Piping for Process Plants Part 6: Testing & Verification

Proper documentation, determination of the fluid service category and operating conditions are among the factors necessary to perform the correct leak test on a piping system.

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This sixth and final part of a series of articles [1-5] on piping for process plants discusses practical issues of leak testing and verification of piping systems.

LEAK TESTING
Leak testing and pressure testing are often used synonymously. However, pressure testing is a misnomer when referring to leak testing of piping systems. By definition, a pressure test is the procedure performed on a relief valve to test its set-point pressure. The intent, when pressure testing a relief valve, is not to check for leaks, but to test the pressure set point of the valve by gradually adding pressure to the relief valve until it lifts the valve off of the seat.

A leak test, on the other hand, is performed to check the sealing integrity of a piping system by applying internal pressure to a pre-determined limit, based on design conditions, then checking joints and component seals for leaks. It is not intended that the MAWP (maximum allowable working pressure) of a piping system be verified or validated.

Before discussing the various types of leak tests and leak-test procedures, I would like to briefly talk about controlling and tracking this activity. Testing, like many aspects of a project, should be a controlled process. There should be a formal method of documenting and tracking this activity as the contractor proceeds through the leak testing process.

Documentation
In documenting the leak testing activity there are certain forms that will be needed. They consist of the following:
1. A dedicated set of piping and instrumentation diagrams (P&IDs) to identify the limits and number the test circuits
2. A form to record components that were either installed or removed prior to testing
3. A checklist form for field supervision to ensure that each step of the test process is accomplished
4. Leak-test data forms

The two sets of documents, from those listed above, that need to be retained are the P&ID's and the leak-test data forms. The other two sets of forms are procedural checklists. The leak-test data forms should contain key data such as the following:
1. Test circuit number
2. P&ID number(s)
3. Date of test
4. Project name or number, or both
5. Location within facility
6. Line number(s)
7. Design pressure
8. Test pressure
9. Test fluid
10. Test fluid temperature
11. Time (military) recorded test begins
12. Pressure at start of test
13. Time (military) recorded test ends
14. Pressure at end of test
15. Total elapsed time of test
16. Total pressure differential (plus or minus) from the beginning to the end of test period
17. Comment section (indicate if leaks were found and system was repaired and retested or if system passed)
18. Signatures and dates

Also make certain that the testing contractor has current calibration logs of his or her test instruments, such as pressure gages.

Primary leak tests
ASME B31.3 defines five primary leak tests as follows:

Initial service leak test. This applies only to those fluid services meeting the criteria as defined under ASME B31.3 Category D fluid service. This includes fluids in which the following apply:
- The fluid handled is nonflammable, nontoxic, and not damaging to human tissue
- The design gage pressure does not exceed 1,035 kPa (150 psi)
- The design temperature is from -29°C (-20°F) through 186°C (366°F)

The initial service leak test is a process by which the test fluid is the fluid that is to be used in the intended piping system at operating pressure and temperature. It is accomplished by connecting to the fluid source with a valved connection and then gradually opening the source valve and filling the system. In liquid systems, air is purged during the fill cycle through high point vents. A rolling examination of all joints is continually performed during the fill cycle and for a period of time after the system is completely filled and is under line pressure.

In a situation in which the pipeline that is being tested has distribution on multiple floors of a facility, there will be pressure differentials between the floors due to static head differences. This will occur in operation
and is acceptable under initial service test conditions. The test pressure achieved for initial service testing is what it will be in operation. The only difference is that the flowing fluid during operation will incur an amount of pressure drop that will not be present during the static test.

