Highlights of ASME PCC-2: Repair of Pressure Equipment and Piping

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ASME Post Construction Committee (PCC-2) Repair and Testing

Contents of this Presentation:

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ASME Post Construction Committee (PCC)

Three PCC Subcommittees:

- Subcommittee on Bolted Joint Assembly
  - Issued **PCC-1**, 2000, *Guidelines for Pressure Boundary Bolted Flange Joint Assembly, next edition in preparation*
- Subcommittee on Repair and Testing
  - Issued **PCC-2**, *Repair of Pressure Equipment and Piping; 2006 and 2009 editions*
- Subcommittee on Inspection Planning
  - Issued **PCC-3**, *Inspection Planning, first edition 2008*

ASME Post Construction Committee (PCC-2) Repair and Testing

- Subcommittee on Repair and Testing (PCC-2) was established in 1999.
- PCC-2 developed a standard to describe and document "*recognized and generally accepted good engineering practice*" for the repair of pressure equipment and piping
- PCC-2 uses the ANSI consensus building and balloting process involving numerous companies and experienced individuals to build these recommended practices
- All R&T articles are relatively generic, and as such may need to amended/adapted as necessary for the conditions associated with specific flaws and defects that need to be repaired at your site

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Current and Planned Editions:

- The first edition of PCC-2 published in 2006 with 17 R&T articles
- A second edition pending publication very shortly with 10 more R&T articles
- A third edition is planned with 10-12 more R&T articles which are now in preparation
- This PCC-2 R&T standard is not intended to be adopted directly by jurisdictions, but all or parts could be and are referenced by existing codes such as API-510, API-570, API-653 and NBIC.

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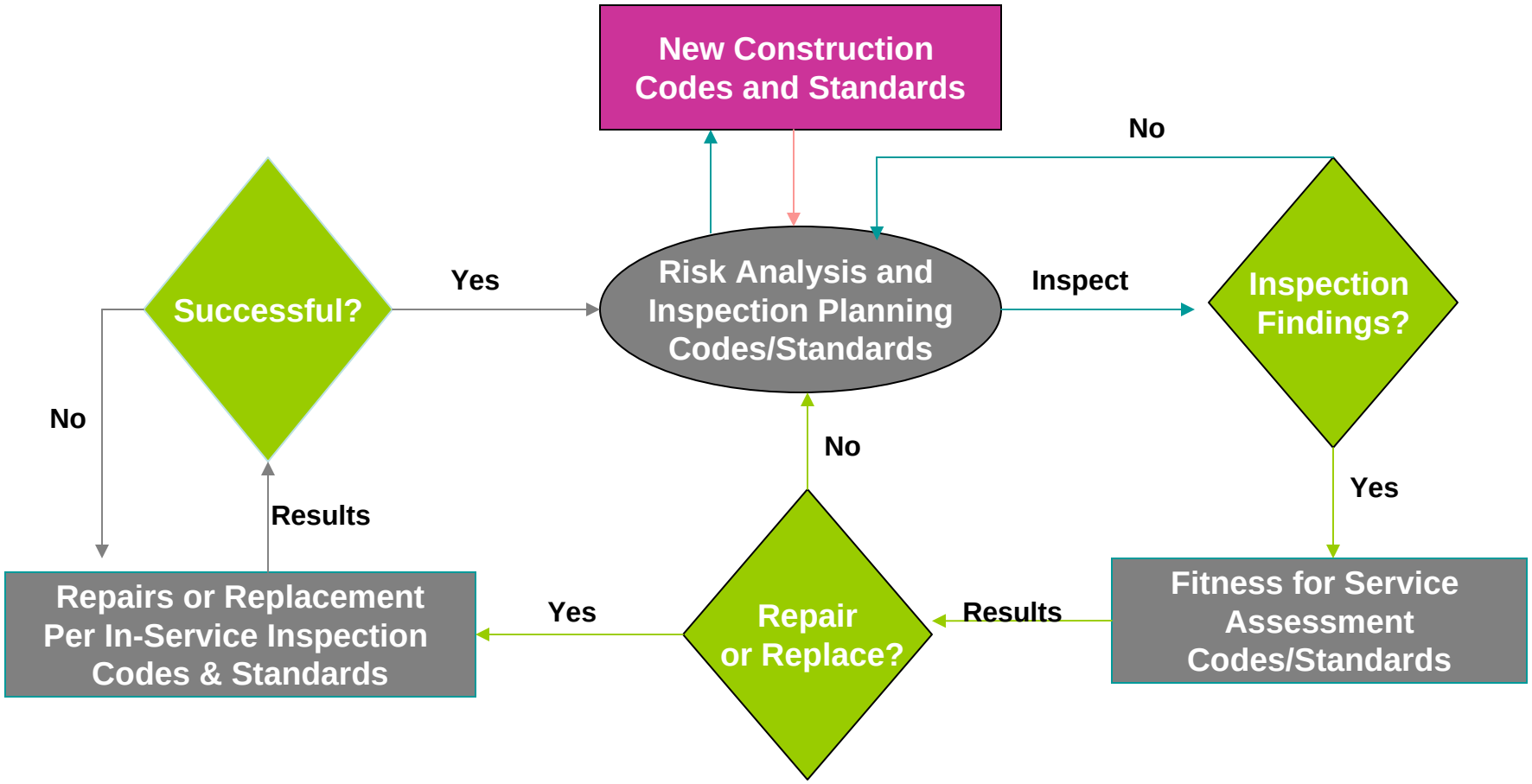
Where does this standard fit into the grand scheme of in-service codes and standards?

