

## Chapter SPS 341 APPENDIX C

### EXCERPTS FROM: ASME BOILER AND PRESSURE VESSEL CODE SECTION VIII - RULES FOR CONSTRUCTION OF PRESSURE VESSELS 2010 EDITION

#### INTRODUCTION

#### SCOPE

##### U-1 SCOPE

##### U-1 (a)

U-1(a)(1) The Foreword provides the basis for the rules described in this Division.

*U-1(a)(2)* For the scope of this Division, pressure vessels are containers for the containment of pressure, either internal or external. This pressure may be obtained from an external source, or by the application of heat from a direct or indirect source, or any combination thereof.

*U-1(a)(3)* This Division contains mandatory requirements, specific prohibitions, and nonmandatory guidance for pressure vessel materials, design, fabrication, examination, inspection, testing, certification, and pressure relief. The Code does not address all aspects of these activities, and those aspects which are not specifically addressed should not be considered prohibited. Engineering judgment must be consistent with the philosophy of this Division, and such judgments must never be used to overrule mandatory requirements or specific prohibitions of this Division. See also informative and nonmandatory guidance regarding metallurgical phenomena in Appendix A of Section II, Part D.

*U-1(b)* This Division is divided into three Subsections, Mandatory Appendices, and Nonmandatory Appendices. Subsection A consists of Part UG, covering the general requirements applicable to all pressure vessels. Subsection B covers specific requirements that are applicable to the various methods used in the fabrication of pressure vessels. It consists of Parts UW, UF, and UB dealing with welded, forged, and brazed methods, respectively. Subsection C covers specific requirements applicable to the several classes of materials used in pressure vessel construction. It consists of Parts UCS, UNF, UHA, UCI, UCL, UCD, UHT, ULW, and ULT dealing with carbon and low alloy steels, nonferrous metals, high alloy steels, cast iron, clad and lined material, cast ductile iron, ferritic steels with properties enhanced by heat treatment, layered construction, and low temperature materials, respectively. Section II, Part D also contains tables of maximum allowable stress values for these classes of materials.

The Mandatory Appendices address specific subjects not covered elsewhere in this Division, and their requirements are mandatory when the subject covered is included in construction under this Division. The Nonmandatory Appendices provide information and suggested good practices.

##### *U-1 (c)*

*U-1(c)(1)* The scope of this Division has been established to identify the components and parameters considered in formulating the rules given in this Division. Laws or regulations issued by municipality, state, provincial, federal, or other enforcement or regulatory bodies having jurisdiction at the location of

an installation establish the mandatory applicability of the Code rules, in whole or in part, within their jurisdiction. Those laws or regulations may require the use of this Division of the Code for vessels or components not considered to be within its Scope. These laws or regulations should be reviewed to determine size or service limitations of the coverage which may be different or more restrictive than those given here.

*U-1(c)(2)* Based on the Committee's consideration, the following classes of vessels are not included in the scope of this Division; however, any pressure vessel which meets all the applicable requirements of this Division may be stamped with the Code U Symbol:

- (a) those within the scope of other Sections;
- (b) fired process tubular heaters;
- (c) pressure containers which are integral parts or components of rotating or reciprocating mechanical devices, such as pumps, compressors, turbines, generators, engines, and hydraulic or pneumatic cylinders where the primary design considerations and/or stresses are derived from the functional requirements of the device;
- (d) except as covered in U-1(f), structures whose primary function is the transport of fluids from one location to another within a system of which it is an integral part, that is, piping systems;
- (e) piping components, such as pipe, flanges, bolting, gaskets, valves, expansion joints, fittings, and the pressure containing parts of other components, such as strainers and devices which serve such purposes as mixing, separating, snubbing, distributing, and metering or controlling flow, provided that pressure containing parts of such components are generally recognized as piping components or accessories;
- (f) a vessel for containing water<sup>1</sup> under pressure, including those containing air the compression of which serves only as a cushion, when none of the following limitations are exceeded:

<sup>1</sup>The water may contain additives provided the flash point of the aqueous solution at atmospheric pressure is 185°F or higher. The flash point shall be determined by the methods specified in ASTM D 93 or in ASTM D 56, whichever is appropriate.

- (1) a design pressure of 300 psi (2 MPa);
- (2) a design temperature of 210°F (99°C);
- (g) a hot water supply storage tank heated by steam or any other indirect means when none of the following limitations is exceeded:
  - (1) a heat input of 200,000 Btu/hr (58.6 kW);
  - (2) a water temperature of 210°F (99°C);
  - (3) a nominal water containing capacity of 120 gal (450 L);
  - (h) vessels not exceeding the design pressure, at the top of the vessel, (see 3.2) limitations below, with no limitation on size [see UG-28(f), 9-1(c)]:

(1) vessels having an internal or external pressure not exceeding 15 psi (100 kPa);

(2) combination units having an internal or external pressure in each chamber not exceeding 15 psi (100 kPa) and differential pressure on the common elements not exceeding 15 psi (100 kPa) [see UG-19(a)];

(i) vessels having an inside diameter, width, height, or cross section diagonal not exceeding 6 in. (152 mm), with no limitation on length of vessel or pressure;

(j) pressure vessels for human occupancy.<sup>2</sup>

<sup>2</sup> Requirements for pressure vessels for human occupancy are covered by ASME PVHO-1.

*U-1(d)* The rules of this Division have been formulated on the basis of design principles and construction practices applicable to vessels designed for pressures not exceeding 3000 psi (20 MPa). For pressures above 3000 psi (20 MPa), deviations from and additions to these rules usually are necessary to meet the requirements of design principles and construction practices for these higher pressures. Only in the event that after having applied these additional design principles and construction practices the vessel still complies with all of the requirements of this Division may it be stamped with the applicable Code symbol.

*U-1(e)* In relation to the geometry of pressure containing parts, the scope of this Division shall include the following:

*U-1(e)(1)* where external piping; other pressure vessels including heat exchangers; or mechanical devices, such as pumps, mixers, or compressors, are to be connected to the vessel:

(a) the welding end connection for the first circumferential joint for welded connections [see UW-13(g)];

(b) the first threaded joint for screwed connections;

(c) the face of the first flange for bolted, flanged connections;

(d) the first sealing surface for proprietary connections or fittings;

*U-1(e)(2)* where nonpressure parts are welded directly to either the internal or external pressure retaining surface of a pressure vessel, this scope shall include the design, fabrication, testing, and material requirements established for nonpressure part attachments by the applicable paragraphs of this Division;<sup>3</sup>

<sup>3</sup> These requirements for design, fabrication, testing, and material for nonpressure part attachments do not establish the length, size, or shape of the attachment material. Pads and standoffs are permitted and the scope can terminate at the next welded or mechanical joint.

*U-1(e)(3)* pressure retaining covers for vessel openings, such as manhole and handhole covers;

*U-1(e)(4)* the first sealing surface for proprietary fittings or components for which rules are not provided by this Division, such as gages, instruments, and nonmetallic components.

