

GP 03-02-04	Pressure Relieving Systems	February 2005
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Pressure Relieving Systems

GP 03-02-04

Scope

- 1) [I] This Global Practice (GP) covers the design and installation of pressure-relieving systems comprising pressure relief devices and associated flare pipe headers. Pressure relieving systems for fixed roof atmospheric storage tanks are covered in [GP 09-07-03](#) and are not included in the scope of this GP.
- 2) [I] Within GP 03-02-04, ASME Pressure Vessel Codes, e.g., ASME I and VIII, Process Piping, e.g., ANSI B31.3, API Recommended Practices 520 Part I, and 520 Part II, 521, and 526 outline requirements around pressure relief systems and are the primary documents that establish ExxonMobil's practices. GP 03-02-04, along with Design Practice XV-C, documents the exceptions and additions to the API documents. Design Practice XV-C, Pressure Relief, provides guidelines around design.
- 3) [I] An asterisk (*) indicates that additional information is required. If a job is contracted, this additional information is furnished in the Job Specification.

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GP 03-02-04	Pressure Relieving Systems	February 2005
-------------	----------------------------	---------------

Table of Contents

Table of Figures	3
Modifications to API RP 520 PT I—Section 1: Introduction	4
Modifications to API RP 520 PT I—Section 2: Pressure Relief Devices	5
Modifications to API RP 520 PT I—Section 3: Procedures for Sizing.....	7
Modifications to API RP 520 PT I—Appendix D: Sizing for Two-Phase Liquid/Vapor Relief	8
Modifications to API RP 520 PT II—Section 1: Referenced Publications	9
Modifications to API RP 520 PT II—Section 2: Inlet Piping to Pressure Relief Devices	10
Modifications to API RP 520 PT II—Section 3: Discharge Piping From Pressure Relief Valves.....	11
Modifications to API RP 520 PT II—Section 4: Isolation (Stop) Valves in Pressure Relief Piping	12
Modifications to API RP 520 PT II—Section 5: Bonnet or Pilot Vent Piping	13
Modifications to API RP 520 PT II—Section 7: Pressure Relief Device Location and Position	14
Modifications to API RP 520 PT II—Bolting and Gasketing	15
Modifications to API RP 520 PT II—Section 10: Pre-installation and Handling and Inspection.....	15
Modifications to API RP 521—Section 3: Determination of Individual Relieving Rates	16
Modifications to API RP 521—Section 4: Selection of Disposal Systems	19
Modifications to API RP 521—Section 5: Disposal Systems.....	22
Appendix: Figures	23
Record of Change	31
Attachment: Purpose Codes Definitions	34

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Page 2 of 34	©ExxonMobil Development Company	



Documents

Document Sharing Hub

GP 03-02-04	Pressure Relieving Systems	February 2005
-------------	----------------------------	---------------

Table of Figures

Figure A–1: Bonnet Vent for Bellows Valves Handling Low Toxic Concentration or Non-Toxic Vapors ⁽¹⁾	23
Figure A–2: Bonnet Vent for Bellows Valves Handling High Toxic Concentration Vapors ⁽¹⁾	24
Figure A–3: Bonnet Vent for Bellows Valves Handling Low Toxic Concentration or Non-Toxic Liquids ⁽¹⁾	25
Figure A–4: Bonnet Vent for Bellows Valves Handling High Concentration Toxic Liquids or Flashing Liquid and Vapor ⁽¹⁾	26
Figure A–5: Rupture Disk-Pressure Relief Valve Installation	27
Figure A–6: Snuffing Steam to Atmospheric Vent–Hard Piped	28
Figure A–7: Snuffing Steam to Atmospheric Vent–Hose Connection	29
Figure A–8: Toroidal Ring for Hydrogen Vents	30

DNST, CHEM, DIOL	For ExxonMobil Use Only	Version 2.0.0
Page 3 of 34	©ExxonMobil Development Company	



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Document Sharing Hub

GP 03-02-04	Pressure Relieving Systems	February 2005
-------------	----------------------------	---------------

Modifications to API RP 520 PT I—Section 1: Introduction

1.3. Addition: Referenced Publications

[I] The following tables list the practices, codes, publications, and standards which shall be used with this practice in addition to those referenced in API RP 520 PT I, Sizing and Selection of Pressure-Relieving Devices in Refineries.

