Changes Between API STD 521 6th Ed and 5th Ed Cataloged

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Abstract

API STD 521, Pressure-relieving and Depressuring Systems, is perhaps the most thorough published guideline on how to size relief devices and flare systems. This paper reviews the differences between the 6th Edition of API STD 521 (Published in 2014) and the 5th edition (Published in 2007). The authors will review changes and highlight several new requirements that are deemed critical to relief systems design. The paper is based on a comprehensive review of the two editions and is a valuable resource for any engineer or process designer who needs to be knowledgeable of the latest relief systems recommendations.

1. Background

This paper provides the reader with a summarized listing of the changes between the current (6th edition) and past (5th edition) of *API Standard 521, Petroleum and natural gas industries—Pressure-relieving and depressuring systems* (hereafter referred to as "521") [1, 2]. This API document provides guidance for determining overpressure scenarios, determining the required relief rate for sizing a relief device, and criteria and considerations for sizing a disposal system.

As Table 1 shows, a considerable amount of guidance has been added to the 6th edition of 521.

Table 1. Summary of Guidance in the 6th/5th Editions of API STD 521

Items	5th Edition (2007)	6th Edition (2014)
"Should" Appears	515	611
"Shall" Appears	137	154
Pages	196	248
ISO Co-branded	Yes	No

The 5th edition was co-branded as an International Organization for Standards (ISO 23251) and American Nation Standards Institute (ANSI) standard. The current (as of the time of writing) 6th Edition is neither an ISO nor ANSI standard.

In addition, a special note was added to ensure that the users knew relief systems design and engineering problems are installation specific, and need to be designed/engineered by a competent person knowledgeable in the art of pressure relief system design.

1.1 Terms and usage

The following familiarizes the reader of this paper with acronyms and terms that may be encountered.

1.1.1 SCPRS

The API Committee on Refinery Equipment (CRE) subcommittee that is responsible for 521 is the Subcommittee on Pressure-Relieving Systems (SCPRS).

1.1.2 Section References

Section numbers that are prefaced by "§" reference the API standard and not this paper. Unless otherwise mentioned, the section numbers referred to are for the 6th ed. of 521.

2. Summary of changes

The changes are broken down into the following categories. The remainder of this paper will follow the order shown in the following table.

Table 2. Organization of the Summary of the Changes.

Paper Section	Topic	Items
2.1	Moved Material	104
2.1	Clarified	12
2.2	New Definitions	14
2.3	Deleted	9
2.4	Equation Modifications	2
2.5	New Sections	24
2.6	Additional Requirements or Guidance	29
	Total	*194*

2.1 Moved Material / Clarified

The SCPRS spent a lot of time trying to organize and clarify this standard. This work was performed to ensure a more useful resource for the end users. As a result a majority of the changes are text moving from one section to another. These changes are numerous, pervasive and do not change the guidance. Therefore, they are not further elaborated in this paper.

2.2 New Definitions

The 6th edition of API STD 521 has had additional definitions added into §3.1 Terms and Definitions. The following terms have been defined.

§3.1.5	availability	§3.1.49	molecular mass
§3.1.8	blowdown drum	§3.1.51	open fire
§3.1.16	choke valve	§3.1.58	pressure-relief device
§3.1.19	combustion efficiency	§3.1.60	pressure system
§3.1.20	confined fire	§3.1.69	required relief rate
§3.1.36	fuel-controlled fire	§3.1.70	risk
§3.1.44	lift-off (Substituted for blow-off)	§3.1.85	ventilation-controlled fire

A few of the definitions have been further discussed in this paper. The reader of this article is encouraged to further read the standard to get the official definition which is not included herein.

2.2.1 Confined Fire / Open Fire

The SCPRS introduced a new definition, concept, and requirements. These specify that if a fire is confined, the heat flux requirements are higher than an open pool fire (see §4.4.13.3). The open pool fire is the historical fire method in 521.

2.2.2 Risk

In the 5th edition, risk was addressed throughout the document and specifically in Annex E. The 6th edition provides the first definition for use in 521 and related relief device decisions.

2.3 Deleted

The following items were addressed in the 5th edition of 521, but have not been included in the 6th edition. The section numbers refer to the 5th edition.

