Crossover Applications for the ASME-BPE Standard

Without harmonization between the various [*American National Standards*] Developers the usefulness of industry Standards would most likely be diminished by conflicting requirements and overlapping stipulations.

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Chemical Processing Industry (CPI) is a broad term generally considered to categorize such industries as chemical, petrochemical, and petroleum refining. It can also be argued that since extensive chemical processing is required in the pharmaceutical and biofuel industries they too fall into the category of a CPI as well. It essentially denotes those industries that use raw and intermediate chemicals in a process to create a finished or intermediate product.

In fact Chemical Engineering is much more definitive in its definition of what constitutes a CPI. It includes: "*...petrochemicals; drugs and cosmetics; explosives and ammunition; fats and oils; fertilizers and agricultural chemicals; foods and beverages; leather tanning and finishing; lime and cement; synthetic fibers; metallurgical and metal products; paints and coatings; petroleum refining and coal products; plastics; rubber; soap and detergents; stone, clay, glass and ceramics; wood, pulp, paper and board; other chemically processed products*."

The initial clarification above is made in an attempt at re-directing the popular notion that the term CPI is narrowly focused on chemical, petrochemical, and petroleum refining facilities alone, the big three as it were. Even though an end product ostensibly defines or characterizes the singular type of industry that produces it, much of the equipment, instrumentation, pipe, tubing, design elements, and industry Standards used to design and construct a facility to manufacture such a product are typically utilized throughout multiple industries; multiple industries that include the big three as well as other industries also characterized as CPI's. Meaning that an industry Standard created for one industry, such as the pharmaceutical industry, will have content that is meaningful and relative to other CPI's such as the biofuel and chemical industries.

Across the wide spectrum of the more than 200 American National Standard (ANS) Developers, those organizations accredited by ANSI (American National Standards Institute) to develop industry Standards, and the more than 10,000 American National Standards that are published by the ANS developers, there is an ongoing effort to ensure harmonization among those Standards.

As a result of this harmonization effort the engineer of a CPI facility can readily make use of multiple Industry Standards on a single project without concern of conflicting statements between those Standards. That is not to say that a more stringent requirement will not exist in one Standard over another. This is normally rectified by including, in proprietary specifications and guidelines, a statement to the effect that, "the more stringent requirement shall govern".

In adopting these industry Standards an engineer is drawing upon the consensus of committees of experts

in which the results of pertinent subject matter have been assessed, analyzed, debated, and voted on at multiple levels, culminating in accredited standardization. Not only is the content of these industry Standards arrived at through a rigid internal process, but also through inter-Standard communication.

What this means for the end user is this: Unless a project is regulated by a specific Code that has been adopted as a Federal, State, or municipal regulation, you may specify, through contract stipulation or project specifications, the requirement to comply with a particular set of Codes and Standards. These requirements may specify ASME B31.3 – Process Piping as the main compliance piping Code for a project, with or without exceptions. Additionally, the project requirements will dictate the need to reference Codes and Standards beyond those requirements captured in B31.3.

Such requirements will include Standards for components and material of construction (MOC), as well as specialized needs such as those carried in the ASME – BPE (Bioprocessing Equipment) Standard or requirements for boiler external piping, which is not covered by B31.3, but is instead covered by B31.1 – Power Piping. In the case of the component related Standards, these are generally adopted as a whole with optional requirements within the particular Standard that need to be specified in the procurement documentation. The same thing holds true with material Standards such as ASTM A53, A106, A312, etc. These Standards too are adopted as a whole with optional requirements within the Standard that need to be specified in the procurement documentation.

When using a piping Code such as B31.3 as a base Code for a project other piping Codes and Standards can be referenced for compliance when the following occurs:

1. The referenced requirement is not already contained in the base Code,
2. The referenced requirement is more stringent than that contained in the base Code,
3. The referenced requirement does not conflict with a "not permitted" statement in the base Code. Such as:
   a. B31.3 Para. 306.4.4*(c) A flared lap is **not permitted** under severe cyclic conditions.*

This discussion thus far leads me to make the point that even though a project has adopted a base piping Code, either by the authority of government regulation or by engineering decision, it is beneficial and even necessary for the engineer to look to other Standards in defining additional requirements a project will need beyond those covered in the base Code. Rather than a company spending time and money defining needed requirements not covered by B31.3 or B31.1, look to other Standards in which vetted requirements matching a project's needs may already exist; Case in point, the BPE Standard.