**Hydrostatic leak test.** This is the most commonly used leak test and is performed by using a liquid, normally water, and in some cases with additives to prevent freezing, under a pressure calculated by Equation (1):

\[
P_T = \frac{1.5 \cdot P \cdot S_T}{S}
\]

(1)

where

- \(P_T\) = Test pressure, psi
- \(P\) = Internal design gage pressure, psig
- \(S_T\) = Stress value at test temperature, psi (see ASME B31.3, Table A-1)
- \(S\) = Stress value at design temperature, psi (see B31.1, Table A-1)

However, as long as the metal temperature of \(S_T\) remains below the temperature at which the allowable stress value for \(S_T\) begins to diminish and the allowable stress value of \(S\) and \(S_T\) are equal, then \(S_T\) and \(S\) cancel each other leaving the simpler Equation (2):

\[
P_T = 1.5 \cdot P
\]

(2)

Unlike initial service testing, pressure variations due to static head differences in elevation have to be accommodated in hydrostatic testing. That means the calculated test pressure is the minimum pressure required for the system. When hydrostatically testing a multi-floor system, the minimum calculated test pressure shall be realized at the highest point. This is not stated, but is inferred in B31.3.

**Pneumatic leak test.** This test is performed using air or a preferred inert gas. This is a relatively easy test to perform simply from a preparation and cleanup standpoint. However, this test has a hazardous potential because of the stored energy in the pressurized gas. And for that reason alone it should be used very selectively.

When pneumatic testing is performed, it must be done under a strictly controlled procedure with on-site supervision in addition to coordination with all other crafts and personnel in the test area.

The test pressure for pneumatic leak testing under B31.3 is calculated using Equation (3), for B31.9 it is calculated using Equation (4), and for B31.1 it is calculated using Equation (5).

\[
P_T = 1.1 \cdot P
\]

(3)

\[
P_T = 1.4 \cdot P
\]

(4)

\[
P_T = 1.2 \cdot P \text{ to } 1.5 \cdot P
\]

(5)

One misconception with pneumatic leak testing is in its procedure, as described in B31.3. There is a misconception that the test pressure should be maintained while the joints are examined. This is not correct. As B31.3 explains, pressure is increased gradually until the test pressure is reached. At that point, the test pressure is held until piping strains equalize throughout the system.

After a sufficient amount of time is allowed for piping strains to equalize, the pressure is then reduced to the design pressure (see Reference [3] for a discussion of the design pressure). While design pressure is held, all joints are examined for leaks. It is not required that the examination take place while holding test pressure. There is more to the entire procedure that is not included here. Please refer to B31.3 or B31.1 for full details on pneumatic leak testing.

**Sensitive leak test.** This leak test is performed when there is a higher-than-normal potential for fluid leakage, such as for hydrogen. I also recommend its use when a fluid is classified as a Category M fluid service. B31.1 refers to this test as Mass-Spectrometer and Halide Testing.

In B31.3, the process for sensitive leak testing is as follows:

The test shall be in accordance with the gas and bubble test method specified in the BPVC Code, Section V, Article 10, or by another method demonstrated to have equal sensitivity. Sensitivity of the test shall be not less than 10⁻³ atm mL/s under test conditions.

a. The test pressure shall be at least the lesser of 105 kPa (15 psi) gage, or 25% of the design pressure.

b. The pressure shall be gradually increased until a gage pressure the lesser of one-half the test pressure or 170 kPa (25 psi) gage is attained, at which time a preliminary check shall be made. Then the pressure shall be gradually increased in steps until the test pressure is reached, the pressure being held long enough at each step to equalize piping strains.

In testing fluid services that are extremely difficult to seal against, or fluid services classified as a Category M fluid service, I would suggest the following in preparation for the process described under B31.3:

- Prior to performing the sensitive leak test, perform a low-pressure test (15 psig) with air or an inert gas using the bubble test method. Check every mechanical joint for leakage.
- After completing the preliminary low-pressure pneumatic test, purge all of the gas from the system using helium. Once the system is thoroughly purged, and contains no less than 98% He, continue using He to perform the sensitive leak test with a mass spectrometer tuned to He.

Helium is the trace gas used in this
process and has a size that is close to that of the hydrogen molecule; this makes it nearly as difficult to seal against as $\text{H}_2$ without the volatility. Test each mechanical joint using the mass spectrometer to determine leak rate, if any.

