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Latest update from API Subcommittee on PRS

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Purpose

- The purpose of this presentation is to increase awareness of the most recent changes to API standards.
  - API 520 Part I, Sizing and Selection of Pressure-relieving Devices
    - Tenth Edition, October 2020
  - API 520 Part II, Installation of Pressure-relieving Devices
    - Seventh Edition, October 2020
  - API 521, Pressure-relieving and Depressuring Systems
    - Seventh Edition, June 2020

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Purpose

- Do you have updated copies of these standards?
- Do you know what has changed?
- How do these changes affect your business?

We will highlight the most significant changes in each of the standards.

Note: Certain text from the standards has been abridged or altered for the sake of space and clarity. Please reference the standard for the complete, unabridged, and unaltered original text.

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API 520 Part I, Sizing and Selection of Pressure-relieving Devices
Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
3.1 Terms & Definitions *Actual*, *Certified*, *Effective*, and *Rated* terms	These new and revised definitions clarify that rated capacity may be determined using either *effective* variables, or *actual* and *certified* variables. These changes clearly separate, define, and tell users how the terms are used in practice. Previous editions contained muddled terms, allowing for multiple (mis)interpretations.
3.1.2 actual orifice area The cross-sectional area (based on the measured diameter) within the pressure-relief device.	
3.1.11 certified capacity The capacity of a pressure-relief device determined using the certification test fluid, at the certification test overpressure, with the certified discharge coefficient, and actual orifice area.	
3.1.12 certified coefficient of discharge The published value for the ratio of the measured relieving capacity to the theoretical relieving capacity of an ideal nozzle, multiplied by a capacity derating factor if required by the code of construction.	
3.1.21 effective coefficient of discharge The value for the ratio of the estimated relieving capacity to the theoretical relieving capacity of an ideal nozzle.	
3.1.22 effective orifice area A nominal cross-sectional area within the pressure-relief device flow path that limits the fluid flow through the pressure-relief device.	
3.1.47 rated capacity The capacity of the pressure-relief device at the certification test overpressure. This capacity can be determined using the effective coefficient of discharge and effective orifice area, or the certified coefficient of discharge and actual orifice area.	

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
4.2.1.4 Pressure-relief Valve Trim Selection	New section that supplements existing sections describing fluid behavior in a PRV. The items of greater interest are Tables 1 and Tables 2…
4.2.1.4.1 PRV trim selection is an important factor when designing relief system installations to minimize the potential for instability.	
4.2.1.4.3 It is important that the user understands how different trims perform within the range of relief conditions that the PRVs could experience. Particular attention should be paid to vapor certified valves that have applicable liquid relief scenarios.	

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

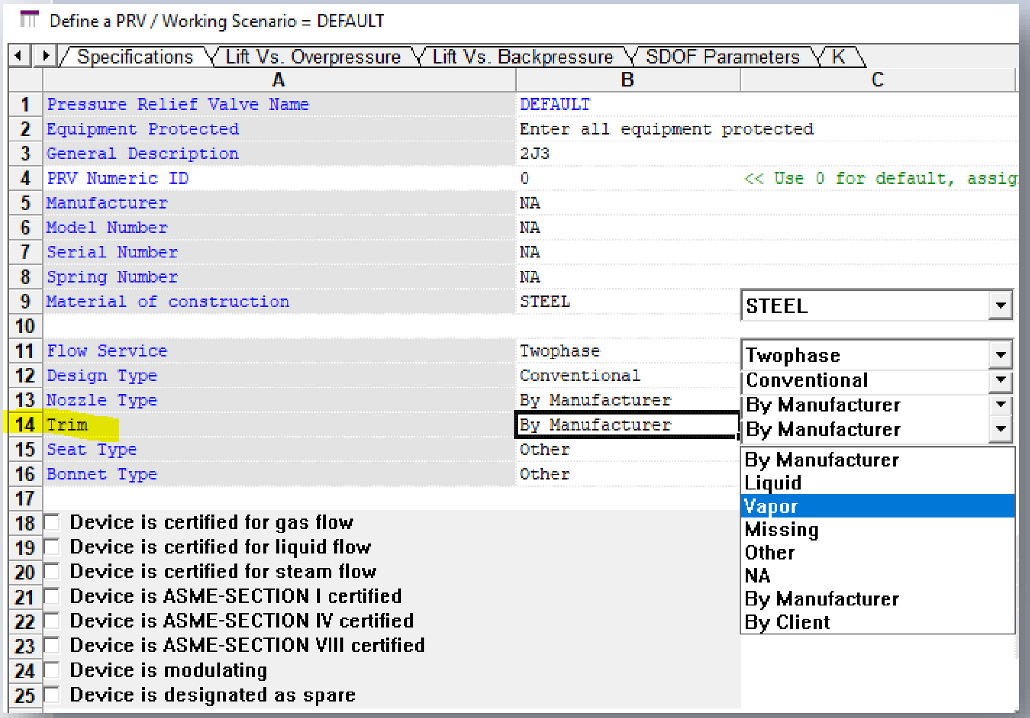
Section & Abridged Text	Significance
4.2.1.4 Pressure-relief Valve Trim Selection	Table 1 quietly highlights the RAGAGEP gap for vapor relief on a liquid certified PRV. And, not so obvious, but implied, is the RAGAGEP gap for two-phase flow through either trim.

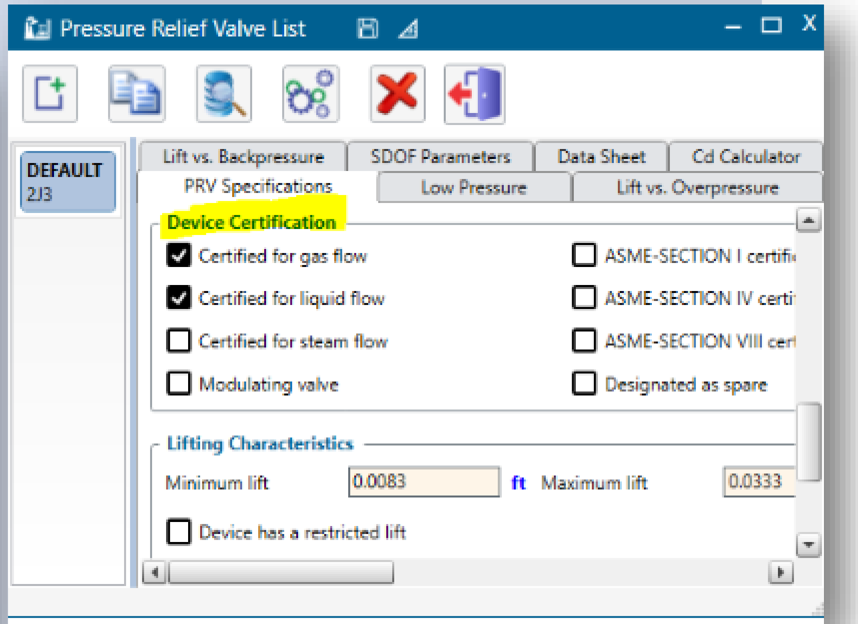
Table 1 - Spring-loaded Pressure-relief Valve Performance Characteristics as a Function of Valve Trim