§3.7	blowdown (Definition)	§3.46	marked burst pressure (Definition)
§3.9	breaking-pin device (Definition)	§3.53	pin device (Definition)
§3.17	closed disposal system (Definition)	§3.71	shear pin device (Definition)
§3.37	huddling chamber (Definition)	§7.3.1.2	design of relief device inlet piping

The SCPRS deleted the design of relief systems inlet piping from API 521 as it is covered in API STD 520 Part II.

2.4 Equation Modifications

The following equations were modified between the 5th and 6th editions.

2.4.1 Estimation of Purge Gas Requirements (Eq. 46/47 6th Ed.)

The Ci term is for the volume fraction of a component in the purge gas and has been changed from a percentage to a fraction. This is for Equations 46/47 in §5.7.6.2 in the 6th edition (Equations 59/60 in §7.3.3.3.3 in the 5th edition).

2.4.2 Equation determining the droplet Velocity in a Flare Knockout Drum (Eq. 55-57, 6th Ed.)

In the 6th edition, the density of the vapor term has been added to the equation determining the droplet velocity in a flare knockout drum. This applies to Equations 55 - 57 in §5.7.9.5 in the 6th edition (Equations 37 - 39 in §7.3.2.1.2 in the 5th edition). Note that these this change was included in the 5th edition with the May 2008 Addendum.

2.5 New Sections

The following sections were added or significantly modified between the 5th and 6th editions.

2.5.1 Additional Considerations Involving Pumps (§4.4.2.2)

The 6th edition provides new guidance on overpressure protection for pumps. In general, centrifugal pumps don't require overpressure protection.

2.5.2 Additional Considerations Involving Reciprocating Compressors (§4.4.2.3)

The 6th edition provides new guidance on overpressure protection for reciprocating compressors.

2.5.3 Choke Valve Failure (§4.4.8.6)

The 6th edition provides new guidance on overpressure protection specifically related to choke valves failing.

2.5.4 Estimating the Required Relief Rate from Check Valve Failure (§4.4.9.3.3)

The 6th edition provides new guidance on estimating the required relief rate from a failed check valve. One method is based on the size of the valve and the other is based on the normal forward flow.

2.5.5 Reciprocating Compressor Rod Packing Failure (§4.4.9.4)

The 6th edition provides new guidance on overpressure protection for reciprocating compressors specifically related to the failure of rod packing and how to estimate the required relief rate.

2.5.6 Alternative Method to Estimate Overpressure from External Fire (§4.4.13.2.4.4)

The 6th edition provides new guidance on overpressure protection from fire in the event that a fluid phase change does not occur.

2.5.7 Confined Pool Fires (§4.4.13.3)

The 6th edition provides new guidance on estimating the required relief rate from a fire inside a building or in a confined area. *The methods in the previous (5th and older) editions of 521 predict a lower relief rate for these cases.*

2.5.8 Additional Considerations for Plate and Frame Exchanger (§4.4.14.4)

The 6th edition provides new guidance on overpressure protection for plate and frame exchangers. In general, full plate failure is not considered likely but a failure from a hole caused by corrosion should be considered.

2.5.9 Overpressure Prevention during Maintenance (§4.4.16)

The 6th edition includes a new section providing guidance for considering overpressure protection during maintenance activities.

2.5.10 Initiation of Depressuring (§4.6.2)

The 6th edition provides a new section with descriptive information and considerations for initiating an emergency depressuring system including a fire and gas detection system.

2.5.11 Depressuring Low Temperature Considerations (§4.6.3)

The 6th edition provides a new section with descriptive information on the potential for auto-refrigeration from depressuring some process systems.

2.5.12 Flare and Outlet Piping Acoustic Fatigue (§5.5.12)

The 6th edition provides a new requirement with the addition of substantive new guidance and requirements on evaluating acoustic fatigue in flare headers primarily based on the work of Carucci and Mueller [3, 4]. *This section adds an additional requirement for flare systems design based on past incidents.*

2.5.13 Flame Stability (§5.7.2.4)

The 6th edition provides a new section with descriptive information on flare flame stability and common language to describe flame instability.