1.3.1. Global Practices—ExxonMobil Engineering Practices

GP 03-15-01	Pressure Relief Valves
GP 03-18-01	Piping Fabrication Shop or Field
GP 04-03-01	Plant Buildings for Operation and Storage
GP 05-02-01	Internals for Towers, Drums, and Fixed Bed Reactors

1.3.2. ACGIH—American Conference of Governmental Industrial Hygienists

ACGIH 0022	Threshold Limit Values and Biological Exposure Indices, 1992-1993
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1.3.3. ASTM—American Society for Testing and Materials

ASTM E 84	Standard Test Method for Surface Burning Characteristics of Building Materials
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1.3.4. NEMA—National Electrical Manufacturers Association

NEMA Z535.2	Environmental and Facility Safety Signs
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1.3.5. Other References

EMBSI	"Exxon Occupational Exposure Limits for Chemical Contaminants," 1999 by EBSI (Exxon Biomedical Sciences, Inc., East Millstone, NJ)
British Health and Safety Executive (HSE)	"Guidance Note for Threshold Limit Values," (in UK), British Health and Safety Executive (HSE)

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Page 4 of 34	©ExxonMobil Development Company	



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Modifications to API RP 520 PT I—Section 2: Pressure Relief Devices

2.2.1.2.11. Exception: Spring-Loaded Pressure Relief Valves

- 1) [O] ASME Capacity Certified liquid relief valves shall not be used for services in which some of the contingencies relieve vapor/gas/two-phases, unless the only contingency capable of generating vapor, gas or two-phase flow is external fire.

2.2.1.3.5. Addition: Spring-Loaded Pressure Relief Valves

- 1) * [S], [E] The use of balanced bellows pressure relief (PR) valves shall be approved by the Owner's Engineer. They should be considered if the following conditions exist:
 - a) Excessive fluctuation in superimposed backpressure.
 - b) The built up back pressure exceeds 10% of the set pressure, based on psig; or it exceeds 21% of set pressure in the case of fire.
 - c) The service is fouling or corrosive.

2.2.1.3.6. Addition: Spring-Loaded Pressure Relief Valves

- 1) [S], [E] Addition to API RP 520 PT I, paragraph 2.2.1.3.5 found in GP 03-02-04 applies to this paragraph.

2.2.2.1. Addition: Pilot-Operated Pressure Relief Valves

- 1) * [S], [E] The use of pilot-operated PR valves shall be approved by the Owner's Engineer.

2.2.2.3. Addition: Pilot-Operated Pressure Relief Valves

- 1) [S] Pilot operated relief valves shall be considered for new installations in non-fouling service when the built-up backpressure or the variable superimposed backpressure is expected to exceed 50 percent of the set pressure.

2.2.2.5., 2.2.2.6., and 2.2.2.7. Addition: Pilot-Operated Pressure Relief Valves

- 1) [S], [R] Pilot operated valves shall meet the following requirements:
 - a) Valve shall be of a piston-type, non-flowing pilot design. Flowing-type pilot requires approval by Owner's Engineer.
 - b) A filter screen shall be provided in the inlet of each pilot.
 - c) Minimum requirements for accessories shall include a back flow preventer.
 - d) Valves shall have lifting devices (e.g., lugs) for lifting in the upright position without damage to the tubing.

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Page 5 of 34	©ExxonMobil Development Company	 Documents Document Sharing Hub

2.3.2.2.1. Addition: Applications of Rupture Disks

- 1) * [S], [E] Soft seated PR valves may be considered as an alternative to rupture disk (RD)/PR valve combinations for services operating below 450°F (232°C) when control of fugitive emissions is required to meet environmental regulations. The use of soft seated PR valves shall be approved by the Owner's Engineer.

2.3.2.2.3. Addition: Applications of Rupture Disks

- 1) * [S], [O] If installed upstream of a PR valve, rupture disks (RD) shall be installed as shown in Figure A-5.
- 2) [S], [O] The rated temperature at which the RDs are specified to function is the minimum temperature of the disk itself before it relieves. This may be lower than the normal process temperature due to ambient cooling of the non-flowing piping, RD, and disk holder, and is strongly affected by the geometry of the inlet piping. The inlet piping must be designed and evaluated before the rated rupture temperature of the RDs is finalized.