Characteristic	Vapor Certified PRV	Liquid Certified PRV	Dual Certified PRV
Liquid relief	Capacity is not certified but can be estimated using guidance in 5.9 (may need up to 25 % overpressure to achieve full lift)	Capacity is certified	Capacity is certified
Vapor relief	Capacity is certified	Capacity is not certified, and is not addressed herein See manufacturer for estimated capacity	Capacity is certified
Range of blowdown available (see manufacturer for PRV-specific blowdown values; see NOTE)	Up to 10 % for vapor, and Up to 10 % for liquid	Up to 25 % for vapor Typically up to 12 % for liquids; some vendors may offer higher blowdowns	Up to 25 % for vapor Typically up to 12 % for liquids; some vendors may offer higher blowdowns
Tendency to chatter in liquid service	Increased	Neutral	Neutral
Effect of medium on the opening characteristic	PRV set on gas or vapor but relieving liquid may open 3 % to 5 % higher	PRV set on liquid but relieving vapor may open 3 % to 5 % lower	Minor effect (i.e. within code tolerances)
Effect of required valve overpressure vs. set medium	Any shift up or down in the opening point may result in a similar shift in the point at which full lift is achieved		

NOTE These are typical values obtained from valve manufacturers. User is cautioned to fully understand the impact on operations when blowdown exceeds the operating margin.

Two ?
PHASE





Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

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API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
4.2.1.4 Pressure-relief Valve Trim Selection	Table 2 is interesting because it makes it plain that inlet pressure drop should be calculated using rated capacity for all cases and flow types unless a valve exhibits modulating characteristics. The unspoken rule in most circles was to always use required liquid relief through liquid trim with a presumption of modulating characteristic. Now, the guidance puts more onus on the user to document the modulating behavior in liquid relief on liquid trim.

Table 2 - Design Guidance for Pressure-relief Valve Trim Options

Relief Medium	Certified PRV Trim	PRV Inlet Line Pressure Drop Hydraulic Calculation Basis Options		Comments
		Use PRV Rated Capacity	Use Required Relief Load	
Vapor	Vapor or Dual	✓	NOTE 1	
Vapor	Liquid	✓	NOTE 1	Caution (NOTE 2)
Liquid	Vapor	NOTE 3	NOTE 3	Caution (NOTE 3)
Liquid	Liquid or Dual	✓	NOTE 1	
Two phase	Liquid, Vapor, or Dual	✓	NOTE 1	
Supercritical	Liquid, Vapor, or Dual	✓	NOTE 1	

NOTE 1 May be used if PRV exhibits modulating behavior.

NOTE 2 Application not recommended if vapor is the controlling sizing case, and the valve is not certified for vapor. Where vapor loads are not controlling, the capacity of the PRV relieving vapor will need to be estimated; see manufacturer for guidance. See Table 1 for blowdown characteristics.

NOTE 3 Application not recommended if liquid is the controlling sizing case, since the valve is not certified for liquid. Where liquid loads are not controlling, the capacity of the PRV relieving liquid will need to be estimated using the noncertified liquid PRV sizing equation; see 5.9. When calculating inlet line pressure drop, required rate may be used if PRV exhibits modulating behavior. See Table 1 for overpressure characteristics.

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
4.2.4 Restricted Lift Pressure-relief Valves 4.2.4.1 API 526 Table 1 shows a 21% to 78% increase in effective orifice area from one lettered orifice to the next lettered orifice. In some applications, the user may desire less capacity than the next size orifice area would provide. A reduction in the pressure relief valve rated capacity can be achieved by restricting the lift. A restricted lift pressure relief valve has a reduced flow area. resulting in a lower rated capacity for the valve. A lower rated capacity. based on the reduced Hit, will lower the inlet and outlet piping pressure losses and reduce the acoustic effects.	New section that highlights an increasingly common approach to restricting rated capacity and thus calculated pressure drop. For as-built installations, the key benefit of restricted lift is that it can mitigate high pressure drops and thus costly pipe modifications.

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
4.3.2.4 Rupture Disk Devices in Series	Completely re-written to generalize and explain multi-disk installations and not imply a single use case limited to CORROSIVE service. This expanded section provides obligatory guidance for double-disk assemblies, which are commonplace. Double-disks are preferable to single disks because a nuisance leak in one disk does not automatically lead to an inadvertent relief path, loss of product, or contamination. If you were not aware of double-disks before, there is no excuse now.
4.3.2.4.1 Rupture disks may be installed in series using two distinct rupture disk holders separated by a spool piece. Rupture disks may also be installed in series using a "Double Disk Assembly."	
4.3.2.4.2 Remember that rupture disks are pressure differential devices and the space between the two disks shall be monitored or vented to ensure that no pressure elevates the burst pressure of the upstream disk. The vapor space between the disks shall have a free vent or suitable telltale indicator for monitoring of pressure.	
4.3.2.4.3 The ASME Code allows rupture disks installed in a double disk assembly to be tested to obtain a single Kr value for the device. If two rupture disk devices in series are used, each rupture disk Kr value must be considered when sizing the relief system.	
4.3.2.4.4 Rupture disks may be installed in series for highly corrosive applications where any corrosion paths (e.g., pinholes) in the upstream disk will be contained by the downstream disk preventing any hazardous product releases. If the first disk develops a leak due to corrosion, the second disk will contain the fluid.	
4.3.2.4.5 Rupture disks may be installed in series to prevent any superimposed backpressure (constant or variable) from elevating the burst pressure of the upstream disk. The burst pressure of the upstream disk is typically specified at the desired system relief pressure, whereas the burst pressure of the downstream disk is specified at a lower value to account for superimposed backpressure. Since some rupture disks designs are better equipped to withstand backpressure, the rupture disk manufacturer should be consulted to ensure that the rupture disk device is suitable for the application.	