**Alternative leak test.** In lieu of performing an actual leak test, in which internal pressure is used, the alternative leak test takes the examination and flexibility analysis approach. This test is conducted only when it is determined that either hydrostatic or pneumatic testing would be detrimental to the piping system or the fluid intended for the piping system, an inherent risk to personnel, or impractical to achieve.

As an alternative to testing with internal pressure, it is acceptable to qualify a system through examination and flexibility analysis. The process calls for the examination of all groove welds, and includes longitudinal welds in the manufacture of pipe and fittings that have not been previously tested hydrostatically or pneumatically. It requires a 100% radiograph or ultrasonic examination of those welds. Where applicable, the sensitive leak test shall be used on any untested mechanical joints. This alternative leak test also requires a flexibility analysis as applicable.

Very briefly, a flexibility analysis verifies, on a theoretical basis, that an installed piping system is within the allowable stress range of the material and components under design conditions if a system: (a) duplicates or replaces without significant change, a system operating with a successful service record; (b) can be judged adequate by comparison with previously analyzed systems; and (c) is of uniform size, has no more than two points of fixation, no intermediate restraints, and falls within the limitations of empirical Equation (6).

\[
\frac{D \cdot y}{(L-U)^2} \leq K_1
\]

where

- \(D\) = Outer dia. of pipe, in. (or mm)
- \(y\) = Resultant of total displacement strains to be absorbed by piping system, in. (or mm)
- \(L\) = Developed length of piping between anchors, in. (or mm)
- \(U\) = Anchor distance, straight line between anchors, ft (or m)
- \(K_1\) = \(208,000 \cdot S_a / E_a\) (mm/m) \(= 30 \cdot S_a / E_a\) (in./ft)
- \(S_a\) = Allowable displacement stress range per Equation (1a) of ASME B31.3, ksi (MPa)
- \(E_a\) = Reference modulus of elasticity at 70°F (21°C), ksi (MPa)

One example in which an alternative leak test might be used is in making a branch tie-in to an existing, in-service line using a saddle with an o-let branch fitting with a weld-neck flange welded to that, and a valve mounted to the flange. Within temperature limitations, the fillet weld used to weld the saddle to the existing pipe can be examined using the dye penetrant or magnetic particle method. The circumferential butt or groove weld used in welding the weld neck and the o-let fitting together should be radiographically or ultrasonically examined. And the flange joint connecting the valve should have the torque of each bolt checked after visually ensuring correct type and placement of the gasket.

There are circumstances, regarding the tie-in scenario we just discussed for alternative leak testing, in which a hydrostatic or pneumatic test can be used. It depends on what the fluid service is in the existing pipeline. If it is a fluid service that can be considered a Category D, then it is quite possible that a hydrostatic or pneumatic leak test can be performed on the described tie-in.

By capping the valve with a blind flange modified to include a test rig of valves, nipples and hose connectors, you can perform a leak test rather than an alternative leak test. As mentioned, this does depend on the existing service fluid. If the existing fluid service is steam or a cryogenic fluid, then you might want to consider the alternative leak test.

**More on documentation**

As seen in Equations (1–5), the leak test pressure, except for initial service testing, is based on design pressure and design temperature, both of which are described in Reference [3]. A few general procedures for cleaning and testing are presented below.

As in all other project functions, control and documentation is a key element in the cleaning and testing of piping systems. It does, however, need to be handled in a manner that is dictated by the type of project. That means you don’t want to bury yourself in unwarranted paperwork and place an unnecessary burden on the contractor.

Building a commercial or institutional type facility will not require the same level of documentation and stringent controls that an industrial type facility would require. But even within the industrial sector there are varying degrees of required testing and documentation.

To begin with, documentation requirements in industry standards are simplistic and somewhat generalized, as is apparent in ASME B31.3, which states in Para. 345.2.7:

**Records shall be made of each piping system during the testing, including:**

- (a) Date of test
- (b) Identification of piping system tested
- (c) Test fluid
- (d) Test pressure
- (e) Certification of results by examiner

These records need not be retained after completion of the test if a certification by the inspector that the piping has satisfactorily passed pressure testing as required by this Code is retained.