What a project's Codes & Standards requirements may look like graphically is represented in the rather simplistic Venn diagram of Fig. 1. What this shows is a basic representation of the necessary piping Codes and Standards needed for a CPI type project and how they overlap and comingle within the framework of a project, or within the infrastructure of plant operations and maintenance. In actuality this graphic would be a great deal more complex due to the sheer volume of Codes and Standards a project or plant operations would require.

The ASME-BPE Standard

The conceptual intent, the basis for what drove a group of engineers in the late 1980's to petition the ASME Council on Codes and Standards for the approval to create what is now titled the ASME-Bioprocessing Equipment (BPE) Standard, was the real need and necessity to inject some sense of continuity and standardization into an industry that sorely needed it — the pharmaceutical industry. However, while the initial impetus for the creation of the BPE Standard was, and still remains, a need in the pharmaceutical industry its content is more universal and can be utilized in other CPI's aside from that of the pharmaceutical industry itself.

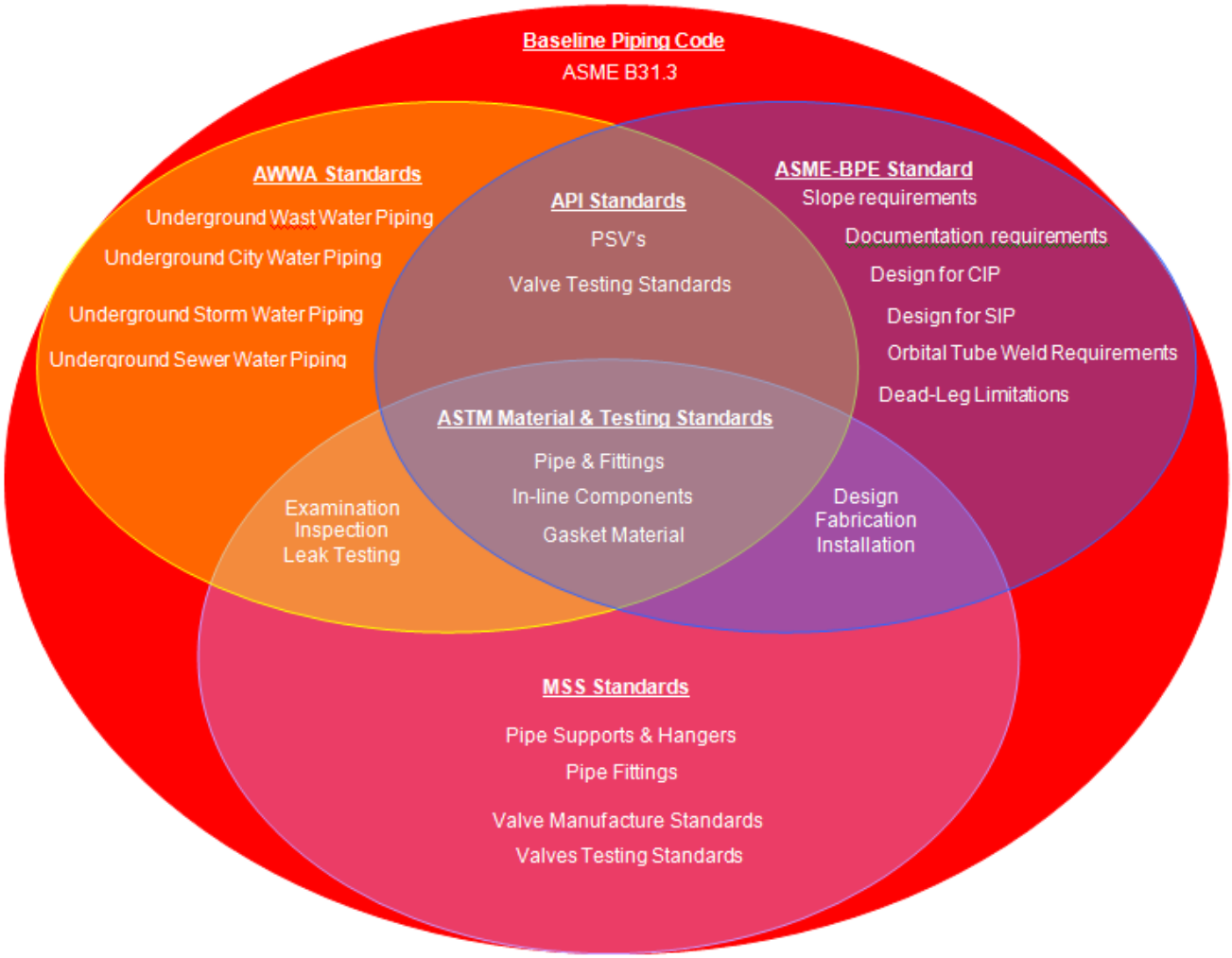


Figure 1 – Venn Diagram of C&S Requirements

The BPE Standard, first issued in 1997, dovetails nicely with the ASME B31.3 Process Piping Code, the essential piping Code for the CPI. The initial BPE Standard consisted of six Parts, which included:

Part GR	–	General Requirements
Part SD	–	Design for Sterility and Cleanability
Part DT	–	Dimensions and Tolerances for Stainless Steel Automatic Welding and Hygienic Clamp Tube Fittings
Part MJ	–	Material Joining
Part SF	–	Stainless Steel and Higher Alloy Surface Finishes
Part SG	–	Equipment Seals

The latest version of the BPE Standard, which at this writing is the 2009 issue, looks much different than its inaugural predecessor with content that is much more encompassing and broad-ranging with three additional subject matter sections referred to as Parts:

Part PM	–	Polymer-Based Material (Added in 2002 issue)
Part MMOC	–	Metallic Materials of Construction (Added in2009 issue)
Part CR	–	Certification (Added in 2009 issue)

In the next issue of the BPE, which is scheduled for 2012, there will be an additional Part added for Process Instrumentation, Part PI. This new Part will cover requirements for design, installation, and application of Process Instrumentation. Referring to process in this context also includes utility fluids such as purified water, water for injection (WFI), clean steam and other utilities which come in contact either directly with the product or indirectly through contact

with the product contact surface during cleaning or sanitization.

At the core of the BPE Standard is the need to install piping systems and equipment that will become and will remain hygienically clean by making them drainable and cleanable, to a microscopic level. Residual hold-up of product, a system that cannot be properly cleaned or sterilized in place, or a system that facilitates the onset and growth of bioburden (a colony of microorganisms) cannot be tolerated in pharmaceutical piping systems. The same can be said for various segments of cellulosic biofuel processing and other CPI type facilities, but for altogether different reasons.

As an example, the initial stages of fermentation in a cellulosic bioethanol process, uses a hybrid fungal enzyme to break down and convert the much tougher cellulosic base, as compared to breaking down a much simpler starch from corn kernels. These hybrid enzymes are generally a suite of enzymes called cellulases that work in concert with one another as catalysts for the fermentation process in the manufacture of sugars from the cellulose.

In the fermentation process, that of converting cellulose to sugar, there is a resident hold time for the manufactured sugar. This is prior to yeast being added to the sugar in the next step of the process, which then starts the conversion of sugar to ethanol. During its resident hold time the sugar is susceptible to bacteria that thrive in that same environment. If the bacteria are permitted to go unchecked it will infect the sugar causing a yield loss thereby creating a major negative impact on production.

In order to keep the detrimental bacteria in check and allow the process to remain stable and viable it is imperative that a segment of the piping system be sterilized in place (SIP) at frequent time intervals. Comparatively there is a need in the ethanol manufacturing process to clean in place (CIP) the fermenters, the beer well, the filtrate tanks, propagators as well as other segments of the process. The CIP step in the process is an efficient means of controlling residue buildup on equipment and piping.

The CIP process itself is a procedure by which a cleaning solution is pumped through a piping system at scheduled intervals to kill and clean out all accumulated bacteria and process residue. The SIP process performs essentially the same procedure using steam with the intent to sterilize the system.

In designing a process system that requires CIP or SIP there are specific piping and equipment design requirements that need to be met. Requirements such as minimum slope, maximum acceptable dead-leg, internal weld finish, fitting and fabrication tolerances, surface finishes, etc. are all necessary to accommodate those procedures. By not understanding the need for these requirements and therefore not integrating them into the design of a system that requires CIP or SIP the goal of cleaning or sterilization will not be met. All of those requirements necessary for this type of design can be found in the BPE Standard.

A process system that may not be concerned with bacteria, but may have a need for sloped piping and a requirement for maximum acceptable dead-legs to minimize the opportunity for entrained particulates to settle out and create blockage problems can also utilize the BPE Standard. There are fabrication requirements and fitting standards within BPE that address these issues as well.