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
5.2 API Effective Area and Effective Coefficient of Discharge 5.2.5 The effective orifice area and the effective coefficient of discharge should not be are used for final PRV selection. The actual orifice area and the certified coefficient of discharge **should** always be used to verify the rated capacity of the PRV corrected for the actual overpressure. In no case **shall** an effective orifice area be used with a certified coefficient of discharge for calculating the capacity of a PRV. Similarly, an actual orifice area **shall** not be used in conjunction with an effective coefficient of discharge. 5.2.6 In summary, the effective orifice size and effective coefficient of discharge specified in API standards are assumed values intended for initial selection of a PRV size from configurations specified in API 526, independent of an individual valve manufacturer's design. In most cases, the actual orifice area and the certified coefficient of discharge for an API letter orifice valve are designed so that the rated capacity corrected for actual overpressure meets or exceeds the rated capacity calculated using the methods presented in API 520 (i.e. using the effective orifice area and effective coefficient of discharge). There are, however, a number of valve designs where this is not so. When the PRY is selected, therefore, the actual orifice area and certified coefficient of discharge for that valve **should** be used to verify the rated capacity of the selected valve, corrected for the actual overpressure, and to verify that the valve has sufficient capacity to satisfy the application.	This subsection was re-written for succinctness and agreement with the new or improved definitions of *effective*, *certified*, and *actual* variables. This section also swaps some *shalls* for *shoulds* and vice versa (**emphasis** added in the text). The key change is that users are no longer required to use the actual area and certified discharge coefficient for final sizing and selection because a *shall* was replaced with a *should*. The user may instead, with appropriate documentation, simply use the preliminary sizing afforded by the effective area and effective discharge coefficient to calculate the rated flow. In some circles, this practice was already commonplace because it reduced calculation burden but is now acknowledged in the RAGAGEP.

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

<table>
<tr><th>Section & Abridged Text</th><th>Significance</th></tr>
<tr><td>5.3.3 Effects of Backpressure on Pressure-relief Valve Operation and Flow Capacity</td><td rowspan="2">Succinctly rewritten section and new supporting section clarifying and exemplifying allowable backpressures on a conventional PRV.</td></tr>
<tr><td>5.3.3.1.3 In a conventional PRV application, the allowable built-up backpressure is equal to the allowable overpressure. Both of these values are referenced to the PRV's set pressure, not to its CDTP. See Equation (1).

$P_{B,Allowable} = AOP = MAWP \times (1 + \%AA) - P_{set}$ (1)

Where
•$P_{B,Allowable}$ is the allowable built-up backpressure, psi;
•AOP is the allowable overpressure, psi;
•MAWP is the maximum allowable working pressure, psig;
•%AA is the allowable accumulation(%);
•P_{set} is the PRV set pressure, psig.</td></tr>
</table>

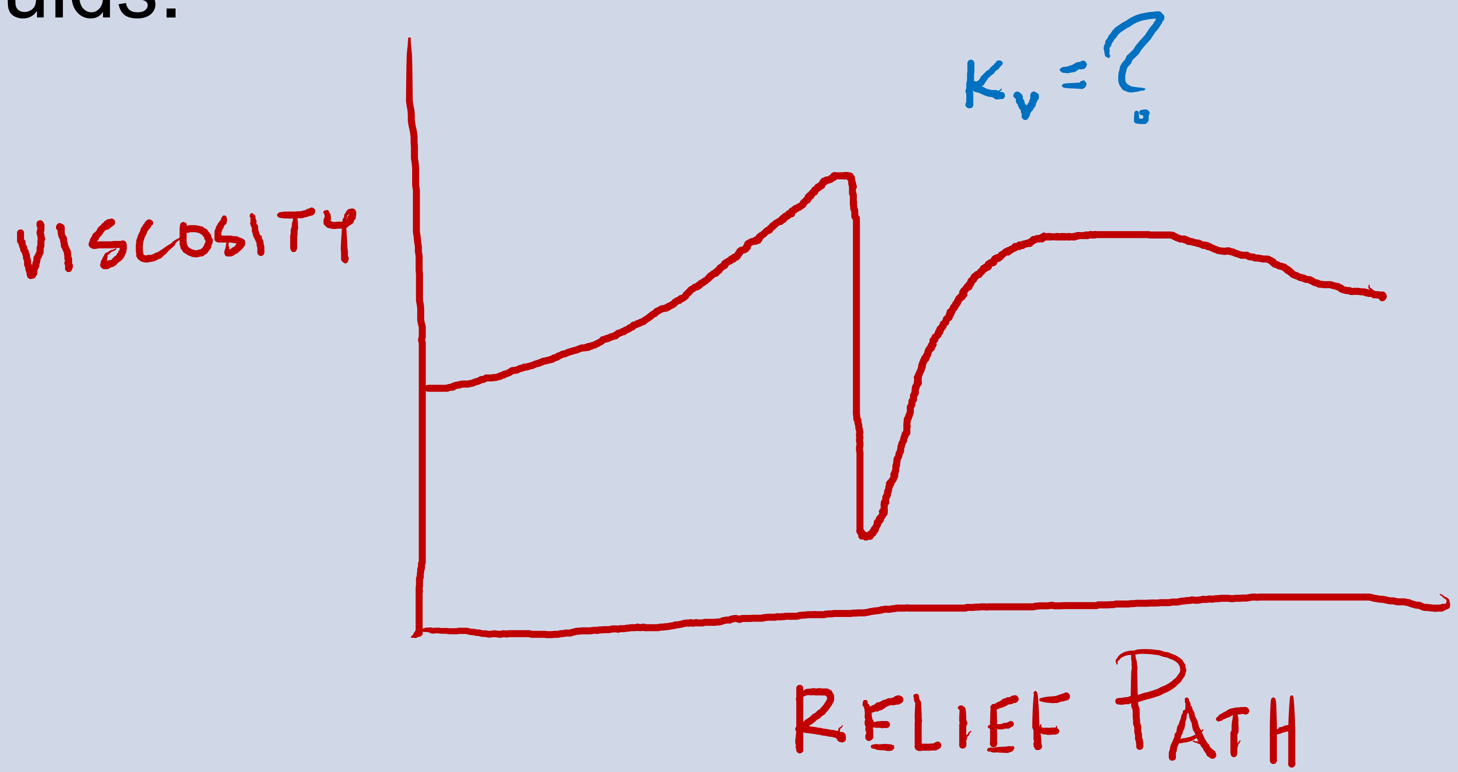
Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
5.6 Sizing for Gas or Vapor Relief	Section expanded to provide greater background on non-ideal gas behavior and to also encourage users to measure nonideality with reduced variables in lieu of compressibility factor alone. In other words, instead of simply using a Z range of 0.8 - 1.1, the user is first encouraged to check whether v_R is < 2.0.
5.6.1 Applicability The sizing equations for PRDs in vapor or gas service provided in this section assume that the pressure-specific volume relationship along an isentropic path is well described by the expansion relation: Pv^k = constant (2) where • P is the pressure, psia (Pa); • v is the specific volume at P, ft^3 /lb (m^3/kg); • k is the ideal gas specific heat ratio at the relieving temperature (see B.3.2.2). For real gas behavior the nonideality of the fluid has been taken into consideration using the compressibility factor Z and the use of the isentropic expansion exponent n in place of the ideal gas k (see B.3.1). However, the validity of this assumption may diminish as the vapor approaches the thermodynamic critical locus, such as at very high pressures or as the fluid exhibits more liquid-like behavior. One indicator of this behavior is when the reduced volume (v_R) of the fluid is less than two (2.0) at the inlet pressure. Another indicator that the vapor or gas may be in one of these regions is a compressibility factor, Z, less than approximately 0.8 or greater than approximately 1.1. Replacement of the ideal gas specific heat ratio, k, with the calculated isentropic expansion coefficient, n, in the gas sizing equation may not be sufficient to correct for the deviation from ideal gas behavior the further this deviation progresses. In such cases, use of the direct integration method is recommended.	