*U-1(f)* The scope of the Division includes provisions for pressure relief devices necessary to satisfy the requirements of UG-125 through UG-137 and Appendix 11.

*U-1(g)(1)* Unfired steam boilers shall be constructed in accordance with the rules of Section I or this Division [see UG-125(b) and UW-2(c)].

*U-1(g)(2)* The following pressure vessels in which steam is generated shall not be considered as unfired steam boilers, and shall be constructed in accordance with the rules of this Division:

*U-1(g)(2)(a)* vessels known as evaporators or heat exchangers;

*U-1(g)(2)(b)* vessels in which steam is generated by the use of heat resulting from operation of a processing system containing a number of pressure vessels such as used in the manufacture of chemical and petroleum products;

*U-1(g)(2)(c)* vessels in which steam is generated but not withdrawn for external use.

*U-1(h)* Pressure vessels or parts subject to direct firing from the combustion of fuel (solid, liquid, or gaseous), which are not within the scope of Sections I, III, or IV may be constructed in accordance with the rules of this Division [see UW-2(d)].

*U-1(i)* Gas fired jacketed steam kettles with jacket operating pressures not exceeding 50 psi (345 kPa) may be constructed in accordance with the rules of this Division (see Appendix 19).

*U-1(j)* Pressure vessels exclusive of those covered in U-1(c), U-1(g), U-1(h), and U-1(i) that are not required by the rules of this Division to be fully radiographed, which are not provided with quick actuating closures (see UG-35), and that do not exceed the following volume and pressure limits may be exempted from inspection by Inspectors, as defined in UG-91, provided that they comply in all other respects with the requirements of this Division:

*U-1(j)(1)* 5 cu ft (0.14 m<sup>3</sup>) in volume and 250 psi (1.7 MPa) design pressure; or

*U-1(j)(2)* 3 cu ft (0.08 m<sup>3</sup>) in volume and 350 psi (2.4 MPa) design pressure;

*U-1(j)(3)* 1½ cu ft (0.04 m<sup>3</sup>) in volume and 600 psi (4.1 MPa) design pressure.

In an assembly of vessels, the limitations in (1) through (3) above apply to each vessel and not the assembly as a whole. Straight line interpolation for intermediate volumes and design pressures is permitted. Vessels fabricated in accordance with this rule shall be marked with the "UM" Symbol in Fig. UG-116 sketch (b) and with the data required in UG-116. Certificates of Compliance shall satisfy the requirements of UG-120(a).

*U-1(k)* The degree of nondestructive examination(s) and the acceptance standards beyond the requirements of this Division shall be a matter of prior agreement between the Manufacturer and user or his designated agent.

## GENERAL

### U-2 GENERAL

(a) The user or his designated agent<sup>4</sup> shall establish the design requirements for pressure vessels, taking into consideration factors associated with normal operation, such other conditions as startup and shutdown, and abnormal conditions which may become a governing design consideration (see UG-22).

<sup>4</sup> For this Division, the user's designated agent may be either a design agency specifically engaged by the user, the Manufacturer of a system for a specific service that includes a pressure vessel as a part and that is purchased by the user, or an organization that offers pressure vessels for sale or lease for specific services.

(1) the need for corrosion allowances;

(2) the definition of lethal services. For example, see UW-2(a).

(3) the need for postweld heat treatment beyond the requirements of this Division and dependent on service conditions;

(4) for pressure vessels in which steam is generated, or water is heated [see U-1(g) and (h)], the need for piping, valves, instru-

ments, and fittings to perform the functions covered by PG-59 through PG-61 of Section I.

(b) *Responsibilities*<sup>5</sup>

<sup>5</sup> See UG-90(b) and UG-90(c)(l) for summaries of the responsibilities of the Manufacturer and the duties of the Inspector.

(1) The Manufacturer of any vessel or part to be marked with the Code Symbol has the responsibility of complying with all of the applicable requirements of this Division and, through proper certification, of assuring that all work done by others also complies. The vessel or part Manufacturer shall have available for the Inspector's review the applicable design calculations. See 10-5 and 10-15(d).

(2) Some types of work, such as forming, nondestructive examination, and heat treating, may be performed by others (for welding, see UW-26 and UW-31). It is the vessel or part Manufacturer's responsibility to ensure that all work so performed complies with all the applicable requirements of this Division. After ensuring Code compliance, the vessel or part may be Code stamped by the appropriate Code stamp holder after acceptance by the Inspector.

(c) A vessel may be designed and constructed using any combination of the methods of fabrication and the classes of materials covered by this Division provided the rules applying to each method and material are complied with and the vessel is marked as required by UG-116.

(d) When the strength of any part cannot be computed with a satisfactory assurance of safety, the rules provide procedures for establishing its maximum allowable working pressure.

(e) It is the duty of the Inspector to make all of the inspections specified by the rules of this Division, and of monitoring the quality control and the examinations made by the Manufacturer. He shall make such other inspections as in his judgment are necessary to permit him to certify that the vessel has been designed and constructed in accordance with the requirements. The Inspector has the duty of verifying that the applicable calculations have been made and are on file at Manufacturer's plant at the time the Data Report is signed. Any questions concerning the calculations raised by the Inspector must be resolved. See UG-90(c)(l).

(f) The rules of this Division shall serve as the basis for the Inspector to:

- (1) perform the required duties;
- (2) authorize the application of the Code Symbol;
- (3) sign the Certificate of Shop (or Field Assembly) Inspection.

(g) This Division of Section VIII does not contain rules to cover all details of design and construction. Where complete details are not given, it is intended that the Manufacturer, subject to the acceptance of the Inspector, shall provide details of design and construction which will be as safe as those provided by the rules of this Division.

(h) Field assembly of vessels constructed to this Division may be performed as follows.

(1) The Manufacturer of the vessel completes the vessel in the field, completes the Form U-1 or U-1A Manufacturer's Data Report, and stamps the vessel.

(2) The Manufacturer of parts of a vessel to be completed in the field by some other party stamps these parts in accordance with Code rules and supplies the Form U-2 or U-2A Manufacturer's Partial Data Report to the other party. The other party, who must hold a valid U Certificate of Authorization, makes

the final assembly, required NDE, final pressure test; completes the Form U-1 or U-1A Manufacturer's Data Report; and stamps the vessel.

(3) The field portion of the work is completed by a holder of a valid U Certificate of Authorization other than the vessel Manufacturer. The stamp holder performing the field work is required to supply a Form U-2 or U-2A Manufacturer's Partial Data Report covering the portion of the work completed by his organization (including data on the pressure test if conducted by the stamp holder performing the field work) to the Manufacturer responsible for the Code vessel. The vessel Manufacturer applies his U Stamp in the presence of a representative from his Inspection Agency and completes the Form U-1 or U-1A Manufacturer's Data Report with his Inspector.

In all three alternatives, the party completing and signing the Form U-1 or U-1A Manufacturer's Data Report assumes full Code responsibility for the vessel. In all three cases, each Manufacturer's Quality Control System shall describe the controls to assure compliance for each Code stamp holder.