2.5.14 Noise from Smokeless Flaring (§5.7.3.2.11)

The 6th edition provides a new section with descriptive information on the issues associated with noise caused when adding assist fluid to attempt smokeless flaring.

2.5.15 Pilot Ignition Systems and monitoring (§5.7.7.3 and §5.7.7.4)

The 6th edition provides new sections with descriptive information on pilot ignition systems and methods for monitoring pilots. These sections refer the users to API STD 537 for additional guidance. [5]

2.5.16 Flare Knockout Drum (§5.7.9.1)

The 6th edition provides a new section with descriptive information in regards to the location of a flare knockout drum.

2.5.17 Risk of Overfilling Flare Knockout Drum (§5.7.9.6)

The 6th edition provides new requirements that ***shall*** be considered (i.e. are required) in reference to flare knockout drums being overfilled (or those that have the potential to be overfilled).

2.5.18 Production Facility Flare Knockout Drums (§5.7.9.8)

The 6th edition provides a new section giving guidance for knock out drum sizing due to the special nature of production facilities.

2.5.19 Siting Considerations for Flares (§5.7.10)

The 6th edition provides a new section with guidance associated with facility siting concerns for flares (topography and dispersion).

2.5.20 Alternative Analytical Method (Fire, Annex A.3)

The 6th edition provides a new section that provides an alternative means to estimate the heat loads from an external fire. The analytical method can apply to situations where the guidance in the main body may not be applicable (e.g. vapor/jet fires).

2.6 Additional Requirements or Guidance

The following existing sections were modified in ways that, in the opinion of the Authors, provide additional requirements or guidance. If the reader of this paper designs or audits relief systems, then he or she is encouraged to purchase a copy of the 6th edition of API STD 521 to ensure designs are per the most recent guidance. The information contained herein is insufficient for design.

2.6.1 Operator Error/ Response Criteria (§4.2.5)

The Operator Error and Effect of Operator Response sections (§4.2.3 and §5.4) in the 5th edition combined to create §4.2.5 with additional recommendations for operator response in overpressure protection. Identifies criteria for deciding to consider operator intervention for relief systems design.

2.6.2 Inadvertent Valve Opening (§4.4.9.2)

The 5th edition sections on Inadvertent Valve Opening and Opening Manual Valves (§4.3.3 and §5.17) were combined and new guidance on relief rate determination provided. Clarification that opening of multiple valves may be credible under certain circumstances was added.

2.6.3 Check Valve Leakage or Failure (§4.4.9.3)

The 6th edition moved this section and provides new guidance on determining the required relief rate. The wording is less strong (as compared to the 5th Edition) and additional guidance on inspection and testing of check valves is provided.

2.6.6 Relief Systems Documentation Requirements (§4.7)

In the 6th edition, the Relief System Design Documentation section was overhauled. The language from the 5th edition was softened to ensure the guidance was not confused as a requirement. Additional suggestions on nature, type, and goal of relief system design documentation were included.

2.6.7 Level Instrumentation (§4.4.7.3)

The section providing guidance on level instrumentation was moved and four additional criteria for consideration of level valve independence were added.

2.6.8 Depressuring Systems Design Criteria (§4.6.5)

The 6th edition provides a new requirement that the discharge location of a depressuring system ***shall*** be a safe location.

2.6.9 Liquid Overfilling (§4.4.7)

The 6th edition provides more concrete language around evaluating the design of systems for overpressure protection from liquid overfilling.

2.6.11 Header Segregation (§5.4.4)

The 6th edition consolidated the guidance related to header segregation and added a list of criteria to consider when designing a flare system with for multiple relief devices, all of which are recommendations (should).

2.6.12 Pipe Anchors, Guides, and Supports (§5.5.16)

The 6th edition updates and consolidates information on *Pipe Anchors, Guides, and Supports* into a section of the same name providing additional guidelines to design effective pipe anchors and supports.

2.6.13 Flaring Guidance on Smokeless Requirements (§5.7.3.1)

The 6th edition provides additional guidance as to when the user is to and how the user should specify the smokeless requirements for a flare.

2.6.14 Flares with Smoke Suppression (§5.7.3.2)

The 6th edition provides additional guidance on how flares achieve smokeless operation and/or suppress the generation of smoke.