2.3.2.4. Addition: Applications of Rupture Disks

- 1) * [S], [O] The addition for API RP 520 PT I, paragraph 2.3.2.2.3 applies to this paragraph.

2.3.6.1. Addition: Rupture Disk Selection and Specification

- 1) * [S] Rupture disks (RD) may be used in conjunction with or as a substitute for PR valves only with the approval of the Owner's Engineer. Acceptable types of RDs are:
 - a) Pre-scored tension loaded conventional (forward acting) for both liquid and gas/two-phase service.
 - b) Pre-scored (cross-scored) reverse buckling for gas/two-phase only service.
 - c) Pre-scored (semi-circular) reverse buckling for gas/two-phase or liquid service. Pre-scored (semi-circular) may not be used under PRVs due to possible fragmentation.
- 2) * The manufacturing range for all RDs shall be the lowest available from the manufacturer. The manufacturing range shall be applied below the design pressure of the equipment. Use of other types of RDs with larger manufacturing ranges shall be approved by the Owner's Engineer.

2.4.2. Addition: Buckling Pin Devices

- 1) [S] * Buckling pin valves (BPV) may be used in conjunction with, or as a substitute for, PR valves only with the approval of the Owner's Engineer. Conventional or balanced BPVs are acceptable. If the BPV contains an internal check valve, it shall be used in clean service only. BPV are recognized by ASME Code Case 2091.

2.5. Addition: Other Types of Devices

- 1) [S] Internal relief valves on diaphragm metering pumps are not acceptable in lieu of external PR valves unless all of the following criteria are met:
 - a) Pump capacity: less than 10 gpm (0.63 L/s).
 - b) * Pump service: Non-corrosive or non-toxic media.
 - c) Internal valve setting: 250 psig (1700 kPa) and under.

DNST, CHEM, DIOL	For ExxonMobil Use Only	Version 2.0.0
Page 6 of 34	©ExxonMobil Development Company	



GP 03-02-04	Pressure Relieving Systems	February 2005
-------------	----------------------------	---------------

When these conditions cannot be met, an external PR valve shall be located on the pump discharge.

- 2) [S] * Other positive displacement pumps shall be provided with external PR valves. Owner's Engineer's approval is required to waive the use of external PR valves when the maximum pump discharge pressure cannot exceed the casing and system design pressure.

Modifications to API RP 520 PT I—Section 3: Procedures for Sizing

3.1. Addition: Determination of Relief Requirements

- 1) [S] Pressure relief devices shall be sized in accordance with API RP 520 PT I and governing regulations or codes, whichever is more stringent.

3.2.1. Addition: API Effective Area and Effective Coefficient of Discharge

- 1) * [O] The minimum size of PR valves shall be as follows:
 - a) 1 in. NPS (25 mm) inlet size with flanged inlet and outlet connections.
 - b) 3/4 in. NPS (20 mm) when used only for protection against liquid thermal expansion. This size may be used with threaded inlet and outlet connections.
- 2) [C] The use of smaller sizes shall be approved by Owner's Engineer. Vessels fabricated from pipe less than 24 in. NPS (600 mm), which are not ASME Code stamped, may not require PR devices for protection against fire.

3.2.2. Addition: API Effective Area and Effective Coefficient of Discharge

- 1) * [O], [R] Unless otherwise specified, pressure relief valves with Q, R, and T size orifices shall not be used where the temperature exceeds 350°F (177°C) and the molecular weight is less than 10 without Owner Engineer's approval. Pressure relief valves with orifice sizes larger than T (16,775 mm² or 26.0 in²) or with inlet flanges larger than NPS 8 in. (200 mm) shall not be used without Owner Engineer's approval.

3.3.3.2.1. Addition: Balanced Pressure Relief Valves

- 1) * [S] In new designs, the total back pressure (built-up plus superimposed) shall be limited to 50 percent of the set pressure for balanced bellows type PR valves for either operating or fire contingencies. In retrofits, the maximum backpressure published by the valve manufacturer for correction factors, Kb may be allowed with approval by the Owner's Engineer. The built up backpressure shall be calculated based on the frictional plus kinetic pressure changes.
- 2) [S] When total backpressure for balanced bellows relief valves exceeds 30 percent of the set pressure, the valve manufacturer shall be consulted. The capacity of the valve and the maximum allowable backpressure on the bellows shall be verified with the manufacturer.