(i) For some design analyses, both a chart or curve and a formula or tabular data are given. Use of the formula or tabular data may result in answers which are slightly different from the values obtained from the chart or curve. However, the difference, if any, is within practical accuracy and either method is acceptable.

#### U-3 STANDARDS REFERENCED BY THIS DIVISION

(a) Throughout this Division references are made to various standards, such as ANSI standards, which cover pressure-temperature rating, dimensional, or procedural standards for pressure vessel parts. These standards, with the year of the acceptable edition, are listed in Table U-3.

(b) Rules for the use of these standards are stated elsewhere in this Division.

#### U-4 UNITS OF MEASUREMENT<sup>6</sup>

<sup>6</sup> Guidance for conversion of units from U.S. Customary to SI is found in Nonmandatory Appendix GG.

Either U.S. Customary, SI, or any local customary units may be used to demonstrate compliance with all requirements of this edition, e.g., materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection.

In general, it is expected that a single system of units shall be used for all aspects of design except where unfeasible or impractical. When components are manufactured at different locations where local customary units are different than those used for the general design, the local units may be used for the design and documentation of that component. Similarly, for proprietary components or those uniquely associated with a system of units different than that used for the general design, the alternate units may be used for the design and documentation of that component.

For any single equation, all variables shall be expressed in a single system of units. When separate equations are provided for U.S. Customary and SI units, those equations must be executed using variables in the units associated with the specific equation. Data expressed in other units shall be converted to U.S. Customary or SI units for use in these equations. The result obtained from execution of these equations may be converted to other units.

Production, measurement and test equipment, drawings, welding procedure specifications, welding procedure and performance qualifications, and other fabrication documents may

be in U.S. Customary, SI, or local customary units in accordance with the fabricator's practice. When values shown in calculations and analysis, fabrication documents, or measurement and test equipment are in different units, any conversions necessary for verification of Code compliance and to ensure that dimensional consistency is maintained, shall be in accordance with the following:

(a) Conversion factors shall be accurate to at least four significant figures.

(b) The results of conversions of units shall be expressed to a minimum of three significant figures.

Conversion of units, using the precision specified above shall be performed to assure that dimensional consistency is maintained. Conversion factors between U.S. Customary and SI units may be found in the Nonmandatory Appendix, Guidance for the Use of U.S. Customary and SI Units in the ASME

Boiler and Pressure Vessel Code. Whenever local customary units are used the Manufacturer shall provide the source of the conversion factors which shall be subject to verification and acceptance by the Authorized Inspector or Certified Individual.

Material that has been manufactured and certified to either the U.S. Customary or SI material specification (e.g., SA-516M) may be used regardless of the unit system used in design. Standard fittings (e.g., flanges, elbows, etc.) that have been certified to either U.S. Customary units or SI units may be used regardless of the units system used in design.

All entries on a Manufacturer's Data Report and data for Code-required nameplate marking shall be in units consistent with the fabrication drawings for the component using U.S. Customary, SI, or local customary units. It is acceptable to show alternate units parenthetically. Users of this Code are cautioned that the receiving jurisdiction should be contacted to ensure the units are acceptable.

Title	Number	Year
Seat Tightness of Pressure Relief Valves	API Std. 527	1991 (R2002) (1)
Unified Inch Screw Threads (UN and UNR Thread Form)	ASME B1.1	2003
Pipe Threads, General Purpose (Inch)	ANSI/ASME B1.20.1	1983 (R2006) (1)
Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250	ASME B16.1	1998
Pipe Flanges and Flanged Fittings	ASME B16.5	2003 (2)
Factory-Made Wrought Butt Welding Fittings	ASME B16.9	2007
Forged Fittings, Socket-Welding and Threaded	ASME B16.11	2005
Cast Bronze Threaded Fittings, Classes 125 and 250	ASME B16.15	1985 (R2004) (1)
Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed	ASME B16.20	2007
Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500, and 2500	ASME B16.24	2001
Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300	ASME B16.42	1998
Large Diameter Steel Flanges, NPS 26 Through NPS 60	ASME B16.47	1996
Square and Hex Nuts (Inch Series)	ASME B18.2.2	1987 (R1999) (1)
Welded and Seamless Wrought Steel Pipe	ASME B36.10M	2004
Guidelines for Pressure Boundary Bolted Flange Joint Assembly	ASME PCC-1	2000
Repair of Pressure Equipment and Piping	ASME PCC-2	2006
Pressure Relief Devices	ASME PTC 25	2001
Qualifications for Authorized Inspection	ASME QAI-1	2003 (3)
ASNT Central Certification Program	ACCP	Rev 3, November 1997
ASNT Standard for Qualification and Certification of Non-destructive Testing Personnel	ANSI/ASNT CP-189	2006
Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing	SNT-TC-1A	2001
Standard Test Methods for Flash Point by Tag Closed Tester	ASTM D 56	2002a
Standard Test Methods for Flash Point by Pensky-Martens Closed Tester	ASTM D 93	2002a
Pressure Relieving and Depressuring Systems	ANSI/API Std.521	5th Ed., January 2007

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<b>TABLE U-3 YEAR OF ACCEPTABLE EDITION OF REFERENCED STANDARDS IN THIS DIVISION (Continued)</b>		
Title	Number	Year
Reference Photographs for Magnetic Particle Indications on Ferrous Castings	ASTM E 125	1963 (R1985) (1)
Hardness Conversion Tables for Metals	ASTM E 140	2007
Standard Reference Radiographs for Heavy-Walled (2 to 4½-in. (51 to 114-mm)) Steel Castings	ASTM E 186	1998
Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels	ASTM E 208	2006
Standard Reference Radiographs for Heavy-Walled (4½ to 12-in. (114 to 305-mm)) Steel Castings	ASTM E 280	1998
Standard Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness	ASTM E 446	1998
Marking and Labeling Systems	ANSI/UL-969	1991
Charpy Pendulum Impact Test Part 1: Test Method	ISO 148-1	2006
Charpy Pendulum Impact Test Part 2: Verification of Test Machines	ISO 148-2	1998
Charpy Pendulum Impact Test Part 3: Preparation and Characterization of Charpy V Reference Test Pieces for Verification of Test Machines	ISO 148-3	1998
<b>Metric Standards</b>		
Metric Screw Thread - M Profile	ASME B1.13M	2001
Metric Screw Thread - MJ Profile	ASME B1.21M	1997
Metric Heavy Hex Screws	ASME B18.2.3.3M	1979 (R2001)
Metric Hex Bolts	ASME B18.2.3.5M	1979 (R2001)
Metric Heavy Hex Bolts	ASME B18.2.3.6M	1979 (R2001)
Metric Hex Nuts, Style 1	ASME B18.2.4.1M	2002
Metric Hex Nuts, Style 2	ASME B18.2.4.2M	1979 (R1995)
Metric Heavy Hex Nuts	ASME B18.2.4.6M	1979 (R2003)
NOTES: (1) R - Reaffirmed. (2) See UG-11 (a) (2). (3) See UG-91 and UG-117 (f).		