Establishing control of material, fabrication, examination, and testing on a project requires documentation. A CPI project, one that is outside the boundaries of what could be characterized as a bioprocessing type facility, will not necessarily require a documentation trail to the extent necessary for a pharmaceutical type project. They may, nonetheless, require a portion of that documentation for safety and conformity requirements, documentation which can be selected from the BPE Standard.

The laundry list of documentation specified in the BPE Standard is one that can be selectively utilized by other industries simply by reference. And this is where the real benefit of industry Standardization becomes apparent. Rather than writing out a requirement that

may already exist in an industry Standard simply reference the respective paragraph in a Standard containing the needed requirement.

Content of the BPE Standard

As alluded to earlier, the BPE Standard, while it dovetails with and references to many aspects of B31.3, it is markedly different in both layout and content. You will see, as we touch on a few key elements of the nine current Parts of the BPE Standard, how universal the Standard actually is.

PART GR

The General Requirements section of the Standard sets the tone and defines the scope of the Standard. This section provides definitions for terminology that may be specific to the bioprocessing industry, or it could be a term used elsewhere, but with different implications in the BPE Standard. Terminology defined elsewhere and adopted by the BPE Standard under that definition, will have the definition referenced rather than re-written or paraphrased in the BPE Standard.

PART SD

The section on Design for Sterility and Cleanability is one aspect of the BPE which departs from the main focus of the B31.3 format. Whereas, B31.3 is developed around the cornerstone of safety and system integrity, it is necessary for the BPE to broaden its content to also include acceptable criteria for system design as well as safety and system integrity.

In doing so, the SD subcommittee, since its inception, has taken on the task of researching industry design practices currently being used in the bioprocessing industry. This is an effort to validate and, where necessary, rectify those largely unqualified design practices and criteria, while at the same time developing new and appropriate design criteria for adoption into the BPE Standard.

Some of the topics covered by PART SD are clear concepts on how to design cleanability and Sterility into a system. It also covers specific design issues with regard to instrumentation, hose assemblies, filtration and other equipment. In addition to hydrostatic testing it also touches on testing fundamentals for spray balls, drainability, cleanability, and sterility. There is also a listing of documentation that can be selected by and used for industries beyond that of bioprocessing.

PART DT

The Dimensions and Tolerances section has basically standardized the bioprocessing industry. Prior to the BPE and PART DT there were no Standard dimensions on fittings and valves. Nor were there a common set of manufacturing tolerances. This meant that components from one manufacturer to the next were not necessarily interchangeable. This presented a logistical nightmare for a project in which all fittings had to be purchased from the same manufacture to ensure compatibility and fit-up.

PART MJ

The Material Joining section touches on all aspects of the welding of pressure vessels, tanks, tube, and fittings. It takes the reader from acceptable material requirements through inspection, examination, and testing requirements. In between it discusses such topics as joining processes and procedures, weld joint design and preparation, weld acceptance criteria, procedure and performance qualification, and documentation requirements. Included are Tables listing weld acceptance criteria and detail graphics on acceptable/unacceptable welds.

PART SF

A crucial element in the ability to attain and maintain a clean system is in the quality of the product contact Surface Finish. Whether in the bioprocessing industry or other industries in which at least a segment of the processing scheme is biological, such as the biofuel industry, the cleanability of the product contact surface is crucial to the efficiency and effectiveness of the process itself. Not only has PART SF brought to the CPI methods by which surface finishes are classified, it also provides acceptance criteria that can be specified for compliance.

PART SG

PART SG covers Equipment Seals, and in so doing has provided a classification describing the required integrity of a seal under specific service conditions.

PART PM

Added to the Standard in 2002, this section on Polymer-Based Material includes both thermoplastics and thermosetting materials. It touches on design considerations, joining methods, interior product contact surfaces, and materials of construction.

PART MMOC

The section on Metallic Materials of Construction was first published in the 2009 issue of the BPE Standard. Its incorporation into the Standard was driven by the need to keep abreast of industry's continuing search for alternative materials of construction (MOC), beyond that of 316L stainless steel. The main objective of Part MMOC is to improve system quality and sustainability as well as improve compatibility for fluids too aggressive for 316L.

Adding PART MMOC allowed the Standard to elaborate and expand its information on metallic material in a way that would otherwise have been too segmented and convoluted. As it turns out, this section on metallic materials provides, not only a definitive listing of acceptable material in its various forms, but also provides such information as PREn (Pitting Resistance Equivalent Number) Rankings, Corrosion Test references for Alloys, discussion points on Superaustenitics, duplex stainless steels, nickel alloys, ferrite content restrictions, and much more.