ASME B31.3 goes on to state, in Para. 346.3:

**Unless otherwise specified by the engineering design, the following records shall be retained for at least 5 years after the record is generated for the project:**

- (a) Examination procedures; and
- (b) Examination personnel qualifications

Standards that cover such a broad array of industrial manufacturing, do not, as a rule, attempt to get too specific in some of their requirements. Beyond the essential requirements, such as those indicated above, the owner, engineer or contractor has to assume responsibility and know-how for providing more specific and proprietary requirements for a particular project specific to the particular needs of the
Which fluid service category?
While Category-D fluid services qualify for initial service leak testing, there are caveats that should be considered. This is a situation in which ASME provides some flexibility in testing by lowering the bar on requirements where there is reduced risk in failure, provided that if failure should occur, the results would not cause catastrophic damage to property or irreparable harm to personnel.

The owner's responsibility for any fluid service selected for initial service leak testing lies in determining what fluid services to place into each of the fluid service categories: Normal, Category D, Category M, and High Pressure.

Acids, caustics, volatile chemicals and petroleum products are usually easy to identify as those not qualifying as a Category-D fluid service. Cooling tower water, chilled water, air and nitrogen are all easy to identify as qualifiers for Category-D fluid services. The fluid services that fall within the acceptable Category D guidelines, but still have the potential for being hazardous to personnel are not so straightforward.

Consider water as an example. At ambient conditions, water will simply make you wet if you get dripped or sprayed on. By OSHA standards, once the temperature of water exceeds 140°F (60°C), it starts to become detrimental to personnel upon contact. At this point, the range of human tolerance becomes a factor. However, as the temperature continues to elevate, it eventually moves into a range that becomes scalding upon human contact. Human tolerance is no longer a factor because the water has become hazardous and the decision is made for you.

Before continuing, a point of clarification. The 140°F temperature mentioned above is with respect to simply coming in contact with an object at that temperature. Brief contact at that temperature would not be detrimental. In various litigation related to scalding it has been determined that an approximate one-second exposure to 160°F water will result in third degree burns. An approximate half-minute exposure to 130°F water will result in third degree burns. And an approximate ten minute exposure to 120°F water can result in third degree burns.

With the maximum temperature limit of 366°F (185.5°C) for Category-D fluid services, what the owner needs to consider are three factors: (1) within that range of 140°F (60°C), the temperature at which discomfort begins to set in, to 366°F (185.5°C), the upper limit of Category-D fluids, what do we consider hazardous; (2) what is the level of opportunity for risk to personnel; and (3) what is the level of assured integrity of the installation.

Assured integrity means that, if there are procedures and protocols in place that require, validate and document third-party inspection of all pipe fabrication, installation and testing, then there is a high degree of assured integrity in the system. If some or all of these requirements are not in place then there is no assured integrity.

All three of these factors — temperature, risk of contact and assured integrity — have to be considered together to arrive at a reasonable determination for borderline Category-D fluid services. If, for instance, a fluid service is not hot enough to be considered hazardous, but is in an area of a facility that sees very little personnel activity, then the fluid service could still be considered as a Category-D fluid service.

One factor I have not included here is the degree of relative importance of a fluid service. If a system failed, how big of a disruption would it cause in plant operation, and how does that factor into this process?

For example, if a safety shower water system has to be shut down for leak repair, the downtime to make the repairs has little impact on plant operations. This system would therefore be of relatively low importance and not a factor in this evaluation process.

If, on the other hand, a chilled water system has to be shut down for leak repair to a main header, this could have a significant impact to operations and production. This could translate into lost production and could be considered a high degree of importance.