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
5.10 Special Considerations for Non-Newtonian Fluids	New section dedicated to cautioning users on viscosity correction factor for non-Newtonian fluids.
The chemical and petroleum industries frequently encounter complex fluids that exhibit non-Newtonian behavior. This is typically manifest as a shear-thinning viscosity and occurs in suspensions of fine solids as well as solutions and melts of high polymers. In laminar flows, the viscosity of these fluids can drop significantly as the shear rate (or shear stress) increases. In turbulent flow, some very high MW polymer solutions exhibit viscoelastic properties that can result in drag reduction, which lowers the flow resistance to below that of the solvent. Thus, the viscosity correction factor, K_v, derived for Newtonian fluids is not reliable for non-Newtonian fluids because the viscosity varies with shear rate. Due to strong velocity gradients in the curtain area between the valve seat and the disk, high shear rates may exist so that the viscosity of a shear-thinning fluid at that location can be much less than the viscosity at relieving conditions (i.e., in the vessel or other protected equipment). The value of the viscosity correction factor might change markedly with the rheological model for the shear-thinning medium. The use of the viscosity at relieving conditions when calculating the viscosity correction factor is likely to result in significantly oversized PRVs.	

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
Annexes Annex A (informative) Rupture Disk Device Specification Sheet Annex D (informative) Pressure-relief Valve Specification Sheets Annex F (informative) Valve Selection Example: Restricted Lift	Annex A & D provide new API spec sheets for disks and PRVs. Annex F provides a thorough example for specifying a restricted lift PRV.

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

API 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

Section & Abridged Text	Significance
Annex C (informative) Sizing for Two-phase Liquid/Vapor Relief C.1.2.3 In applications where the homogeneous equilibrium assumption is not valid, the user is encouraged to apply non-equilibrium methods. The Burnell bubble delay factor, if used, can remove some of the conservatism associated with the homogeneous equilibrium assumption.	New subsection that opens the door in API 520 Part I for non-HEM considerations (e.g., slip flow or other non-mechanical equilibrium) that users may learn more about from DIERS.

Source: API Standard – 520 Part I, Sizing and Selection of Pressure-relieving Devices Tenth Edition, October 2020

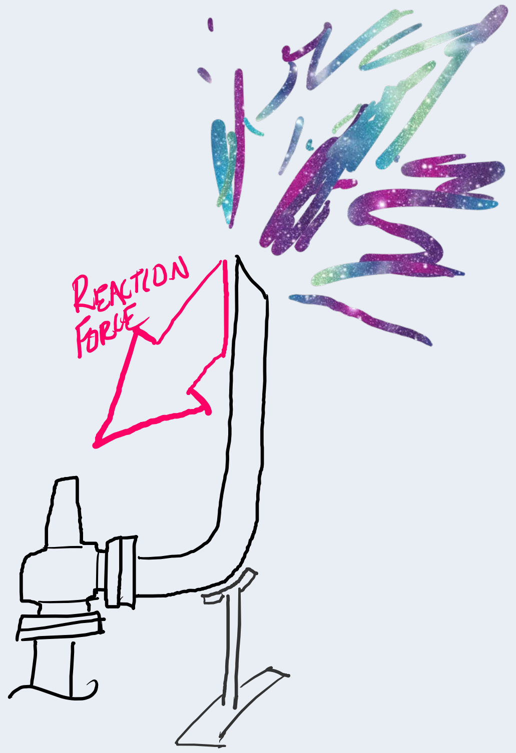
API 520 Part II, Installation of Pressure-relieving Devices
Seventh Edition, October 2020

API 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

Section & Abridged Text	Significance
5.2 Inlet Piping Diameter Requirements The nominal size of the inlet piping and fittings shall be the same as or larger than the nominal size of the pressure-relief valve inlet connection. When two or more active pressure-relief valves are placed on one connection, the inlet internal cross-sectional area of this connection shall be sized to avoid restricting flow to the pressure-relief devices or made at least equal to the combined inlet areas of the in-service pressure-relief devices connected to it. The flow characteristics 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.	This section is rewritten specifically to differentiate it as only applying to the PRD inlet. More important is the less-restrictive guidance for multi-PRV installations sharing common piping. Previously, the document stated that the inlet piping shall have a flow area at least equal to the sum of inlet areas of the multiple PRVs connected to the same piping. Whereas now, the language allows the user to have piping flow less than the combined flow are of active (i.e., non-spared) PRVs if the capacity is not diminished. This is consistent with ASME Section VIII UG-135 (c) and Appendix M-6 (b). This updated guidance is an elegant solution to the quandary often created by users whose LOPA IPL guidance requires shoehorning an additional online PRV into an existing pressure relief system.