PART CR

This Part on Certification was first included in the 2009 issue as a means of providing a program that would assure end users that tubing and fittings they purchase are compliant with the BPE. This is accomplished through a well defined and implemented certification program for compliance of the BPE Standard by those manufactures, fabricators, and service providers who qualify. The certification process is a multi-faceted program based on an in-depth Quality Management System (QMS) that is defined in PART CR.

The program requires that the applicant for certification create a QMS manual, as defined in the BPE Standard, which is expected to mirror the quality program actually being used in their production process. Among many other requirements, the manual should reflect a company's organizational hierarchy, inspection protocol, material handling procedures (from receiving through manufacturing and shipping), segregation of materials, inspection personnel qualification, reject resolution, documentation, and much more.

FIGURES, TABLES AND NON-MANDATORY APPENDIXES

The BPE Standard is loaded with over 60 Figures, over 60 Tables, and 9 Non-Mandatory Appendixes, all in an effort to make very clear what it is the user needs to comply with. The Figures graphically represent everything from fitting dimensions to mechanical seals. It also includes acceptable nozzle projections, side and bottom nozzle pads (Ref Fig. 2), vessel sight glass mounting design (Ref. Fig. 3), double mechanical cartridge seal design (Ref. Fig. 4), single dry running contact seal (Ref. Fig. 5), weld profiles, design diagrams, and much more.