You could also extend this logic a bit further by assigning normal fluid-service status to the primary headers of a chilled water system and assigning Category D status to the secondary distribution branches, then leak test accordingly. You need to be cautious in considering this. By applying different category significance to the same piping system it could cause more confusion than it is worth. In other words it may be more value added to simply default to the more conservative category of normal.

Once it has been established that there is a high assured integrity value for these piping systems, there are two remaining factors to be considered. First, within the temperature range indicated above, at what temperature should a fluid be considered hazardous? Second, how probable is it that personnel could be in the vicinity of a leak, should one occur?

For this discussion, let us determine that any fluid at 160°F (71°C) and above is hazardous upon contact with human skin. If the fluid you are considering is within this temperature range, then it has the potential of being considered a normal fluid, as defined in B31.3, pending its location as listed in Table 1.

For example, if you have a fluid that is operating at 195°F (90.6°C), it would be considered hazardous in this evaluation. But, if the system is located in a Group 5 area (Table 1) it could still qualify as a Category D fluid service.

Leak test examples
After the above exercise in evaluating a fluid service, we can now continue with a few examples of leak test procedures. Using the designations given in Table 2, these leak test procedures will be categorized as follows:

Testing Category T-1.
T-1.1 — This category covers liquid piping systems categorized by ASME B31.3 as Category-D fluid service and

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TABLE 1. AREAS UNDER CONSIDERATION FOR CATEGORY D

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Personnel occupied space</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Corridor frequently by personnel</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sensitive equipment (MCC, control room, and so on)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Corridor infrequently used by personnel</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Maintenance &amp; operations personnel only access</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
will require initial service leak testing only.

1. If the system is not placed into service or tested immediately after flushing and cleaning, and has been idle for an unspecified period of time, it shall require a preliminary pneumatic test at the discretion of the owner. In doing so, air shall be supplied to the system at a pressure of 10 psig and held there for 15 min to ensure that joints and components have not been tampered with, and that the system is still intact. After this preliminary pressure check, proceed.

2. After completion of the flushing and cleaning process, connect the system, if not already connected, to its permanent supply source and to all of its terminal points. Open the block valve at the supply line and gradually feed the liquid into the system.

3. Start and stop the fill process to allow proper high-point venting to be accomplished. Hold pressure to its minimum until the system is completely filled and vented.

4. Once it is determined that the system has been filled and vented properly, gradually increase pressure until 50% of operating pressure is reached. Hold that pressure for approximately two minutes to allow piping strains to equalize. Continue to supply the system gradually until full operating pressure is achieved.

5. During the process of filling the system, check all joints for leaks. Should leaks be found at any time during this process, drain the system, repair leak(s) and begin again with Step 1. (Caveat: Should the leak be no more than a drip every minute or two on average at a flange joint, it could require simply checking the torque on the bolts without draining the entire system. If someone forgot to fully tighten the bolts, then do so now. If it happens to be a threaded joint you may still need to drain the system, disassemble the joint, clean the threads, add new sealant and reconnect the joint before continuing.)

6. Record test results and fill in all required fields on the leak test form.

**T-1.2.** — This category covers pneumatic piping systems categorized by ASME B31.3 as Category-D fluid service and will require initial service leak testing.

1. After completion of the blow-down process, the system shall be connected to its permanent supply source, if not already done so, and to all of its terminal points. Open the block valve at the supply line and gradually feed the gas into the system.

2. Increase the pressure to a point equal to the lesser of one-half the operating pressure or 25 psig. Make a preliminary check of all joints by sound or bubble test. If leaks are found, release pressure, repair leak(s) and begin again with Step 1. If no leaks are identified, continue to Step 3.

3. Continue to increase pressure in 25 psi increments, holding that pressure momentarily (approximately 2 min) after each increase to allow piping strains to equalize, until the operating pressure is reached.

4. Check for leaks by sound or bubble test, or both. If leaks are found, release pressure, repair leak(s) and begin again with Step 2. If no leaks are found, the system is ready for service.

