressure of corrosive or high viscosity fluids, or both. The primary material(s) in contact with the pressure medium may be identified on the dial. It may be equipped with a chemical (diaphragm) seal, pulsation damper, or pressure relief device, or a combination. These devices help to minimize potential damage to personnel and property in the event of gauge failure. They may, however, also reduce accuracy or sensitivity, or both.

4.3.8.5 Oxygen Gauge. A gauge designed to indicate oxygen pressure. Cleanliness shall comply with Level IV (see Section 5). The dial shall be clearly marked with a universal symbol and/or USE NO OIL in red color (see para. 6.1.2.1).

4.4 Reuse of Pressure Gauges

It is not recommended that pressure gauges be moved from one application to another. Should it be necessary, however, the following must be considered.

4.4.1 Chemical Compatibility. The consequences of incompatibility can range from contamination to explosive failure. For example, moving an oil service gauge to oxygen service can result in explosive failure.

4.4.2 Partial Fatigue. The first installation may involve pressure pulsation that has expended most of the gauge life, resulting in early fatigue in the second installation.

4.4.3 Corrosion. Corrosion of the pressure element assembly in the first installation may be sufficient to cause early failure in the second installation.

4.4.4 Other Considerations. When reusing a gauge, all guidelines covered in this Standard relative to application of gauges should be followed in the same manner as when a new gauge is selected.

In addition to the ASME B40.1-1991 standard, the following additional instructions and warnings should be read and understood before using this product.

A very important aspect of selecting and installing pressure gauges is the consideration of the hazards that will result in the event the gauge fails. The primary causes of failure are misapplication and/or abuse of the gauge. Those people who are responsible for the selection and installation of pressure gauges must recognize conditions which will adversely affect the ability of the gauge to perform its function or which will lead to early failure. These conditions may then be discussed with the manufacturer to obtain their recommendations.

Failure may constitute:

1. Loss of accuracy.
2. Clogging of the pressure port, or damage to the internal mechanism so that there is either:
 - a. no indication when pressure is applied or
 - b. there is an indication of pressure even though none is applied.
3. A leak in the pressure containing parts or joints.
4. A crack or fatigue failure of the bourdon.
5. Bursting of the bourdon due to severe overpressure.
6. An explosion within the system due to a chemical reaction of the pressure medium with contaminants causing the bourdon to explode.

When specifying, using or installing a pressure gauge, the following factors must be given attention:

1. Operating Pressure

Do not continuously operate the gauge at more than 75% of the span. Bourdon tubes are necessarily highly stressed, especially in ranges over 1000 psi and continuous operation at full scale will result in early fatigue failure and subsequent rupture.

2. Materials

Be certain the materials of the pressure containing portions of the gauge are compatible with the pressurized medium. Gauges are commonly made of copper alloys (brass, bronze, etc.) and may be subject to stress corrosion or chemical attack. Bourdons have relatively thin walls, and the accuracy of the indication is directly affected by any reduction in the wall thickness. Use of the same material for the bourdon as used for the tank or associated piping is not necessarily good practice. A material having a corrosion rate of .001"/year may be suitable for the piping, but will be entirely unsuitable for a bourdon having a wall thickness of, for example, .008 inches. It is imperative that the proper bourdon material be selected for the service on which the gauge is used. Gauges specially constructed for corrosion service are available.

3. Cyclic Pressure and Vibration

Continuous, rapid pointer motion will result in excessive wear of the internal mechanism and cause gross errors in the pressure indicated and possibly early fatigue failure of the bourdon. If the pointer motion is due to mechanical vibration, the gauge must be remotely mounted on a non-vibrating surface and connected to the apparatus by flexible tubing. If the pointer motion is due to pressure pulsations, a suitable damper must be used between the pressure source and the gauge.

4. Fatigue

As with any spring, the bourdon will fail after extended use and release the pressurized medium. The larger the number of applied pressure cycles and the greater the extent of the pressure cycle, the earlier failure will occur. The fatigue failure may be explosive. Since such a failure will be hazardous to personnel or property, precautions must be taken to contain or direct the release of the pressurized medium in a safe manner.

5. Frequency of Accuracy Evaluation

Where the pressure measurement is critical and gauge failure or gross inaccuracy will result in hazard to personnel or property, the gauge should be checked for accuracy and proper operation on a periodic basis.

6. Use with Oxygen

Gauges used for measurement of oxygen pressure must be free of contamination within the pressure containing portion. Various levels of cleanliness are specified in ANSI B40.1. The gauge itself and the equipment to which the gauge is attached (pressure regulators, cylinders, etc.) must be kept clean so as not to contaminate the gauge. Filters on the equipment must be examined periodically and cleaned or replaced. The sudden in-rush of a high pressure gas will momentarily create a very high temperature which in the presence of oxygen may ignite the contaminant causing a violent explosion. Therefore, when the valve on the oxygen supply tank is opened, to admit oxygen to the regulator, the valve should be opened very slowly so as to allow the pressure to build up slowly. In order to accomplish this it is recommended that the tank valve be opened momentarily and then closed snugly but not excessively before attaching the regulator. This will not only blow out accumulated dirt in the valve, but will also place the valve in a condition that will permit it to be opened slowly rather than suddenly breaking loose as a result of being closed too tightly. When bleeding the oxygen tank prior to attaching the regulator, be certain the valve opening is directed away from any open flame and the operator. When opening the oxygen tank valve, the operator must not stand in front of or behind the gauge and must wear eye and face protection. In this position if there is an explosion due to contaminated equipment any particles projected from the gauge will not be propelled directly at the operator.

7. Use with Hydrogen

Steel bourdons including 400 series stainless steel are subject to hydrogen embrittlement when stressed. Measurement of gas or liquids containing hydrogen (such as natural gas, sour oil) require the use of special materials for the bourdon.

8. Venting of Case

Vents provided in the pressure gauge case (clearance around pressure connection, rubber grommets, pressure relief back, etc.) must not be closed or restricted from operating. There is always the possibility that the pressure medium will be admitted to the case interior as a result of a leaking joint or bourdon tube failure. If this occurs, the pressure medium must be vented from the case so as not to build up sufficient pressure to rupture the case or window. However, venting will not prevent case rupture in the event of a violent explosion.

9. Liquid Filled Gauges

Performance of pressure gauges used in severe vibration or pulsating pressure service, can be improved by filling the gauge case with a viscous fluid. Gauges constructed in this manner necessarily require sealed cases to prevent the escape of the liquid. However, some means of venting the case must be provided. In some instances this vent is sealed to prevent loss of fluid during shipment, and must be released after the gauge is installed. Be certain to follow the installation instructions for properly venting the gauge after installation. The liquid filling most commonly used is a mixture of glycerin and water.

Glycerin can combine with strong oxidizing agents including (but not limited to) chlorine, nitric acid and hydrogen peroxide, and result in an explosion which can cause property damage and personal injury. If gauges are to be used in such service, do not use glycerin filled gauges; consult the factory for proper filling medium.

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