Source: API Standard 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

API 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

Section & Abridged Text	Significance
5.8 Inlet Stresses that Originate from Discharge Reaction Forces The user is cautioned that terminating the PRV discharge piping to any angle other than vertical with a perpendicular cut may increase the system stresses. The designer is responsible for analyzing the discharge system in compliance with the code of construction (e.g., ASME B31.3) to determine if the reaction forces and the associated bending moments will cause excessive stresses on any of the components in the system.  	This section was updated with a warning against the ubiquitous 45° chamfer cut made on vertical discharge stacks. Nobody seems to know why these types of cuts ever became commonplace, but they are problematic because the direction of reaction forces is not often counteracted by braces or piping supports. Additionally, the section now ties calculating reaction forces with a compliance requirement for process piping.

Source: API Standard 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

API 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

Section & Abridged Text	Significance
6.3 Backpressure Limitations and Sizing of Pipe For pressure drop calculations, when discharging incompressible or subsonic compressible flow to either a closed reservoir or the atmosphere, the static pressure within the exit of the pipe is numerically equal to the reservoir or, atmospheric pressure, respectively. When discharging sonic compressible flow, the pressure within the exit of the pipe is the calculated choking pressure. Additional information on sizing of discharge piping systems for vapor or gas service is covered in API 521.	At the beginning of the API revision cycle this section was intended to be updated with direct, concise, and practical advice to users regarding whether to use a head loss K = 1 value for piping exits to large reservoirs, like the atmosphere. Instead, committee disagreement resulted in technically correct, yet obtuse, guidance.

Source: API Standard 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

API 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

<table>
<tr><th>Section & Abridged Text</th><th>Significance</th></tr>
<tr><td>7.3.7 Calculating Non-recoverable PRV Inlet Losses

7.3.7.3 Flow Rates for Hydraulic Calculations
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In applying the criteria given in 7.3.4, it is not necessary to calculate the inlet pressure drop for overpressures greater than the capacity certification overpressure. This is independent of the pressure at which the PRV provides adequate capacity. Where the allowable overpressure exceeds the capacity certification overpressure, the additional inlet pressure loss caused by the increased flow capacity due to the increased internal pressure is not expected to result in PRV instability.

⋮
For a relief device downstream of a positive displacement pump, the required relief rate may be used provided the system is liquid full and only the pump flow will be relieved.</td><td>This first additional paragraph clarifies that IPL only needs to be calculated at the capacity certification overpressure. In other words, you don't need to calculate the inlet pressure drop associated with a 21% overpressure, but only at a 10% overpressure.

The second additional paragraph, related to require relief rate for positive displacement pumps, is straightforward at first glance, but contradictory to the guidance in API 520 Part I Table 2, which states that the user should use rated PRV capacity on liquid trim valves unless the valve has modulating characteristics.</td></tr>
</table>

Source: API Standard 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

API 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

Section & Abridged Text	Significance
13.9 Heat Tracing and Insulation For materials that are highly viscous, materials that could result in corrosion upon cooling, or materials that could potentially solidify in PRDs, adequate heat tracing or insulation should be provided for the PRDs themselves (including pilots). including both the inlet and outlet piping to PRDs, as well as remote sensing and exhaust lines for pilot-operated PRVs. Ensure that any discharge or vent ports are not covered when the valve is insulated. PRD heat tracing should be appropriate for the materials of construction. service conditions. and relief device design. The reliability of the tracing system shall be maintained in order to ensure proper operation of the PRD.	Section rewritten to emphasize that heat tracing and insulation should be provided not just for piping to and from the PRD, but for the PRD itself. Additionally, new emphasis is added on the appropriate selection of heat tracing for the service conditions. These edits stem from lessons learned from a poorly implemented heat trace installed on a PRD in an extremely cold climate.

Source: API Standard 520 Part II, Installation of Pressure-relieving Devices Seventh Edition, October 2020

API 521, Pressure-relieving and Depressuring Systems
Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4 Causes of Overpressure and Their Relieving Rates **4.1 General** ⋮ All equipment operations/status should be considered when establishing overpressure protection for the equipment, including, but not limited to, nonroutine situations such as start-up, shutdown, maintenance, standby, and out-of-service as defined by the user. Overpressure protection shall be considered when mass and/or energy exchange is possible for the equipment being considered. Equipment protection should consider the isolation practices as defined by the user. The equipment operations/status and protection methods should be consistent with isolation practice as defined by the user. ⋮	New paragraph written in response to a CSB recommendation related to the Williams Olefins Plant Explosion and Fire. Reference CSB recommendation 2013-3-I-LA-4.

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4.2.2 Use of Administrative Controls if Corrected Hydrotest Pressure Not Exceeded It is the responsibility of the user to determine the overpressure scenarios upon which the pressure relief system is designed, and to determine the method of overpressure protection used to mitigate each scenario in accordance with the relevant codes. It is the responsibility of the user to determine whether administrative controls are included in the basis for the pressure relief system design. If administrative controls are used to eliminate an overpressure scenario as a basis for the pressure relief system design, the user shall evaluate the potential overpressure in the event the administrative control fails, compare it to the equipment corrected hydrotest pressure, and consider additional risk reduction if the corrected hydrotest pressure can be exceeded. ⋮	Revamped paragraphs for the contentious subject of administrative controls against overpressures that do not exceed hydrotest pressure. The general sentiment is that the previous language was not firm and that some users were overusing or abusing administrative controls to ignore overpressure scenarios.

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4.4.6 Entrance of Volatile Material into the System	This entire section has been completely overhauled to provide emphasis and practical guidance on identifying superheat limit temperature scenarios. The previous guidance only provided generalized guidance to water in hot oil and light hydrocarbons in hot oil.
4.4.6.1 General Violent explosions have occurred in the refining, petrochemical, LNG, and other industries due to mixing water or a light hydrocarbon with a significantly hotter fluid or direct contact of the volatile fluid with a hot surface. These physical explosions are termed "superheat-limit explosions," "vapor explosions," "steam explosions," or "rapid phase transitions" (RPTs). The commonality of these explosions is that cold, volatile liquid is superheated well above its normal boiling temperature at a given pressure. The consensus of published research on this phenomenon is that in order for such explosions to occur, the hot liquid or surface temperature must exceed the superheat limit temperature (SLT) of the cooler volatile liquid. At constant pressure, the SLT is defined as the highest temperature below thermodynamic critical temperature that a liquid can attain without undergoing RPT to vapor. If the SLT is reached or exceeded, the liquid will flash into vapor, in some cases within microseconds. This timeframe is analogous to a detonation. Similar to a chemical detonation, a superheat limit explosion can produce shock waves that generate significantly more damage than that generated by the volume expansion accompanying the conventional vaporization of a liquid. Because of the shock wave potential, PRDs do not provide any mitigation against a superheat limit explosion. ⋮	