5. Record test results and fill in all required fields on the leak test form.

**Category T-3.1 — Hydrostatic Leak Test.**

**T-3.1.** — This category covers liquid piping systems categorized by ASME B31.3 as normal fluid service. In the event that the system is not placed into service or tested immediately after flushing and cleaning, and has been idle for an unspecified period of time, the system shall require a preliminary pneumatic test at the discretion of the owner. In doing so, air shall be supplied to the system at a pressure of 10 psig and held there for 15 minutes to ensure that joints and components have not been tampered with, and that the system is still intact. After this preliminary pressure check, proceed.

2. After completion of the flushing and cleaning process, with the flush/test manifold still in place and the temporary potable water supply still connected (reconnect if necessary), open the block valve at the supply line and complete filling the system with potable water.

3. Start and stop the fill process to allow proper high-point venting to be accomplished. Hold pressure to its minimum until the system is completely filled and vented.

4. Once it is determined that the system has been filled and vented properly, gradually increase pressure until 50% of the test pressure is reached. Hold that pressure for approximately two minutes to allow piping strains to equalize. Continue to supply the system gradually until test pressure is achieved.

5. During the process of filling the system and increasing pressure to 50% of the test pressure, check all joints for leaks. Should any leaks be found, drain system, repair leak(s) and begin again with Step 1.

6. Once the test pressure has been achieved, hold it for a minimum of 30 min or until all joints have been checked for leaks. This includes valve and equipment seals and packing.

7. If leaks are found, evacuate system as required, repair and repeat from Step 2. If no leaks are found, evacuate system and replace all items temporarily removed.

8. Record all data and activities on leak test forms.

The three examples above should provide an idea as to the kind of guideline that needs to be created in providing direction to the contractor responsible for the work.

**Preparation**

For leak testing to be successful on your project, careful preparation is key. This preparation starts with gathering information on test pressures, test fluids, and the types of tests that will be required. The most convenient place for this information to reside is the piping line list or piping system list.

A piping line list and piping system list achieve the same purpose, only to different degrees of detail. On some projects, it may be more practical to compile the information by entire service fluid systems. Other projects may require a more detailed approach.
by listing each to and from line along with the particular data for each line. The line list itself is an excellent control document that might include the following for each line item:
1. Line size
2. Fluid
3. Nominal material of construction
4. Pipe specification
5. Insulation specification
6. P&ID
7. Line sequence number
8. From and to information
9. Pipe code
10. Fluid service category
11. Heat tracing
12. Operating pressure
13. Design pressure
14. Operating temperature
15. Design temperature
16. Type of cleaning
17. Test pressure
18. Test fluid
19. Type of test

Developing this type of information on a single form provides everyone involved with the basic information needed for each line. Having access to this line-by-line information in such a concise, well-organized manner reduces guess-work and errors during testing.

Test results, documented on the test data forms, will be maintained under separate cover. Together, the line list provides the required information on each line or system, and the test-data forms provide signed verification of the actual test data of the test circuits that make up each line or system.

**VALIDATION**

The process of validation has been around for longer than the 40 plus years the author has been in this business. You may know it by its less formal namesakes walk-down and checkout. Compared to validation, walk-down and checkout procedures are not nearly as complex, stringent, or all inclusive.

Validation is actually a subset activity under the umbrella of commissioning and qualification (C&Q). It is derived from the need to authenticate and document specifically defined requirements for a project and stems indirectly from, and in response to, the Code of Federal Regulation 29CFR Titles 210 and 211 current Good Manufacturing Practice (cGMP) and U.S. Food and Drug Administration (FDA) requirements. These CFR Titles and FDA requirements drove the need to demonstrate or prove compliance.

These requirements can cover everything from verification of examination and inspection, documentation of materials used, software functionality and repeatability to welder qualification, welding machine qualification, and so on.

The cGMP requirements under 29CFR Titles 210 and 211 are a vague predecessor of what validation has become, and continues to become. From these basic governmental outlines, companies, and the pharmaceutical industry as a whole, have increasingly provided improved interpretation of these guidelines to meet many industry-imposed, as well as self-imposed requirements.