## PRESSURE RELIEF DEVICES

### UG-125 GENERAL

(a) All pressure vessels within the Scope of this Division, irrespective of size or pressure, shall be provided with pressure relief devices in accordance with the requirements of UG-125 through UG-137.

(1) It is the responsibility of the user to ensure that the required pressure relief devices are properly installed prior to initial operation.

(2) It is the responsibility of the user or his/her designated agent to size and select the pressure relief device(s) based on its intended service. Intended service considerations shall include, but not necessarily be limited to, the following:

- (a) normal operating and upset conditions
- (b) fluids
- (c) fluid phases

(3) These pressure relief devices need not be supplied by the vessel Manufacturer.

(4) Unless otherwise defined in this Division, the definitions relating to pressure relief devices in Section 2 of ASME PTC 25 shall apply.

(b) An unfired steam boiler, as defined in U-1(g), shall be equipped with pressure relief devices required by Section I insofar as they are applicable to the service of the particular installation.

(c) All pressure vessels other than unfired steam boilers shall be protected by a pressure relief device that shall prevent the pressure from rising more than 10% or 3 psi (20 kPa), whichever is greater, above the maximum allowable working pressure except as permitted in (1) and (2) below. (See UG-134 for pressure settings.)

(1) When multiple pressure relief devices are provided and set in accordance with UG-134(a), they shall prevent the pressure from rising more than 16% or 4 psi (30 kPa), whichever is greater, above the maximum allowable working pressure.

(2) When a pressure vessel can be exposed to fire or other unexpected sources of external heat, the pressure relief device(s) shall be capable of preventing the pressure from rising more than 21% above the maximum allowable working pressure. Supplemental pressure relief devices shall be installed to protect against this source of excessive pressure if the pressure relief devices used to satisfy the capacity requirements of UG-125(c) and UG-125(c)(1) have insufficient capacity to provide the required protection. See Nonmandatory Appendix M, para.

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M-13 for cases where the metal temperature due to fire or other sources of external heat can cause vessel failure prior to reaching the MAWP.

(3) Pressure relief devices, intended primarily for protection against exposure of a pressure vessel to fire or other unexpected sources of external heat installed on vessels having no permanent supply connection and used for storage at ambient temperatures of nonrefrigerated liquefied compressed gases<sup>42</sup> are excluded from the requirements of (c)(1) and (c)(2) above, provided:

<sup>42</sup> For the purpose of these rules, gases are considered to be substances having a vapor pressure greater than 40 psia (300 kPa absolute) at 100°F (40°C).

(a) the pressure relief devices are capable of preventing the pressure from rising more than 20% above the maximum allowable working pressure of the vessels;

(b) the set pressure marked on these devices shall not exceed the maximum allowable working pressure of the vessels;

(c) the vessels have sufficient ullage to avoid a liquid full condition;

(d) the maximum allowable working pressure of the vessels on which these pressure relief devices are installed is greater than the vapor pressure of the stored liquefied compressed gas at the maximum anticipated temperature<sup>43</sup> that the gas will reach under atmospheric conditions; and

<sup>43</sup> Normally this temperature should not be less than 115°F (45°C).

(e) pressure relief valves used to satisfy these provisions also comply with the requirements of UG-129(a)(5), UG-131(c)(2), and UG-134(d)(2).

(d) Pressure relief devices shall be constructed, located, and installed so that they are readily accessible for inspection, replacement, and repair and so that they cannot be readily rendered inoperative (see Appendix M).

(e) Pressure relief valves or nonreclosing pressure relief devices<sup>44</sup> may be used to protect against overpressure. Nonreclosing pressure relief devices may be used either alone or, if applicable, in combination with pressure relief valves on vessels.

<sup>44</sup> A *pressure relief valve* is a pressure relief device which is designed to reclose and prevent the further flow of fluid after normal conditions have been restored. A *nonreclosing pressure relief device* is a pressure relief device designed to remain open after operation.

**Note:** Use of nonreclosing pressure relief devices of some types may be advisable on vessels containing substances that may render a pressure relief valve inoperative, where a loss of valuable material by leakage should be avoided, or where contamination of the atmosphere by leakage of noxious fluids must be avoided. The use of rupture disk devices may also be advisable when very rapid rates of pressure rise may be encountered.

(f) Vessels that are to operate completely filled with liquid shall be equipped with pressure relief devices designed for liquid service, unless otherwise protected against overpressure.

(g) The pressure relief devices required in (a) above need not be installed directly on a pressure vessel when either of the following conditions apply:

(1) the source of pressure is external to the vessel and is under such positive control that the pressure in the vessel cannot exceed the maximum allowable working pressure at the operating temperature except as permitted in (c) above (see UG-98), or under the conditions set forth in Appendix M.

(2) there are no intervening stop valves between the vessel and the pressure relief device or devices except as permitted under UG-135(d).

**Note:** Pressure reducing valves and similar mechanical or electrical control instruments, except for pilot operated pressure relief valves as permitted in UG-126(b), are not considered as sufficiently positive in action to prevent excess pressures from being developed.

(h) Pressure relief valves for steam service shall meet the requirements of UG- 131(b).

#### UG-126 PRESSURE RELIEF VALVES<sup>45</sup>

<sup>45</sup> A *safety valve* is a pressure relief valve actuated by inlet static pressure and characterized by rapid opening or pop action. A *relief valve* is a pressure relief valve actuated by inlet static pressure which opens in proportion to the increase in pressure over the opening pressure. A *safety relief valve* is a pressure relief valve characterized by rapid opening or pop action, or by opening in proportion to the increase in pressure over the opening pressure, depending on application. A *pilot operated pressure relief valve* is a pressure relief valve in which the major relieving device is combined with and is controlled by a self-actuated auxiliary pressure relief valve.

(a) Safety, safety relief, and relief valves shall be of the direct spring loaded type.

(b) Pilot operated pressure relief valves may be used, provided that the pilot is self-actuated and the main valve will open automatically at not over the set pressure and will discharge its full rated capacity if some essential part of the pilot should fail.

(c) The spring in a pressure relief valve shall not be set for any pressure more than 5% above or below that for which the valve is marked, unless the setting is within the spring design range established by the valve Manufacturer or is determined to be acceptable to the Manufacturer. The initial adjustment shall be performed by the Manufacturer, his authorized representative, or an Assembler, and a valve data tag shall be provided that identifies the set pressure capacity and date. The valve shall be sealed with a seal identifying the Manufacturer, his authorized representative, or the Assembler performing the adjustment.

(d) The set pressure tolerances, plus or minus, of pressure relief valves shall not exceed 2 psi (15 kPa) for pressures up to and including 70 psi (500 kPa) and 3% for pressures above 70 psi (500 kPa).

#### UG-127 NONRECLOSING PRESSURE RELIEF DEVICES

##### (a) Rupture Disk Devices<sup>46</sup>

<sup>46</sup> A *rupture disk device* is a nonreclosing pressure relief device actuated by inlet static pressure and designed to function by the bursting of a pressure containing disk. A *rupture disk* is the pressure containing and pressure sensitive element of a rupture disk device. Rupture disks may be designed in several configurations, such as plain flat, prebulged, or reverse buckling. A *rupture disk holder* is the structure that encloses and clamps the rupture disk in position.