2.6.15 Ground Flares (§5.7.4.1)

Additional guidance provided on the design, specification, and operation of ground flares including a reference to API STD 537 for more detailed description.

2.6.16 Steam Injection for Smokeless Operation (§5.7.3.2.2)

The notes for Table 14 (Table 11 in 5th edition) are updated to ensure that the user is properly specifying and designing the steam injection for smokeless flare operation.

2.6.17 General Purge Requirements (§5.7.6)

The section is updated and organized to include all design aspects of purging a disposal system to reduce the possibility of flashback.

2.6.18 Seal Drum Design (§5.7.8.7)

The 6th edition provides new equation / criteria to determine the minimum required diameter for a vertical seal drum and minimum free liquid surface area of a horizontal seal drum (Equations 50 and 51).

2.6.19 Flare Knockout Drum (§5.7.9.2)

The 6th edition provides new guidance "In general, vapor outlet nozzles should ***not*** be fitted with any devices (e.g. deflection plates)." which is ***opposite*** of previous guidance. This is due to an incident where a flare drum internal blocked the flare system of a platform on the Visund field. For more information on this incident see the PSA investigation online [6].

2.6.20 Flare Liquid Separation Droplet Size (§5.7.9.4)

The 6th edition provides additional guidance for different types of flares that can handle different liquid loading and droplet sizes.

2.6.20 Vent Stacks (§5.8.8)

The 6th edition provides additional guidance given for vent tips in applications where existing space and other restrictions have to be considered.

2.6.21 Sizing of Vent Stacks (§5.8.10.3.1)

The 6th edition provides updates to the calculation of noise level for vent stacks. If the reader is designing a vent stack they should be warned that the Vent Stacks section (§5.8.10) contains ***shall*** 8 different times.

2.6.23 Sample Calculations (Annex C)

The 6th edition provides all the sample calculations in a single location, Annex C.

2.6.24 High-integrity Protection Systems (Annex E)

The 6th edition changes the ASME Boiler and Pressure Vessel Code exception that allows instrumentation in lieu of relief devices from Code Case 2211-1 to UG-140. This was adopted in the 2008 addendum to the 2007 publication of ASME B&PVC Section VIII Division I. [7] The author has previously written more information on the specific requirements to use instrumentation / system design instead of relief devices in accordance with UG-140. [8]

3. Conclusion

The 6th Edition of API STD 521 has been reformatted and updated. This document has changed extensively from the previous addition. The following lists the largest changes (in the view of the authors) for this document:

- Guidance on Flare Knockout Drum internals is ***opposite*** of previous editions of this standard.
- New requirements for acoustically induced vibrations are included.
- Confined external fires are defined and guidance is provided.

4. References

[1] API Standard 521, FIFTH ED., JANUARY 2007 (w/ ERRATA JUNE 2007) ADDENDUM, MAY 2008 ISO 23251 (Identical), Petroleum and natural gas industries—Pressure-relieving and depressuring systems

[2] API Standard 521, SIXTH ED., JANUARY 2014, Petroleum and natural gas industries—Pressure-relieving and depressuring systems

[3] V. A. Carucci and R. T. Mueller, "Acoustically Induced Piping Vibration in High Capacity Pressure Reducing Systems," ASME 82-WA/PVP-8; 1982.

[4] J. Cowling, "Design Strategies for Acoustically Induced Vibration in Process Piping," INTER-NOISE 2012 Proceedings, August 9–22, 2012, New York, available from Institute of Noise Control Engineering of the USA (INCE/USA)

[5] API Standard 537, Flare Details for General Refinery and Petrochemical Service

[6] "PSA completes investigation of Visund incident," June 2006, http://www.psa.no/news/psa-completes-investigation-of-visund-incident-article2733-878.html (accessed March. 15, 2015)

[7] American Society of Mechanical Engineers. 2007 ASME Boiler & Pressure Vessel Code: Section VIII,Division I. with 2008 Addendum

[8] Smith, D. J. (2014), Safety instrumented systems in lieu of pressure relief valves. Proc. Safety Prog., 33: 345–349. doi: 10.1002/prs.11681