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4.4.12 Hydraulic Expansion **4.4.12.1 Causes** ⋮ b) A heat exchanger is blocked in on the cold side with flow in the hot side. Caution - Block valves have the potential to leak, thereby admitting either cold or hot fluid into a heat exchanger that is intended to be blocked in, resulting in a potential overpressure. ⋮ Review each installation before deciding that administrative controls can be used to eliminate hydraulic expansion. For example, an isolation valve can leak on an isolated heat exchanger or piping containing cold fluid can be blocked-in by a control or shutdown system **Caution - If the trapped liquid can be heated above its bubble point temperature at the relief pressure, vaporization can occur when the fluid is still contained causing potential loss of containment with possible boiling liquid expanding vapor explosion (BLEVE) unless a significantly larger PRD is installed to protect the equipment from overpressure. See 4.4.13.2.5.3 for guidance.** **Caution - In some cases, the contained fluid can be heated above its SLT. In such cases, experience has shown that equipment failure due to thermal hydraulic expansion can result in a BLEVE instead of a minor flange release. See 4.4.6 for a discussion of the SLT.** ⋮	This section was modified to add emphasis to potential overpressures in offline equipment, especially heat exchangers. Written in response to a CSB recommendation related to the Williams Olefins Plant Explosion and Fire. Reference CSB recommendation 2013-3-I-LA-5.

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

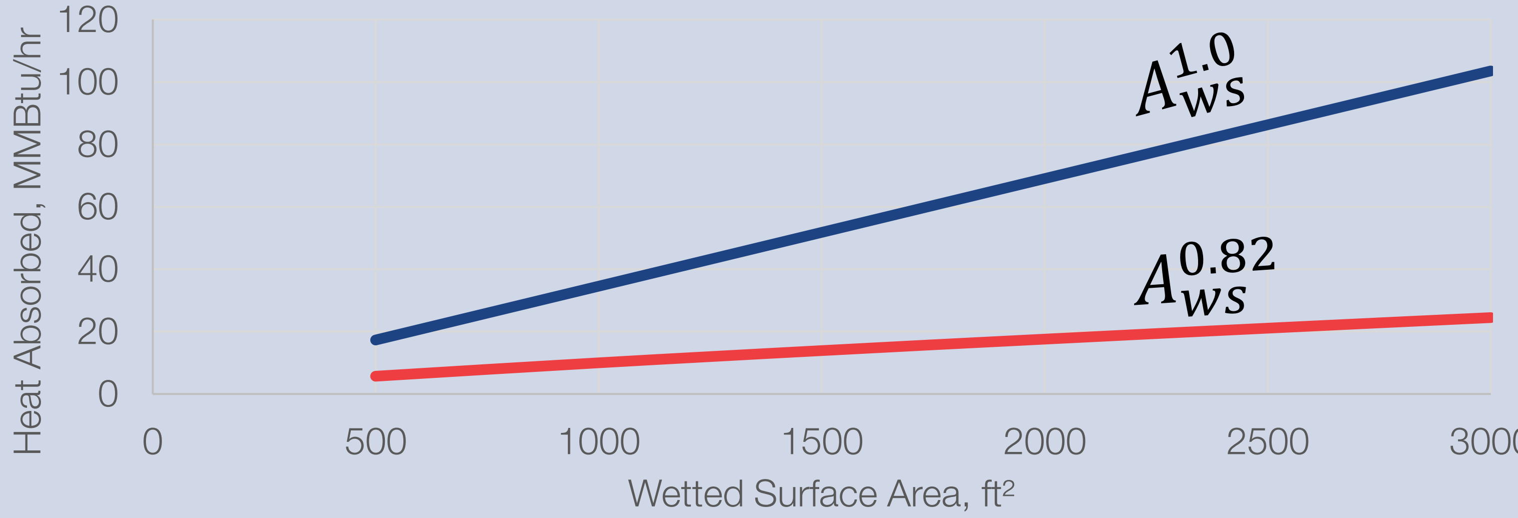
Section & Abridged Text	Significance
4.4.13.3 Confined Pool Fires	Yikes! Section partially re-written to make it very clear that confined fire cases should use the high C_2 constant poor fire-fighting *and* use an exponent of 1.0 for the wetted surface area. This will result in substantially higher absorption than typical calculations using the 0.82 exponent.

⋮

Partial confinement can also result in higher heat fluxes and enhanced exposure of the wetted surfaces to the pool fire. An example is where a vessel is partially confined by adjacent embankments or walls with a height comparable to the vessel's height. Full-scale tests have been performed with this type of configuration. The test data indicate that the heat input into the vessel was higher than predicted by Equation (8) on the sides of the vessel adjacent to the embankment. If a PRD is sized for the fire scenario involving vessels with this type of configuration, then a conservative approach would be to apply Equation (23). This approach is supported by the earlier API work described in Reference [80] and more recent fire test data (see C.6.5.1.2 and C.6.5.2).

$$Q = C_2 \times F \times A_{ws} \qquad (8)$$

⋮



Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4.4.14.3 Double-pipe Heat Exchangers ⋮ If the fluids or flow are such that the inner pipe wall is susceptible to significant thinning through corrosion or erosion, then internal pipe failure should be considered. Thinning is likely to be a localized phenomenon. Where no specific experience is available, one method would be to consider a nominal hole size [e.g. 6.4 mm (0.25 in.) in diameter]. ⋮	Additional sentence added that might encourage users to begin considering leakage scenarios in double-pipes, which are often ignored outright.

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4.4.14.4 Plate-and-frame, Spiral-plate, and Welded-block Heat Exchangers	Section completely overhauled to include additional heat exchanger types and internal failure scenario application criteria.
For the purpose of overpressure protection, plate-and-frame, spiral-plate, and welded-block heat exchangers are similar enough in construction that each features the same type of leakage failure modes from the high-pressure side to the low-pressure side. The most common cause for leaking is a hole or crack in a plate. Vibration damage is not likely. In the case of gasket leaks, plate-and-frame heat exchangers are more likely to leak at the external gaskets rather than internally between the high-pressure and low-pressure side. For spiral-plate heat exchangers, a gasket leak will short circuit the flow bypassing loops in the spiral so would not cause an overpressure. The welded-block heat exchanger does not have gaskets. ⋮ Rupture of an internal plate. Minor leakage can seldom overpressure a heat exchanger during operation. Loss of containment of the low-pressure side to atmosphere is unlikely to result from an internal plate rupture where the maximum possible pressure in the low-pressure side during the failure does not exceed the corrected hydrotest pressure (see 3.1.19 and 4.2.2). Pressure relief for an internal plate rupture is not required where the low-pressure heat exchanger side (including upstream and downstream systems) does not exceed this criterion. However, if the high-side maximum operating pressure can exceed the low-side maximum allowable accumulated pressure per the design code, the heat exchanger should be evaluated for a small internal leak on a plate.	