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Page 7 of 34	©ExxonMobil Development Company	



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3.3.4.1. Addition: Effect of Back Pressure and Header Design on PRV Sizing and Selection

- 1) * [S] The maximum superimposed backpressure for non-discharging PR valves during a maximum system release (from either single or multiple valve releases under a design contingency) shall be as follows:

For spring-loaded, conventional PR valves:

$$P_{si(max)} = 0.826 C P_{set} - P_d$$

For balanced bellows and pilot operated valves:

$$P_{si(max)} = 0.50 C P_{set}$$

Where:

- $P_{si(max)}$ = Maximum superimposed back pressure
 P_{set} = Pressure relief valve set pressure
 P_d = Differential spring pressure
 C = Multiplier applied to design pressure to obtain hydrostatic test pressure per [GP 05-03-01](#), dimensionless

3.5.2.2.2. Addition: Operating Contingencies

- 1) Where not prohibited by local legislation and in accordance with the requirements of the ASME Code, Section VIII, Division 1 (ASME SEC VIII D1), accumulated pressure can be increased when multiple PRVs are installed as follows:
- 116% of the maximum allowable working pressure for operating contingencies,
 - 121% of the maximum allowable working pressure when fire is the only contingency requiring a PRV,
 - 106% of the maximum allowable working pressure for boilers.

Modifications to API RP 520 PT I—Appendix D: Sizing for Two-Phase Liquid/Vapor Relief

D.2.2.1. Addition: Step 4 Equation D-11

- 1) [S] Equation D-11 shall be used only for valves requiring capacity certification for liquid service per Section VIII, Division 1 of the ASME Code (ASME SEC VIII D1). For valves not requiring capacity certification, the following equation shall be used:

$$G = 96.3 \left[\rho_{lo} (1.25 P_{set} + 14.7 - P) \right]^{1/2}$$

Where:

- G = mass flux (lb/s • ft²)
 P_{set} = pressure relief valve set pressure, psig

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Page 8 of 34	©ExxonMobil Development Company	



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GP 03-02-04	Pressure Relieving Systems	February 2005
-------------	----------------------------	---------------

ρ_{lo} = liquid density at PRV inlet (lb/ft³)

P = Saturation pressure or downstream backpressure (psia)

All other terms as defined in Appendix D of API RP 520 PT I

D.2.2.1. Exception: Step 5

- 1) [S] Equation D-12 shall be replaced with the following equation which determines the required effective discharge area:

$$A = 0.3208 \frac{Q \rho_{lo}}{K_d K_b K_c K_p G}$$

Where:

K_p = correction factor due to overpressures other than 25%

K_p = 1 for valves requiring capacity certification for liquid service

K_p = 1 when flashing occurs upstream of the throat (see D.2.2.1 Step 2)

K_p is obtained from API RP 520 PT I, Figure 37 for all other cases.

All other terms as defined in Appendix D of API RP 520 PT I

D.2.2.1. Addition: Step 5

- 2) [S] The following default values shall be used for K_d in the absence of manufacturer's recommendations:

If $P_s \geq \eta_{st} P_O$ (flashing occurs upstream of throat), $K_d = 0.85$

If $P < \eta_{st} P_O$ (flashing occurs downstream of throat), $K_d = 0.65$ for valves requiring capacity certification for liquid service per ASME SEC VIII D1.

- 3) If $P_s < \eta_{st} P_O$ (flashing occurs downstream of throat), $K_d = 0.62$ for valves not requiring capacity certification for liquid service per ASME SEC VIII D1.

Modifications to API RP 520 PT II—Section 1: Referenced Publications

1.3. Addition: Referenced Publications

Sections 1.3.1 – 1.3.5 in Modifications to API RP 520 PT I—Section 1 list the practices, codes, publications, and standards which shall be used with this Practice in addition to those referenced in API RP 520 PT II.