(1) *General.* Every rupture disk shall have a marked burst pressure established by rules of UG- 137(d)(3) within a manufacturing design range<sup>47</sup> at a specified disk temperature<sup>48</sup> and shall be marked with a lot<sup>49</sup> number. The burst pressure tolerance at the specified disk temperature shall not exceed  $\pm 2$  psi ( $\pm 15$  kPa) for marked burst pressure up to and including 40 psi (300 kPa) and  $\pm 5\%$  for marked burst pressure above 40 psi (300 kPa).

<sup>47</sup> The *manufacturing design range* is a range of pressure within which the marked burst pressure must fall to be acceptable for a particular requirement as agreed upon between the rupture disk Manufacturer and the user or his agent. The manufacturing design range must be evaluated in conjunction with the specified burst pressure to ensure that the marked burst pressure of the rupture disk will always be within applicable limits of UG-134. Users are cautioned that certain types of rupture disks have manufacturing ranges that can result in a marked burst pressure greater than the specified burst pressure.

<sup>48</sup> The specified disk temperature supplied to the rupture disk Manufacturer shall be the temperature of the disk when the disk is expected to burst.

<sup>49</sup> A lot of rupture disks is those disks manufactured of a material at the same time, of the same size, thickness, type, heat, and manufacturing process including heat treatment.

(2) *Relieving Capacity.* The rated flow capacity of a pressure relief system which uses a rupture disk device as the sole relief device shall be determined by a value calculated under the requirements of (a) using a coefficient of discharge or (b) using flow resistances below.

(a) When the rupture disk device discharges directly to atmosphere and

(1) is installed within eight pipe diameters from the vessel nozzle entry; and

(2) with a length of discharge pipe not greater than five pipe diameters from the rupture disk device; and

(3) the nominal diameters of the inlet and discharge piping are equal to or greater than the stamped NPS designator of the device, the calculated relieving capacity of a pressure relief system shall not exceed a value based on the applicable theoretical flow equation [see UG-131(e)(2) and Appendix 11] for the various media multiplied by a coefficient of discharge  $K$  equal to 0.62. The area  $A$  in the theoretical flow equation shall be the minimum net flow area<sup>50</sup> as specified by the rupture disk device Manufacturer.

<sup>50</sup> The *minimum net flow area* is the calculated net area after a complete burst of the disk with appropriate allowance for any structural members which may reduce the net flow area through the rupture disk device. The net flow area for sizing purposes shall not exceed the nominal pipe size area of the rupture disk device.

(b) The calculated capacity of any pressure relief system may be determined by analyzing the total system resistance to flow. This analysis shall take into consideration the flow resistance of the rupture disk device, piping and piping components including the exit nozzle on the vessels, elbows, tees, reducers, and valves. The calculation shall be made using accepted engineering practices for determining fluid flow through piping systems. This calculated relieving capacity shall be multiplied by a factor of 0.90 or less to allow for uncertainties inherent with this method. The certified flow resistance<sup>51</sup>  $K_R$  for the rupture disk device, expressed as the velocity head loss, shall be determined in accordance with UG-13 1(k) through (r).

<sup>51</sup> The *certified flow resistance*  $K_R$  is a dimensionless factor used to calculate the velocity head loss that results from the presence of a rupture disk device in a pressure relief system.

### (3) *Application of Rupture Disks*

(a) A rupture disk device may be used as the sole pressure relieving device on a vessel.

**Note:** When rupture disk devices are used, it is recommended that the design pressure of the vessel be sufficiently above the intended operating pressure to provide sufficient margin between operating pressure and rupture disk bursting pressure to prevent premature failure of the rupture disk due to fatigue or creep.

Application of rupture disk devices to liquid service should be carefully evaluated to assure that the design of the rupture disk device and the dynamic energy of the system on which it is installed will result in sufficient opening of the rupture disk.

(b) A rupture disk device may be installed between a pressure relief valves<sup>52</sup> and the vessel provided:

<sup>52</sup> Use of a rupture disk device in combination with a pressure relief valve shall be carefully evaluated to ensure that the media being handled and the valve operational characteristics will result in opening of the valve coincident with the bursting of the rupture disk.

(1) the combination of the pressure relief valve and the rupture disk device is ample in capacity to meet the requirements of UG-133(a) and (b);

(2) the marked capacity of a pressure relief valve (nozzle type) when installed with a rupture disk device between the inlet of the valve and the vessel shall be multiplied by a factor of 0.90 of the rated relieving capacity of the valve alone, or alternatively, the capacity of such a combination shall be established in accordance with (3) below;

(3) the capacity of the combination of the rupture disk device and the pressure relief valve may be established in accordance with the appropriate paragraphs of UG-132;

(4) the space between a rupture disk device and a pressure relief valve shall be provided with a pressure gage, a try cock, free vent, or suitable telltale indicator. This arrangement permits detection of disk rupture or leakage.<sup>53</sup>

<sup>53</sup> Users are warned that a rupture disk will not burst at its design pressure if back pressure builds up in the space between the disk and the pressure relief valve which will occur should leakage develop in the rupture disk due to corrosion or other cause.

(5) the opening<sup>50</sup> provided through the rupture disk, after burst, is sufficient to permit a flow equal to the capacity of the valve [(2) and (3) above], and there is no chance of interference with proper functioning of the valve; but in no case shall this area be less than the area of the inlet of the valve unless the capacity and functioning of the specific combination of rupture disk device and pressure relief valve have been established by test in accordance with UG-132.

<sup>50</sup> The *minimum net flow area* is the calculated net area after a complete burst of the disk with appropriate allowance for any structural members which may reduce the net flow area through the rupture disk device. The net flow area for sizing purposes shall not exceed the nominal pipe size area of the rupture disk device.

(c) A rupture disk device may be installed on the outlet side<sup>54</sup> of a pressure relief valve which is opened by direct action of the pressure in the vessel provided:

<sup>54</sup> This use of a rupture disk device in series with the pressure relief valve is permitted to minimize the loss by leakage through the valve of valuable or of noxious or otherwise hazardous materials, and where a rupture disk alone or disk located on the inlet side of the valve is impracticable, or to prevent corrosive gases from a common discharge line from reaching the valve internals.

(1) the pressure relief valve will not fail to open at its proper pressure setting regardless of any back pressure that can accumulate between the pressure relief valve disk and the rupture disk. The space between the pressure relief valve disk and the rupture disk shall be vented or drained to prevent accumulation of pressure, or suitable means shall be provided to ensure that an accumulation of pressure does not affect the proper operation of the pressure relief valve.<sup>55</sup>

<sup>55</sup> Users are warned that many types of pressure relief valves will not open at the set pressure if pressure builds up in the space between the pressure relief valve disk and the rupture disk device. A specially designed pressure relief valve such as a diaphragm valve, pilot operated valve, or a valve equipped with a balancing bellows above the disk may be required.