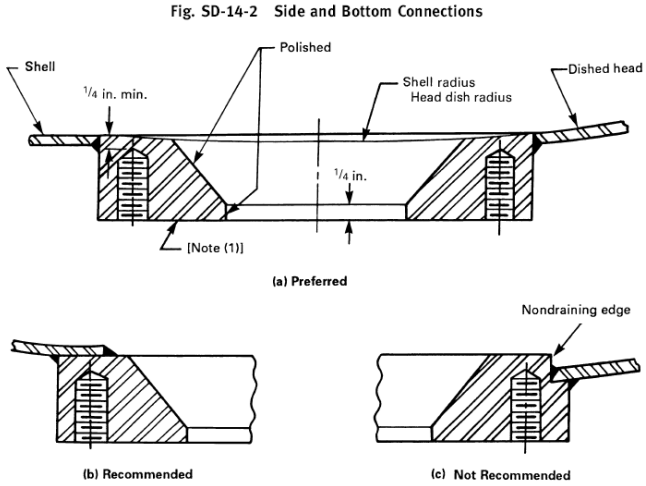


Figure 2 – Side and Bottom Nozzle Pads

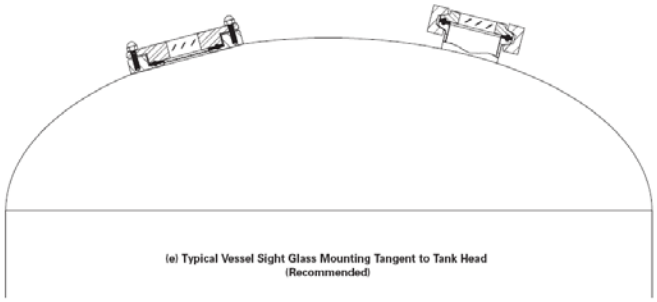


Figure 3 – Sight Glass Mounting

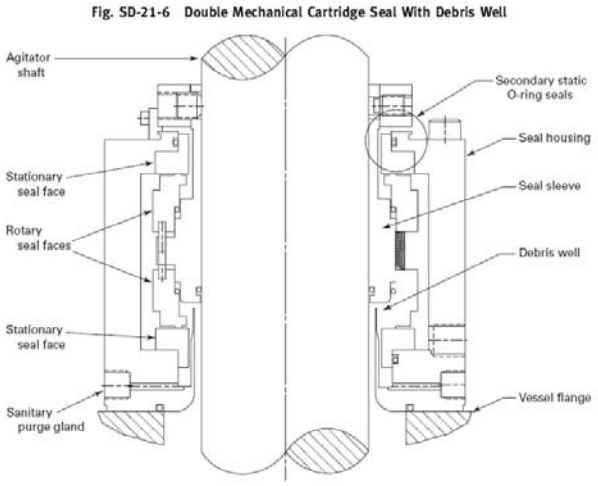


Figure 4 – Double Mechanical Cartridge Seal

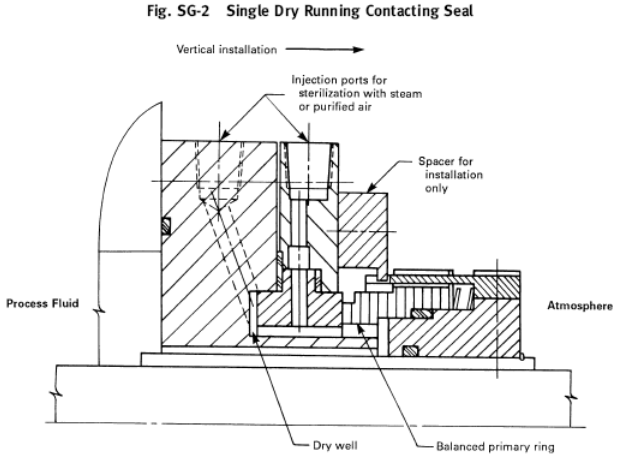


Figure 5 – Single Dry Running Contact Seal

In addition to the many Tables on dimensions and tolerances for the manufacture of fittings there are tables that include such information as Weld Acceptance Criteria for: welds on Pressure Vessels and Tanks; welds on Pipe; welds on Tubing; and Tube Attachment Welds. There is also a Table for Acceptance Criteria for Stainless Steel and Higher Alloy Mechanically Polished Product Contact Surface, and a Table of Surface Finish Designations (Table 1).

Table SF-3 R_a Readings for Product Contact Surfaces

Surface Designation	Mechanically Polished [Note (1)] R_a Max. µ-in.	Mechanically Polished [Note (1)] R_a Max. µm
SF0	No finish requirement	No finish requirement
SF1	20	0.51
SF2	25	0.64
SF3	30	0.76
	Mechanically Polished [Note (1)] and Electropolished	
	R_a Max.	
	µin.	µm
SF4	15	0.38
SF5	20	0.51
SF6	25	0.64

GENERAL NOTES:
(a) This table replaces previously published Tables SF-2, SF-4, SF-6, SF-8, and SF-10.
(b) All R_a readings are taken across the lay, wherever possible.
(c) No single R_a reading shall exceed the R_a max. value in this table.
(d) Other R_a readings are available if agreed upon between owner/user and manufacturer, not to exceed values in this table.

NOTE:
(1) Or any other finishing method that meets the R_a max.

Table 1 – Table of Surface Finish Designations

The Tables, Graphics, and intellectual information that end up in the BPE Standard are the product of a very structured data refining process. The information that makes it into the BPE Standard is typically distilled from a much larger data source compiled over time as a result of research performed or directed by personnel within its membership, who, I might add, very often absorb the time and expense in executing this research. A great deal of that research information is very useful, but cannot be considered as suitable for the body of the Standard.

Not wanting this useful information to end up residing in a file box or to sit idly on a hard drive, and therefore not get shared with industry, the BPE has added a Section for Non-Mandatory Appendixes. This is a section of the Standard in which information, deemed useful to readers of the Standard, but not appropriate for codification, can be posted for use while remaining segregated from the requirements of the Standard should the entire Standard be adopted as Code.

The Non-Mandatory Appendixes covers such topics as:

Appendix A – Slag
Appendix B – Material Examination Log & Weld Log
Appendix C – Slope Measurement
Appendix D – Rouge and Stainless Steel
Appendix E – Passivation Procedure Qualification
Appendix F – Corrosion Testing
Appendix G – Ferrite
Appendix H – Electropolishing Procedure Qualification
Appendix I – Vendor Documentation Requirements for New Instruments

And Finally

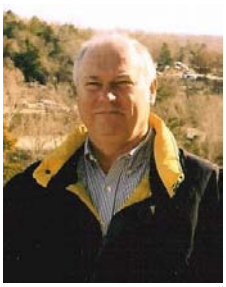
What you hopefully take away from this article is not just a cursory understanding of the BPE Standard itself, but also the understanding that there is a great deal of useful, vetted information at your fingertips in the form of American National Standards. While some Standards may require compliance from a regulatory standpoint others are yours to adopt and specify as you need. And as stated previously, it is not necessary to adopt an entire Standard if all you need are isolated references.

As an example, if all you need from the BPE Standard is some or all of its content on CIP requirements then reference that segment of the Standard. Only that referenced segment of the Standard becomes contractual for your project or facility. The same thing holds true if your project is handling, let's just say, hydrogen gas. There may be circumstances in which it may be practical to specify compliance with isolated segments of a Compressed Gas Association (CGA) Standard such as G-5 "Hydrogen" and/or G-5.4 "Standard for Hydrogen Piping Systems at Consumer Locations." If so, then simply adopt and reference that segment of the Standard.