To a lesser extent, industrial projects outside the pharmaceutical, food and beverage, and semi-conductor industries, industries not prone to require such in-depth scrutiny, could benefit from adopting some of the essential elements of validation, such as: material verification, leak-test records, welder and welding operator-qualification records, and so on.

At face value this exercise would provide an assurance that the fabricating and installing contractor is fulfilling its contractual obligation. The added benefit is that, in knowing that this degree of scrutiny will take place, the contractor will take extra measures to minimize the possibility of any rejects.

This is not to imply that all contractors are out to get by with as little as they can. Just the opposite is actually true. Most contractors qualified to perform at this level of work are in it to perform well and to meet their obligations. Most will already have their own verification procedure in place.

The bottom line is that the owner is still responsible for the end result. No one wants to head for the litigation table at the end of a project. And the best way to avoid that is for the owner to be proactive in developing its requirements prior to initiating a project. This allows the specification writers and reviewers the benefit of having time to consider just what those requirements are and how they should be defined without the time pressures imposed when this activity is project driven.

Performing this kind of activity while in the heat of a project schedule tends to force quick agreement to specifications and requirements written by parties other than those with the owner's best interest at heart.

Validating a piping system to ensure compliance and acceptability is always beneficial and money well spent.

**FINAL REMARKS**

Before concluding this series of articles, there are just a couple of final points to be made.

**Evolving standards**

We have previously discussed industry standards and how they are selected and applied on a project [4]. What was not covered is the fact that most projects will actually have a need to comply with multiple industry standards.

In a large grassroots pharmaceutical project you may need to include industry compliance standards for much of the underground utility piping, ASME B31.1 for boiler external piping (if not included with packaged boilers), ASME B31.3 for chemical and utility piping throughout the facility, and ASME-BPE for any hygienic piping requirements.

These and other standards, thanks in large part to the cooperation of the standards developers and ANSI, work hand-in-hand with one another by referencing each other where necessary. These standards committees have enough work to do within their defined scope of work without inadvertently duplicating work done by other standards organizations.

An integrated set of American National Standards is the reason that, when used appropriately, these standards can be used as needed on a project without fear of conflict between those standards.

One thing that should be understood with industry standards is the fact that they will always be in a state of flux; always changing. And this is a good thing. These are changes that reflect updating to a new understanding, expanded clar-
ification on the various sections that make up a standard, staying abreast of technology, and simply building the knowledge base of the standard.

For example, two new parts are being added to the seven parts currently existing in ASME-BPE. There will be a Metallic Materials of Construction Part (MMOC), and a Certification Part (CR). This is all part of the ever-evolving understanding of the needs of the industrial community and improved clarification, through discussion and debate on content.

Conclusion
This series of articles attempted to cover a wide range of topics on industrial piping in order to provide a basic broad understanding of some key points, without going into great detail on any specific topic. It is hoped that the readers of this series will dig deeper into this subject matter to discover and learn some of the more finite points of what was discussed in this and previous articles. It is hoped that this series provides enough basic knowledge of piping for you to recognize when there is more to a piping issue than what you are being told.

Edited by Gerald Ondrey

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References

Author
W. M. (Bill) Huitt has been involved in industrial piping design, engineering and construction since 1965. Positions have included design engineer, piping design instructor, project engineer, project supervisor, piping department supervisor, engineering manager and president of W. M. Huitt Co. (P.O. Box 31154, St. Louis, MO 63131-0154. Phone: 314-966-8919; Email: wmhuitt@aol.com) a piping consulting firm founded in 1987. His experience covers both the engineering and construction fields and crosses industrial lines to include petroleum refining, chemical, petrochemical, pharmaceutical, pulp and paper, nuclear power, and coal gasification. He has written numerous specifications including engineering and construction guidelines to ensure that design and construction comply with code requirements, owner expectations and good design practices. 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 contributor to ASME-BPE and sits on two corporate specification review boards.