- It does not cover:
  - *New construction requirements*
  - *Inspection planning and preparation*
  - *Risk assessment for inspection planning*
  - *In-service inspection methods/techniques*
  - *Flaw evaluation and fitness-for-service assessment*

- Each of the above issues are covered by a different standard/code, which are all integrated with PCC-2 to help the user maintain pressure equipment integrity →



THE INTEGRATION OF IN-SERVICE INSPECTION AND REPAIR CODES AND STANDARDS

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Scope of PCC-2 Standard:

- Covers equipment within the scope of API and ASME Pressure Equipment Codes and Standards, including:
  - *Piping and pipelines including piping components (such as valves, flanges and fittings)*
  - *Boilers/Heaters*
  - *Pressure vessels (including heat exchanger bundles)*
  - *Storage tanks.*
- Coverage is not limited to equipment built to ASME Codes
- Covers repairs after equipment has been placed in service.
- Repairs during construction are covered by the new construction codes (supposedly).

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Organization of PCC-2 Standard:

- **Part I** covers Scope, Organization and Intent of the standard and applies to all R&T articles in the standard.
- Each different type of repair is covered by a stand-alone article.
- All articles are organized into four separate sections:
  - ***Part 2****: Welded Repairs*
  - ***Part 3****: Mechanical Repairs*
  - ***Part 4****: Nonmetallic and Bonded Repairs*
  - ***Part 5****: Examination and Testing*

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Standard Outline/Format for Each Article:

- Description of the repair
- Limitations and Precautions associated with the repair
- Design/Fabrication issues associated with the repair
- Examination and Testing QA/QC practices following the repair
- Additional references

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Administrative Requirements:

- Administrative requirements are those provisions of a code, standard or regulation other than technical requirements, such as
  - *Inspection reporting*
  - *Hold points*
  - *Documentation requirements*
  - *Approvals and registration requirements, etc.*
- PCC-2 does not contain this type of administrative requirements, which are left to the responsibility of the in-service codes and jurisdictions that reference this repair standard
- Instead, the PCC-2 R&T Standard focuses on the technical issues for repair and testing i.e. guidance on recommended methods for conducting repairs

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Temporary versus Permanent Repairs

- The repair standard does not categorize repairs as either temporary or permanent
- It's up to the owner-user to determine the predicted life of each repair
- Technical considerations that affect service life are described in the individual repair articles to permit the user to determine appropriate inspection and replacement intervals.
- The life of a repair may depend upon many things, including:
  - *Design of the repair*
  - *Number and magnitude of temperature and pressure cycles*
  - *Time at various load conditions.*
  - *Environment (operating and external)*
  - *Consequence of failure and risk tolerance*

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Welded Repair Articles:

- **Repair Method for Butt Welded Insert Plates in Pressure Components**
- **External Weld Overlay to Methods for Internal Thinning**
- **Seal Welding Threaded Connections and Seal Welded Repairs**
- **Full Encirclement Steel Sleeves for Piping**
- **Welded Leak Enclosures**
- *Fillet Welded Patches with Reinforcing Plug Welds*
- *Alternatives to Traditional Welding Preheat*
- *Alternatives to Post Weld Heat Treatment*
- *In-Service Welding onto Carbon Steel Pressure Components or Pipelines*
- *Weld Buildup, Weld Overlay and Clad Restoration*
- *Fillet Welded Patches*
- *Threaded or Welded Plug Repairs*