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
4.4.14.5 Sulfur Recovery Unit Thermal Reactor Waste Heat Steam Generators	Brand new section covering overpressure protection of the process (sulfur) side of waste heat steam generator in sulfur condensing service. If you work in a refinery with sulfur recovery units, please take a closer look at the complete text of this guidance.
4.4.14.5.1 General A special case of heat transfer equipment failure involves a tube failure in a sulfur recovery unit (SRU) waste heat steam generator (WHSG). SRU designs convert hydrogen sulfide to elemental sulfur operating near ambient pressure and at temperatures up to 1540 °C (2800 °F). The shell side of the WHSG generates steam to cool gases containing elemental sulfur. WHSG steam-side design pressures range from about 345 - 5170 kPag (50 - 750 psig). The tube side design pressures might range from 105 - 1035 kPag (15 - 150 psig). Tubes in WHSGs are typically large (e.g. DN50 - DN150, (2 - 6 in. in diameter). The process side of SRUs is designed with an open path to the atmosphere that can provide a relief path but some SRU designs contain switching valves that can block or restrict the open relief path to atmosphere. **4.4.14.5.2 Relief Protection Evaluation Procedure** PRDs in a process containing elemental sulfur can be unreliable due to solidification of sulfur, resulting in plugging of the relief path. Atmospheric relief from a sulfur pit vent is a concern due to molten sulfur, H_2S and SO_2 relief. Reported WHSG tube failures include full-bore tube ruptures, cracks, tubesheet joint leaks, and fish-mouth failures. The resultant open area can be conservatively assumed equivalent to that of a full-bore tube rupture. ⋮	

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Section & Abridged Text	Significance
4.4.14.2 Shell-and-tube Heat Exchangers	Separate, but similarly-themed sections emphasizing review of mechanical loads for piping systems subject to slug or high velocity flow.
4.4.14.2.4 Influence of Piping and Process Conditions ⋮ The effect of bends present in the low-pressure piping should be taken into account in the mechanical design of the system. For example, short radius bends can excessively increase pipe stresses when the low-pressure side is liquid-full in a tube rupture scenario, as the low-pressure piping can be subject to slug flow. See 5.5.11 for further guidance on mechanical design considerations for the low-pressure side piping.	
4.4.17 Piping Design Considerations	There is increased awareness and impetus of documenting mechanical forces on PRS piping.
Certain scenarios such as inadvertent valve opening (see 4.4.9.2) and vapor breakthrough (see 4.4.8.3 and 4.4.8.7) can result in slug flow and high flow velocities in the piping between the locations of vapor breakthrough or inadvertent valve opening and the inlet to the PRD. The resultant dynamic (transient) loads on the process and PRD inlet piping should be taken into account, including the mechanical design and pipe supports.	

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Section & Abridged Text	Significance
4.4.15.4.2 Cautions for Double Actuated Valves Double actuated valves use instrument air to drive the valve to its specified failure position. Typical designs have an instrument air pressure reservoir (air bottle) and utilize pilot valves to re-route the instrument air to drive the valve to its specified failure position. Double actuated valves can be less likely to move to the specified failure position than spring actuated valves during an instrument air failure (for example, a latent failure of the pilot valve could cause the double actuated valve to not move on loss of instrument air (see 4.2.4)). Consideration should be given to the effect on flare or vent system for the valve moving to a position other than its specified failure position.	New section for the not-often considered scenarios where double-actuated valves do not move to their failure position on loss of air. As a bit of practical advice, consider reviewing only the double-actuated valves whose incorrect failure position in an instrument air loss scenario could lead to substantial flare loading.

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

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Section & Abridged Text	Significance
5.7 Disposal to Flare	A significant portion of flare-related items were relocated from API 521 to API 537 during the last revision cycle. Both standards are required for flare design, but the general distinction is that API 521 is process design-centric and API 537 is mechanical design-centric.
5.7.1 General ⋮ Flare design requires both API 537 and API 521. Flare design aspects include, but are not limited to: a) combustibility of the fluid being flared (see F.1.1); b) thermal radiation (see 5.7.2 and F.2); c) flame stability (see API 537); d) flaring toxic gases (see 5.7.3); e) destruction efficiency (see API 537); f) combustion methods (see 5.7.4); g) smoking/smokeless performance (see API 537); h) cautions on freezing and icing in flares (see 5.7.5); i) flare noise (see API 537); j) flare tip pressure drop (see API 537); k) purging/air ingress/flashback prevention (see API 537 and 5.7.6); l) ignition system (see API 537); m) liquid seal drums (see 5.7.7); n) liquid removal (knockout drums) (see 5.7.8); o) siting and safe dispersion for loss of flame/safe dispersion of combustion products (see 5.7.9); p) flare gas recovery systems (see 5.7.10); q) mechanical design, operation, and maintenance of flare equipment (see API 537). API 537 also provides datasheets for exchanging both process and mechanical design information. An example for sizing the flare stack is given in C.2. This example applies the preliminary screening equations for thermal radiation given in F.2.	

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
5.7.2.3 Thermal Radiation Calculation Methods F.2 provides a method to calculate thermal radiation levels that can be used for preliminary screening. It is recommended that the manufacturer of the specific flare tip be consulted to determine/verify the thermal radiation levels. C.2 provides a flare stack sizing example using the F.2 method for thermal radiation.	Did you know that you can calculate stack size and flare tip radiation with a simple spreadsheet? Not many people do, which is why this new section was added. This section reminds users that thermal radiation and stack sizing can be calculated with existing guidance within the standard. The approaches may not apply to all situations, but it’s a great reminder for users that otherwise ignore the back half of API 521.