(2) the pressure relief valve is ample in capacity to meet the requirements of UG-125(c);

(3) the marked burst pressure of the rupture disk at the specified disk temperature plus any pressure in the outlet piping shall not exceed the design pressure of the outlet portion of the pressure relief valve and any pipe or fitting between the valve

and the rupture disk device. However, in no case shall the marked burst pressure of the rupture disk at the specified disk temperature plus any pressure in the outlet piping exceed the maximum allowable working pressure of the vessel or the set pressure of the pressure relief valve.

(4) the opening provided through the rupture disk device after breakage is sufficient to permit a flow equal to the rated capacity of the attached pressure relief valve without exceeding the allowable overpressure;

(5) any piping beyond the rupture disk cannot be obstructed by the rupture disk or fragment;

(6) the system is designed to consider the adverse effects of any leakage through the pressure relief valve or through the outlet side rupture disk device, to ensure system performance and reliability.<sup>56</sup>

<sup>56</sup> Some adverse effects resulting from leakage may include obstructing the flow path, corrosion of pressure relief valve components, and undesirable bursts of the outlet side rupture disk.

(7) the bonnet of a balancing bellows or diaphragm type pressure relief valve shall be vented to prevent accumulation of pressure in the bonnet.

(b) *Breaking Pin Device*<sup>57</sup>

<sup>57</sup> A *breaking pin device* is a nonreclosing pressure relief device actuated by inlet static pressure and designed to function by the breakage of a load-carrying section of a pin which supports a pressure containing member. A *breaking pin* is the load-carrying element of a breaking pin device. A *breaking pin housing* is the structure which encloses the breaking pin mechanism. The material of the housing shall be listed in Section II and be permitted for use in this Division.

(1) Breaking pin devices shall not be used as single devices but only in combination between the pressure relief valve and the vessel.

(2) The space between a breaking pin device and a pressure relief valve shall be provided with a pressure gage, a try cock, a free vent, or suitable telltale indicator. This arrangement permits detection of breaking pin device operation or leakage.

(3) Each breaking pin device shall have a rated pressure and temperature at which the pin will break. The breaking pin shall be identified to a lot number and shall be guaranteed by the Manufacturer to break when the rated pressure, within the following tolerances, is applied to the device:

Rated Pressure, psi (kPa)		Tolerance, Plus or Minus, psi (kPa)
Min.	Max.	
30 (200)	150 (1 000)	5 (35)
150 (1 000)	275 (1 900)	10 (70)
275 (1 900)	375 (2 600)	15 (100)

(4) The rated pressure of the breaking pin plus the tolerance in psi shall not exceed 105% of the maximum allowable working pressure of the vessel to which it is applied.

(5) The rated pressure at the specified temperature<sup>58</sup> shall be verified by breaking two or more sample breaking pins from each lot of the same material and the same size as those to be used. The lot size shall not exceed 25. The test shall be made in a device of the same form and pressure dimensions as that in which the breaking pin is to be used.

<sup>58</sup> The specified temperature supplied to the breaking pin manufacturer shall be the temperature of the breaking pin when an emergency condition exists and the pin is expected to break.

(c) *Spring Loaded Nonreclosing Pressure Relief Device*

(1) A spring loaded nonreclosing pressure relief device,

pressure actuated by means which permit the spring loaded portion of the device to open at the specified set pressure and remain open until manually reset, may be used provided the design of the spring loaded nonreclosing device is such that if the actuating means fail, the device will achieve full opening at or below its set pressure. Such a device may not be used in combination with any other pressure relief device. The tolerance on opening point shall not exceed  $\pm 5\%$ .

(2) The calculated capacity rating of a spring loaded nonreclosing pressure relief device shall not exceed a value based on the applicable theoretical formula (see UG-131) for the various media, multiplied by:  $K = \text{coefficient} = 0.62$ .

The area  $A$  (square inches) in the theoretical formula shall be the flow area through the minimum opening of the spring loaded nonreclosing pressure relief device.

(3) In lieu of the method of capacity rating in (2) above, a Manufacturer may have the capacity of a spring loaded nonreclosing pressure relief device design certified in general accordance with the procedures of UG-131, as applicable.

**UG-128 LIQUID PRESSURE RELIEF VALVES**

Any liquid pressure relief valve used shall be at least NPS  $\frac{1}{2}$  (DN 15).

**UG-129 MARKING**

(a) *Safety, Safety Relief, Relief, Liquid Pressure Relief, and Pilot Operated Pressure Relief Valves*. Each safety, safety relief, relief, liquid pressure relief, and pilot operated pressure relief valve NPS  $\frac{1}{2}$  (DN 15) and larger shall be plainly marked by the Manufacturer or Assembler with the required data in such a way that the marking will not be obliterated in service. The marking may be placed on the valve or on a plate or plates that satisfy the requirements of UG-119:

(1) the name, or an acceptable abbreviation, of the Manufacturer and the Assembler;

(2) Manufacturer's design or type number;

(3) NPS size (DN) \_\_\_\_\_ (the nominal pipe size of the valve inlet);

(4) set pressure \_\_\_\_\_ psi (kPa), and, if applicable per UG-136(d)(4), cold differential test pressure \_\_\_\_\_ psi (kPa);

(5) certified capacity (as applicable):

(a) lb/hr (kg/hr) of saturated steam at an overpressure of 10% or 3 psi (20 kPa), whichever is greater for valves certified on steam complying with UG-131 (b); or

(b) gal/min of water at 70°F (20°C) at an overpressure of 10% or 3 psi (20 kPa), whichever is greater for valves certified on water; or

(c) SCFM [standard cubic feet per minute at 60°F and 14.7 psia] ( $M^3/\text{min}$ , cubic meters per minute at 20°C and 101 kPa), or lb/min (kg/min), of air at an overpressure of 10% or 3 psi (kPa), whichever is greater. Valves that are capacity certified in accordance with UG-131 (c) (2) shall be marked "at 20% overpressure."

(d) In addition to one of the fluids specified above, the Manufacturer may indicate the capacity in other fluids (see Appendix 11).

(6) year built, or alternatively, a coding may be marked on the valve such that the valve Manufacturer or Assembler can identify the year the valve was assembled or tested;

(7) ASME Symbol as shown in Fig. UG-129.1. The pilot of a pilot operated pressure relief valve shall be plainly marked by the Manufacturer or Assembler showing the name of the Manufacturer, the Manufacturer's design or type number, the set pres-



sure in pounds per square inch (kPa), and the year built, or alternatively, a coding that the Manufacturer can use to identify the year built.

On valves smaller than NPS ½ (DN 15), the markings may be made on a metal tag attached by wire or adhesive meeting the requirements of UG-119 or other means suitable for the service conditions.

(8) Restricted lift \_\_\_\_\_ in. (mm) (For restricted lift valves only)

(b) Safety and safety relief valves certified for a steam discharging capacity under the provisions of Section I and bearing the official Code Symbol Stamp of Section I for safety valves may be used on pressure vessels. The rated capacity in terms of other fluids shall be determined by the method of conversion given in Appendix 11. [See UG- 131(h).]