In providing an example of the type of piping related Codes and Standards needed for CPI capital projects and for ongoing plant maintenance work refer to Table 2. This is a modified version of B31.3 Table 326.1 Component Standards. In this Table you will find a laundry list of piping related Codes and Standards typically used in engineering guidelines, construction guidelines, and material specifications. And this, by no means, covers the wide range of available Standards used in piping related requirements.

Table 2 (below) is segregated into six groups: Piping Codes and Standards; Bolting; Metallic Fittings, Valves, and Flanges; Metallic Pipe and Tubes; Material of Construction; and Miscellaneous. Under each of these groups is a sample listing of the type of Standards you would need in developing specifications and guidelines for a project or as guidance in performing maintenance work.

You can see by looking at Table 2 that there is a diverse number of Standards Developers (ASME, API, CGA, etc.) required to deliver the necessary specifications and guidelines to a project. Without harmonization, as mentioned earlier, between the various Developers the usefulness of industry Standards would most likely be diminished by conflicting requirements and overlapping stipulations. However, with harmonization and self familiarization of these Standards our work of selecting and employing the many available Standards is made much easier and more relevant. ■



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crosses industry lines to include petroleum refining, chemical, petrochemical, pharmaceutical, pulp & paper, nuclear power, biofuel, and coal gasification. He has written numerous specifications, guidelines, papers, and magazine articles on the topic of pipe design and engineering. Bill is a member of ISPE (International Society of Pharmaceutical Engineers), CSI (Construction Specifications Institute) and ASME (American Society of Mechanical Engineers). He is a member of three ASME-BPE subcommittees, a member of the ASME Board on Conformity Assessment BPE Certification, several Task Groups, an API Task Group, and sets on two corporate specification review boards. He can be reached at:

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Table 2 – Piping Related American National Standards

Standard or Specification	Designation
Piping Codes and Standards	
Power Piping	ASME B31.1
Process Piping	ASME B31.3
Refrigeration Piping and Heat Transfer Components	ASME B31.5
Building Services Piping	ASME B31.9
Bioprocessing Equipment	ASME BPE
Sizing, Selecting, and Installation of Pressure Relieving Devices in Refineries	API RP-520
Acetylene	CGA G-1
Acetylene Metering and Piping	CGA G-1.2
American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia	CGA G-2.1
Oxygen Pipeline Systems	CGA G-4.3
Standard for Hydrogen Piping Systems at Consumer Locations	CGA G-5.4
Bolting	
Square and Hex Bolts and Screws (Inch Series)	ASME B18.2.1
Square and Hex Nuts (Inch Series)	ASME B18.2.2
Metallic Fittings, Valves, and Flanges	
Cast Iron Pipe Flanges and Flanged Fittings	ASME B16.1
Malleable Iron Threaded Fittings	ASME B16.3
Gray Iron Threaded Fittings	ASME B16.4
Pipe Flanges and Flanged Fittings	ASME B16.5
Factory-Made Wrought Steel Buttwelding Fittings	ASME B16.9
Face-to-Face and End-To-End Dimensions of Valves	ASME B16.10
Forged Fittings, Socket-Welding and Threaded	ASME B16.11
Ferrous Pipe Plugs, Bushings, and Locknuts With Pipe Threads	ASME B16.14
Cast Bronze Threaded Fittings, Class 125 and 250 [Notes (1), (2)]	ASME B16.15
Cast Copper Alloy Solder Joint Pressure Fittings	ASME B16.18
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	ASME B16.22
Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500	ASME B16.24
Cast Copper Alloy Fittings for Flared Copper Tubes	ASME B16.26
Valves-Flanged, Threaded, and Welding End	ASME B16.34
Orifice Flanges, Class 300, 600, 900, 1500, and 2500	ASME B16.36
Malleable Iron Threaded Pipe Unions, Class 150, 250, and 300	ASME B16.39
Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300	ASME B16.42
Large Diameter Steel Flanges, NPS 26 Through NPS 60	ASME B16.47
Steel Line Blanks	ASME B16.48
Flanged Steel Pressure-Relief Valves	API 526
Wafer and Wafer-Lug Check Valves	API 594
Metal Plug Valves—Flanged, Threaded, and Welding Ends	API 599
Bolted Bonnet Steel Gate Valves for Petroleum and Natural Gas Industries	API 600
Compact Steel Gate Valves — Flanged, Threaded, Welding and Extended Body Ends	API 602
Class 150, Cast, Corrosion-Resistant, Flanged-End Gate Valves	API 603
Metal Ball Valves-Flanged, Threaded, and Welding End	API 608
Lug- and Wafer-Type Butterfly Valves	API 609
Ductile-Iron and Gray-Iron Fittings, 3 Inch Through 48 Inch (75 mm Through 1200 mm), for Water and Other Liquids	AWWA C110
Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges	AWWA C115
Steel Pipe Flanges for Waterworks Service, Sizes 4 inch Through 144 inch (100 mm Through 3,600 mm)	AWWA C207
Dimensions for Fabricated Steel Water Pipe Fittings	AWWA C208
Metal-Seated Gate Valves for Water Supply Service	AWWA C500
Rubber-Seated Butterfly Valves	AWWA C504
Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings	MSS SP-6
Spot Facing for Bronze, Iron and Steel Flanges	MSS SP-9
Standard Marking Systems for Valves, Fittings, Flanges, and Unions	MSS SP-25
Class 150 Corrosion Resistant Gate, Globe, Angle and Check Valves With Flanged and Butt Weld Ends	MSS SP-42
Wrought Stainless Steel Butt-Welding Fittings Including Reference to Other Corrosion Resistant Materials	MSS SP-43
Steel Pipe Line Flanges	MSS SP-44
Bypass and Drain Connections	MSS SP-45
Class 150LW Corrosion Resistant Flanges and Cast Flanged Fittings	MSS SP-51
High Pressure Chemical Industry Flanges and Threaded Stubs for Use with Lens Gaskets	MSS SP-65
Cast Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70