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Modifications to API RP 520 PT II—Section 2: Inlet Piping to Pressure Relief Devices

2.2.2. Exception: Size and Length of Inlet Piping to Pressure Relief Valves

- 1) [S] When relieving at rated capacity, the total frictional (fluid acceleration effects not included) pressure drop between the vessel and PR valve shall not exceed 3% of the set pressure (gauge) for both conventional and balanced bellows type PR valves, for set pressures 50 psig (345 kPag) or higher; or 5% of set pressures below 50 psig (345 kPag).
- 2) [S] The **nominal cross-sectional area of the inlet line**, or the inlet manifold for multiple valves, must be at least equal to the sum of the flow areas of the PR valve inlet flange(s).

2.2.3. Addition: Remote Sensing for Pilot-Operated Pressure Relief Valves

- 1) [S] Unless otherwise specified, pilot sensing points for pilot operated pressure relief valves shall be at the pressure relief valve location. Pilot sensing points may be located remotely from the pressure relief valve only with Owner's Engineer approval. Lead lines to remote sensing pilots shall be sloped to prevent liquid accumulation. Valves in the sensing line shall be designed to prevent accidental closure (i.e., quarter turn or tubing valves should not be used in sensing lines) and valves in the sensing line should be car sealed open.
- 2) [S] For a remote sensing pilot, the remote sensing point must be at least 80% of the highest anticipated operating condition at the main valve.
- 3) [S] If nitrogen or other gas purge is used in the pilot line, the Owner's Engineer must approve the final configuration.

2.2.4. Addition: Configuration of Inlet Piping for Pressure Relief Valves

- 1) [S] Inlet piping to PR devices shall be installed to continuously slope away from the PR device at a rate similar to flare lines (1:480)

2.3.2. Addition: Mechanical Stresses

- 1) [S] PR device piping, including discharge risers and supports, shall be designed to permit PR device removal including independent support of discharge risers.

2.4.2. Addition: Determining Reaction Forces in a Closed Discharge System

- 1) [S] PR device piping, including discharge risers and supports, shall be designed to:
 - a) Resist reactive forces from discharge
 - b) Prevent excessive vibration during discharge.

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Page 10 of 34	©ExxonMobil Development Company	



GP 03-02-04	Pressure Relieving Systems	February 2005
-------------	----------------------------	---------------

- 2) [S] PR devices that discharge primarily liquid or mixed phase fluids shall not discharge directly into a vapor disposal system unless the system has been designed to absorb the reaction forces arising from liquid or mixed phase flow. The magnitude of the reaction forces shall be estimated from the following equation to determine if the integrity of the disposal system can absorb the reaction force without damage. Contact the Owner's engineer for additional information.

$$F = \left(\frac{W}{g} \right) V \cos \left(\frac{1}{2} \theta \right)$$

Where:

- F = Force, lb (kg)
W = Flow rate, lb/sec (kg/sec)
g = 32.2 ft/sec² (9.81 m/sec²)
V = Fluid velocity, ft/sec (m/sec)
θ = Included angle of the direction change

An alternative equation may be used with the approval of the Owner's Engineer.

2.6. Addition: Rupture Disk Devices in Combination with Pressure Relief Valves

- 1) [S], [E] See addition outlined for API RP 520 PT I, paragraph 2.3.2.2.1 that applies to this paragraph.
2) [S], [O] See addition outlined for API RP 520 PT I, paragraph 2.3.2.2.3 that applies to this paragraph.
3) [S] See additions under API RP 520 PT I, paragraph 2.3.6.1 which applies to this paragraph.

Modifications to API RP 520 PT II—Section 3: Discharge Piping From Pressure Relief Valves

3.1. Addition: General Requirements

- 1) [S] Discharge piping for PR devices discharging to a closed system shall be installed to continuously slope downward toward the flare header. The line shall connect into the top of the flare header or into the vapor space of process/collection equipment to prevent liquid from entering the line. If the discharge piping cannot be continuously sloped, a 3/4 in. NPS (20 mm) drain line shall be installed from the lowest point in the discharge piping to a small drain pot equipped with a high level alarm. The drain line and pot shall be winterized when appropriate. A 3/4 in. NPS (20 mm) drain line, with a normally closed block valve, shall be installed from the drain pot to a catch basin or other safe location. Such piping arrangements require approval by the Owner's Engineer.

3.3. Addition: Back Pressure Limitations and Sizing of Pipe

- 1) * [S] The nominal cross-sectional area of the outlet line, or manifold for multiple valves, should be at least equal to the sum of the flow areas of the PR valve outlet flange(s). Smaller cross-sectional areas

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