(c) *Pressure Relief Valves in Combination With Rupture Disk Devices.* Pressure relief valves in combination with rupture disk devices shall be marked with the capacity as established in accordance with UG-127(a)(3)(b)(2) (using 0.90 factor) or the combination capacity factor established by test in accordance with UG-132(a) or (b), in addition to the marking of UG-129(a) and (f) below. The marking may be placed on the pressure relief valve or rupture disk device or on a plate or plates that satisfy the requirements of UG-119. The marking shall include the following:

- (1) name of Manufacturer of valve;
- (2) design or type number of valve;
- (3) name of Manufacturer of rupture disk device;
- (4) design or type number of rupture disk device;
- (5) capacity or combination capacity factor;

(6) name of organization responsible for this marking. This shall be either the vessel user, vessel Manufacturer, rupture disk Manufacturer, or pressure relief valve Manufacturer.

(d) *Pressure Relief Valves in Combination With Breaking Pin Devices.* Pressure relief valves in combination with pin devices shall be marked with the capacity as established in accordance with UG-127 (b) (3) (b) (2) (using 0.90 factor) or the combination capacity factor established by test in accordance with UG-132 (a) or (b), in addition to the marking of UG-129 (a) and (f) below. The marking may be placed on the pressure relief valve or pin device or on a plate or plates that satisfy the requirements of UG-119. The marking shall include the following:

- (1) name of Manufacturer of valve.
- (2) design or type number of valve.
- (3) name of Manufacturer of pin device.
- (4) design or type number of pin device.
- (5) capacity or combination capacity factor.
- (6) name of organization responsible for this marking.

This shall be either the vessel user, vessel Manufacturer, pin device Manufacturer, or pressure relief valve Manufacturer.

**FIG. UG-129.1 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR PRESSURE RELIEF VALVES**



**FIG. UG-129.2 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR RUPTURE DISK DEVICES**



(e) *Rupture Disk Devices.* Every rupture disk shall be plainly marked by the Manufacturer in such a way that the marking will not be obliterated in service. The rupture disk marking may be placed on the flange of the disk or on a metal tab that satisfies the requirements of UG-119. The marking shall include the following:

- (1) the name or identifying trademark of the Manufacturer;
- (2) Manufacturer's design or type number;
- (3) lot number;
- (4) disk material;
- (5) size \_\_\_\_\_ [NPS (DN) of rupture disk holder];
- (6) marked burst pressure \_\_\_\_\_ psi (kPa);
- (7) specified disk temperature \_\_\_\_\_ °F (°C);
- (8) minimum net flow area \_\_\_\_\_ sq in. (sq mm);
- (9) certified flow resistance (one or more as applicable);
- (a)  $K_{RG}$  \_\_\_\_\_ for rupture disk certified on air or gases;
- (b)  $K_{RL}$  \_\_\_\_\_ for rupture disk certified on liquid;
- (c)  $K_{RGL}$  \_\_\_\_\_ for rupture disk certified on air or gases, and liquid;
- (10) ASME symbol as shown in Fig. UG-129.2;
- (11) year built, or alternatively, a coding may be marked on the rupture disk such that the rupture disk device Manufacturer can identify the year the rupture disk device was assembled and tested.

Items (1), (2), (5), (10), and (11) above and flow direction shall also be marked on the rupture disk holder.

(f) *Pin Devices and Pin Actuated Pilot Operated Pressure Relief Devices.* Pin devices shall be plainly marked by the Manufacturer with the required data in such a way that the marking will not be obliterated in service. The marking may be placed on the device housing or on a plate or plates that satisfies the requirements of UG-119. The marking shall include the following:

- (1) the name, or an acceptable abbreviation of the Manufacturer
- (2) Manufacturer's design or type number
- (3) NPS (DN) size (the nominal pipe size of the device inlet)
- (4) set pressure psi (kPa)
- (5) flow direction
- (6) pin to pin device identifier
- (7) for capacity certified devices
  - (a) lb/hr of saturated steam at an overpressure 10% or 3 psi (20 kPa), whichever is greater for devices certified on steam complying with UG-131(b), or
  - (b) gal/min of water at 70°F (20°C) at an overpressure of 10% or 3 psi (20 kPa), whichever is greater for devices certified on water, or
  - (c) SCFM [standard cubic feet per minute at 60°F and 14.7 psia (20°C and 101 kPa)], or lb/min, of air at an overpressure of

10% or 3 psi, whichever is greater. Devices that are capacity certified in accordance with UG-131 (c) (2) shall be marked “at 20% overpressure.”

(d) In addition to one of the fluids specified above, the Manufacturer may indicate the capacity in other fluids (see Appendix 11).

(8) for flow resistance certified devices:

(a) minimum net flow area \_\_\_\_\_ in<sup>2</sup> (mm<sup>2</sup>)

(b) certified flow resistance (one or more as applicable)

(1)  $K_{RG}$  \_\_\_\_\_ for pin devices certified on air or gases

(2)  $K_{RL}$  \_\_\_\_\_ for pin devices certified on liquid

(3)  $K_{RGL}$  \_\_\_\_\_ for pin devices certified on air or gases, and liquid

(9) ASME symbol as shown in Fig. UG-129.2

(10) year built, or alternatively, a coding may be marked on the device such that the device Manufacturer can identify the year the device was tested

(11) The pin shall be marked according to one of the following methods:

(a) for pin devices using a replaceable pin to control set pressure, the pin shall be marked with its lot number, pin temperature °F (°C) and the information required by (f) (l), (f) (4), (f) (6), (f) (10), or

**Note:** When the pin size or configuration does not permit the use of an attached metal tag, a metal tag may be attached using a nonmetallic connector with an adhesive that complies with Appendix 18 of this Division.

(b) for pin devices that are single use and permanently assembled, the marking requirements of (f) (8) (a), (f) (8) (b), and (f) (11) (a) shall be applied to the device, or

(c) for pin devices that have a replaceable pin within the sealed body per UG-138, the pin shall be marked with its lot number.

(g) *Spring Loaded Nonreclosing Pressure Relief Devices.* Spring loaded nonreclosing pressure relief devices shall be marked in accordance with (a) above except that the Code Symbol Stamp is to be applied only when the capacity has been established and certified in accordance with UG-127 (c) (3) and all other requirements of UG-130 have been met.

(h) For units other than those included above, see U-4.

#### UG-130 CODE SYMBOL STAMP

Each pressure relief device<sup>59</sup> to which the Code Symbol (see Figs. UG-129.1 and UG-129.2) will be applied shall have been fabricated or assembled by a Manufacturer or Assembler holding a valid Certificate of Authorization (UG-117) and capacity certified in accordance with the requirements of this Division. A Certified Individual (CI) shall provide oversight as required by UG-117(a). Each use of the Code Symbol shall also be documented on a Certificate of Conformance Form UV-1 or UD-1, as appropriate.