Table 1 – Piping Related American National Standards (cont.)

Standard or Specification	Designation
Class 3000 Steel Pipe Unions, Socket-Welding and Threaded	MSS SP-83
Gray Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85
Diaphragm Type Valves	MSS SP-88
Swage(d) Nipples and Bull Plugs	MSS SP-95
Integrally Reinforced Forged Branch Outlet Fittings — Socket Welding, Threaded, and Buttwelding Ends.	MSS SP-97
Instrument Valves for Code Applications	MSS SP-105
Factory-Made Wrought Belled End Socket Welding Fittings [Note (4)]	MSS SP-119
Refrigeration Tube Fittings — General Specifications.	SAE J513
Hydraulic Tube Fittings.	SAE J514
Hydraulic Flanged Tube, Pipe, and Hose Connections, Four-Bolt Split Flanged Type	SAE J518
Metallic Pipe and Tubes	
Welded and Seamless Wrought Steel Pipe.	ASME B36.10M
Stainless Steel Pipe	ASME B36.19M
Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges	AWWA C115
Thickness Design of Ductile-Iron Pipe	AWWA C150
Ductile-Iron Pipe, Centrifugally Cast, for Water	AWWA C151
Steel Water Pipe 6 inches (150 mm) and Larger	AWWA C200
Material of Construction	
Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	ASTM A53
Standard Specification for Carbon Steel Forgings for Pipe Applications	ASTM A105
Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service	ASTM A106
Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High-Pressure Service and Other Special Purpose Applications	ASTM A193
Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High Temperature Service or Both	ASTM A194
Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength	ASTM A307
Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes	ASTM A312
Standard Specification for Nickel-Chromium-Iron Alloys	ASTM B166
Miscellaneous	
Unified Inch Screw Threads (UN and UNR Thread Form)	ASME B1.1
Pipe Threads, General Purpose (Inch)	ASME B1.20.1
Dryseal Pipe Threads (Inch)	ASME B1.20.3
Hose Coupling Screw Threads (Inch).	ASME B1.20.7
Metallic Gaskets for Pipe Flanges — Ring: Joint, Spiral Wound, and Jacketed	ASME B16.20
Nonmetallic Flat Gaskets for Pipe Flanges	ASME B16.21
Buttwelding Ends	ASME B16.25
Surface Texture (Surface Roughness, Waviness, and Lay)	ASME B46.1
Specification for Threading, Gaging and Thread Inspection of Casing, Tubing, and Line Pipe Threads	API 5B
Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.	AWWA C111
Flexible Metal Hose [Notes	BS 6501, Part 1
Pipe Hangers and Supports — Materials, Design, and Manufacture.	MSS SP-58
Brazing Joints for Copper and Copper Alloy Pressure Fittings.	MSS SP-73
Standard for Fire Hose Connections	NFPA 1963