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Section & Abridged Text	Significance
5.7.5 Freezing and Icing in Flare Tips	This rewritten section points out the special hazards presented in cold climates based on lessons learned following a flare stack being blocked in by frozen water dripping from a steam assist ring. Mechanical aspects moved to API 537.
5.7.5.1 Steam-assist Flares in Cold Climates Design and operation of a steam injection system in cold climates where ice formation can occur needs to be performed with care as steam can condense and freeze within the flare stack. This has been experienced both with injection from an internal center steam nozzle and upper steam ring (see API 537). In low-temperature conditions. this may result in partial or full blockage of the flare stack or flare header. Consideration should be given to the following: a) supplying steam to an internal steam nozzle through a separately controlled steam line so that it can be turned off in cold conditions; b) ensuring minimum steam flow and/or superheating are high enough to avoid condensation in the flare tip upper steam ring (condensate can eject from the upper steam ring and fall into and freeze inside the flare stack and/or flare header, creating the risk of a restriction and/or an ice plug in freezing temperatures c) ensuring proper layout and insulation of piping and valves (having the pressure let down as close to the flare stack as possible will reduce heat loss and condensation); d) establishing inspection/maintenance routines to detect possible leakages in steam riser (as such leakage will lead to increased risk of condensation in upper steam ring; e) ensuring adequate condensate removal located near the steam riser. Improper sequencing of the steam on a multiple steam injection tip/burner can cause burnback in the flare tip (see API 537).	

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

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<table>
<tr><th>Section & Abridged Text</th><th>Significance</th></tr>
<tr><td>5.7.5.2 Low-pressure Forced-air Flares in Cold Process Service

The user is cautioned when flaring cryogenic or cold vapors (below 0 °C) that there is potential for condensation and freezing of moisture in the assist air leading to blockage of the flare gas flow paths. This has been experienced with tankage/loading flares in LNG service during continuous flaring.

Consideration should be given to the following:
- consulting the flare vendor to ensure the suitability of the design to avoid ice buildup (e.g. to avoid designs with narrow flow paths and cold bridges between flare gas and assist air passages);
- ensuring that all credible operating modes and durations are identified to the vendor and fully documented to specify the worst-case design basis.

Operating company design basis documentation should include clear statements of the intended operating envelope of the flare system, including flaring scenarios that have been either included or excluded from the flare's design basis.</td><td>This rewritten section points out the special hazards presented in humid climates where humid assist air can freeze during continuous flaring of cold/cryogenic vapors. Mechanical aspects moved to API 537.</td></tr>
</table>

Source: API Standard 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

API 521, Pressure-relieving and Depressuring Systems Seventh Edition, June 2020

Section & Abridged Text	Significance
Annex G (informative) Vapor Breakthrough into Liquid-containing Systems Failure of high-pressure vessel liquid bottoms level control and/or bypass valves discharging into a low-pressure system may result in a significant increase in the low-pressure system liquid level. Depending on the high-pressure and low-pressure system volumes, Liquid inventories and liquid properties, the low-pressure downstream system may overfill with liquid. Of special concern, in certain cases this scenario may be followed by loss of liquid Level in the highpressure system that can result in vapor breakthrough across the level control and/or bypass valves to the low-pressure systems (the scenario described in 4.4.8.3). As the vapor passes through the level control valve, the vapor will expand and push (displace) the liquid in the downstream system until a relief path is established. This transient scenario is commonly described as liquid displacement. During the scenario, the liquid level in the low-pressure vessel can rise creating the potential for liquid or two-phase relief. This can result in increased low-pressure system relief requirements relative to a vapor breakthrough with only vapor relief. The consequences of liquid displacement are sensitive to the size of the low-pressure system and liquid inventories in the high and low-pressure systems prior to the start of the scenario. Hence, a review should be undertaken to identify the worst-case conditions (e.g. combined liquid inventories and system pressures) for the liquid displacement assessment considering all equipment operations/status. ⋮	New informative annex with step-by-step guidance on the vapor breakthrough (gas blow-by) scenario. Previously, the “appropriate” approach to vapor breakthrough analysis depended on who you asked, but this informative annex provides a firm consensus.

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Section & Abridged Text	Significance
Annex H (informative) Flow-induced Vibration	New informative annex that provides awareness of flow-induced vibration (FIV). The Energy Institute document *Guidelines for the avoidance of vibration induced fatigue in process pipework* is still the go-to for additional information and screening.
Pressure-relieving systems are usually designed with relatively high fluid velocities. The resultant turbulence energies increase after tees, reducers, bends, valves, etc. due to vortex formations with pressure fluctuations. These pressure fluctuations increase with higher fluid velocities, and their frequency spectra have broadband characteristics with peaks in the lower frequency region. These pressure fluctuations may induce piping vibrations at relatively low frequencies if the piping system has insufficient stiffness. This phenomenon is called flow-induced vibration. This vibration may result in fatigue failure of the piping system. The turbulence energy becomes enlarged particularly just after the expansion at laterals or reducers (enlargements). NOTE Piping codes (e.g. ASME B31.3 [18]) require that piping be designed, arranged, and supported to mitigate the effects of vibration from sources. A screening method of flow-induced vibration is included in an Energy Institute document. Experimental studies on flow-induced vibration for tee junctions are available in References [115], [129], and [130]. Common examples of the mitigation options to prevent piping fatigue failure due to flow-induced vibration include, but are not limited to, the following: a) reducing the velocity by enlarging the pipe diameter; b) adding piping supports; c) increasing wall thickness.	

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Conclusion

Conclusion

- ioMosaic works at the forefront of the art and science of pressure relieving systems. We actively participate and contribute to our industrial consensus standards, improving the practice of RAGAGEP for our customers. Process Safety Office is the tool of choice to handle the complex phenomena that the consensus standards have only started to shed light on.
- It is the author’s opinion that API 520 part II (installation) the greatest opportunities for revision in the next 5 – 10 years.
  - Imagine a world where industry casts away the “3% rule” in favor of a simple stability analysis.

About ioMosaic Corporation

Through innovation and dedication to continual improvement, ioMosaic has become a leading provider of integrated process safety and risk management solutions. ioMosaic has expertise in a wide variety of areas, including pressure relief systems design, process safety management, expert litigation support, laboratory services, training, and software development.

ioMosaic offers integrated process safety and risk management services to help you manage and reduce episodic risk. Because when safety, efficiency, and compliance are improved, you can sleep better at night. Our extensive expertise allows us the flexibility, resources, and capabilities to determine what you need to reduce and manage episodic risk, maintain compliance, and prevent injuries and catastrophic incidents.

Our mission is to help you protect your people, plant, stakeholder value, and our planet.

For more information on ioMosaic, please visit: **www.ioMosaic.com**