<sup>59</sup> Vacuum relief devices are not covered by Code Symbol Stamp requirements.

#### UG-133 DETERMINATION OF PRESSURE RELIEVING REQUIREMENTS

(a) Except as permitted in (b) below, the aggregate capacity of the pressure relief devices connected to any vessel or system of vessels for the release of a liquid, air, steam, or other vapor shall be sufficient to carry off the maximum quantity that can be generated or supplied to the attached equipment without permitting a rise in pressure within the vessel of more than 16%

above the maximum allowable working pressure when the pressure relief devices are blowing.

(b) Pressure relief devices as permitted in UG-125(c)(2), as protection against excessive pressure caused by exposure to fire or other sources of external heat, shall have a relieving capacity sufficient to prevent the pressure from rising more than 21% above the maximum allowable working pressure of the vessel when all pressure relief devices are blowing.

(c) Vessels connected together by a system of adequate piping not containing valves which can isolate any vessel, and those containing valves in compliance with Appendix M, M-5, may be considered as one unit in figuring the required relieving capacity of pressure relief devices to be furnished.

(d) Heat exchangers and similar vessels shall be protected with a pressure relief device of sufficient capacity to avoid overpressure in case of an internal failure.

(e) The official rated capacity, or the certified flow resistance and minimum net flow area, of a pressure relief device shall be that which is stamped on the device and guaranteed by the Manufacturer.

(f) The rated pressure relieving capacity of a pressure relief valve for other than steam or air shall be determined by the method of conversion given in Appendix 11.

(g) The relieving capacity of a pressure relief device for compressible fluids may be prorated at any relieving pressure greater than  $1.10p$ , as permitted under UG-125, by applying a multiplier to the official relieving capacity as follows:

(U.S. Customary Units)

$$\frac{P + 14.7}{1.10p + 14.7}$$

(SI Units)

$$\frac{P + 101}{1.10p + 101}$$

where

$P$  = relieving pressure, psig(kPa gage)

$p$  = set pressure, psig(kPa gage)

For steam pressures above 1,500 psig (10 MPa gage), the above multiplier is not applicable. For steam valves with relieving pressures greater than 1,500 psig (10 MPa gage) and less than or equal to 3,200 psig (22.1 MPa gage), the capacity at relieving pressures greater than  $1.10p$  shall be determined using the equation for steam and the correction factor for high pressure steam in UG-131 (e) (2) with the permitted absolute relieving pressure and the coefficient  $K$  for that valve design.

(h) When sizing and selecting valves, the restricted lift nameplate capacity shall be determined by multiplying the capacity at full rated lift as defined in UG-131 (e) (3) by the ratio of the restricted lift to the full rated lift.

#### UG-134 PRESSURE SETTINGS AND PERFORMANCE REQUIREMENTS

(a) When a single pressure relief device is used, the set pressure<sup>61</sup> marked on the device shall not exceed the maximum allowable working pressure of the vessel. When the required capacity is provided in more than one pressure relief device, only one pressure relief device need be set at or below the maximum allowable working pressure, and the additional pressure relief devices may be set to open at higher pressures but in no case at a pressure higher than 105% of the maximum allowable working pressure, except as provided in (b) below.

<sup>61</sup> The *set pressure* is the value of increasing inlet static pressure at which a pressure relief device displays one of the operational characteristics as defined by opening pressure, popping pressure, start-to-leak pressure, burst pressure, or breaking pressure. (The applicable operating characteristic for a specific device design is specified by the device Manufacturer.)

(b) For pressure relief devices permitted in UG-125(c)(2) as protection against excessive pressure caused by exposure to fire or other sources of external heat, the device marked set pressure shall not exceed 110% of the maximum allowable working pressure of the vessel. If such a pressure relief device is used to meet the requirements of both UG-125(c) and UG-125(c)(2), the device marked set pressure shall not be over the maximum allowable working pressure.

(c) The pressure relief device set pressure shall include the effects of static head and constant back pressure.

(d) (1) The set pressure tolerance for pressure relief valves shall not exceed  $\pm 2$  psi (15 kPa) for pressures up to and including 70 psi (500 kPa) and  $\pm 3\%$  for pressures above 70 psi (500 kPa), except as covered in (d)(2) below.

(2) The set pressure tolerance of pressure relief valves which comply with UG-125(c)(3) shall be within -0%, +10%.

(e) The burst pressure tolerance for rupture disk devices at the specified disk temperature shall not exceed  $\pm 2$  psi (15 kPa) of marked burst pressure up to 40 psi (300 kPa) and  $\pm 5\%$  of marked burst pressure 40 psi (300 kPa) and over.

(f) Pressure relief valves shall be designed and constructed such that when installed per UG-135, the valves will operate without chattering and shall not flutter at the flow-rated pressure in a way that either would interfere with the measurement of capacity or would result in damage.

#### UG-135 INSTALLATION

(a) Pressure relief devices intended for relief of compressible fluids shall be connected to the vessel in the vapor space above any contained liquid or to piping connected to the vapor space in the vessel which is to be protected. Pressure relief devices intended for relief of liquids shall be connected below the liquid level. Alternative connection locations are permitted, depending on the potential vessel overpressure scenarios and the type of relief device selected, provided the requirements of UG-125(a)(2) and UG-125(c) are met.

(b)(1) The opening through all pipe, fittings and nonreclosing pressure relief devices (if installed) between a pressure vessel and its pressure relief valve shall have at least the area of the

pressure relief valve inlet. The characteristic of this upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief valve.

(2) The opening in the vessel wall shall be designed to provide unobstructed flow between the vessel and its pressure relief device (see Appendix M).<sup>62</sup>

<sup>62</sup> Users are warned that the proper operation of various rupture disk devices depends upon following the Manufacturer's installation instructions closely with regard to the flow direction marked on the device. Some device designs will burst at pressures much greater than their marked burst pressure when installed with the process pressure on the vent side of the device.

(c) When two or more required pressure relief devices are placed on one connection, the inlet internal cross-sectional area of this connection shall be either sized to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the safety devices connected to it. The flow characteristics of the upstream system shall satisfy the requirements of (b) above. (See Appendix M.)

(d) There shall be no intervening stop valves between the vessel and its pressure relief device or devices, or between the pressure relief device or devices and the point of discharge, except:

(1) when these stop valves are so constructed or positively controlled that the closing of the maximum number a of block valves possible at one time will not reduce the pressure relieving capacity provided by the unaffected pressure relief devices below the required relieving capacity; or

(2) under conditions set forth in Appendix M.

(e) The pressure relief devices on all vessels shall be so installed that their proper functioning will not be hindered by the nature of the vessel's contents.

(f) Discharge lines from pressure relief devices shall be designed to facilitate drainage or shall be fitted with drains to prevent liquid from lodging in the discharge side of the pressure relief device, and such lines shall lead to a safe place of discharge. The size of the discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief devices below that required to properly protect the vessel, or adversely affect the proper operation of the pressure relief devices. [See UG- 136(a)(8) and Appendix M.]