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Mechanical Repair Articles:

- **Replacement of Pressure Components**
- **Freeze Plugging**
- **Repair of Damaged Threads in Tapped Holes**
- **Flaw Excavation and Weld Repair**
- **Flange Refinishing**
- **Mechanical Clamps**
- **Pipe Straightening**
- **Repair Guidelines for Damaged Anchors in Concrete**
- *Hot and Half Bolting Removal Procedures*
- *Inspection and Repair of Shell and Tube Heat Exchangers*

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Non-Metallic Repair Articles:

- **Non-Metallic Composite Wrap Systems for Piping and Pipelines: High Risk Applications**
- **Non-Metallic Composite Wrap Systems for Pipe: Low Risk Metal Pipe**
- **Non-metallic Internal Lining for Pipe-Sprayed Form for Buried Pipe**

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Testing and Examination Articles:

- Examination and testing requirements for each specific type of specific repair are covered in the last section of each article
- However, Two Separate Generic Examination and Testing Articles are also included:
  - **Pressure and Tightness Testing of Piping and Equipment**
  - *NDE in Lieu of Pressure Testing*

Part 2: Welded Repairs (5 existing)

- **Article 2.1 Butt-Welded Insert Plates in Pressure Components**
- **Article 2.2 External Weld Overlay to Repair Internal Thinning**
- **Article 2.3 Seal-Welded Threaded Connections and Seal Weld Repairs**
- **Article 2.4 Welded Leak Box Repair**
- Article 2.5 Welded Lip Seals (in preparation)
- **Article 2.6 Full Encirclement Steel Reinforcing Sleeves for Piping**

Article 2.1: Butt Welded Insert Plates in Pressure Components

- Replacement of pressure boundary material with insert plate with full penetration butt welds
- Covers portions of plates (not complete plates, courses, or components)
- Can apply to internal or external pressure
- Replacement plate may include nozzles
- Limited in size only as required to meet tolerances

Article 2.2: External Weld Overlay to Repair Internal Thinning

- Covers repairs due to internally thinned components by external weld overlay
- Excludes repair of components with cracks
- In some cases, may be performed in service
- Used more in the power industry than in the petroleum industry

Article 2.3: Seal Welded Threaded Connections and Seal Weld Repairs

- Covers requirements for seal welding of threaded connections where greater leak tightness is needed
- Can be used for original construction or in-service piping systems
- Includes many important limitations and precautions to advise the user

Article 2.4: Welded Leak Box Repair

- Covers welded enclosures placed over a component being repaired/welded in place
- Can repair pipe, flanges, valves, fittings, etc.
- Includes a variety of shapes and sizes
- May be installed with/without pumping of sealant into the box
- Can be designed for leak tightness or just structural reinforcement
- Does not include bolted or clamped boxes, which are covered under mechanical repairs

Article 2.6: Full Encirclement Steel Reinforcing Sleeves for Piping

- Type A Sleeves:
  - Not pressure containing, reinforcing only
  - For non-leaking, non-growing defects
- Type B Sleeves:
  - Welded circumferentially to carrier pipe
  - For leaking defects and to provide full pressure & load carrying capability

Part 3: Mechanical Repairs (8 existing)

- **Article 3.1** Replacement of Pressure Components
- **Article 3.2** Freeze Plugs
- **Article 3.3** Damaged Threads in Tapped Holes
- **Article 3.4** Flaw Excavation and Weld Repair
- **Article 3.5** Flange Repair & Conversion (formerly Flange Refinishing)
- **Article 3.6** Mechanical Clamp Repair
- **Article 3.7** Pipe Straightening or Alignment Bending
- **Article 3.8** Damaged Anchors in Concrete

Article 3.1: Replacement of Pressure Components

- Covers replacement of pressure equipment or piping components or subassemblies
- May be replacement in kind or a modification

Article 3.2: Freeze Plugs

- A technique for isolating a section of metallic piping by cryogenically cooling the outer wall of the pipe and freezing the contained liquid to form a plug
- CO_2 and liquid nitrogen typically used as cooling medium
- Can be used on a variety of liquids
- Experience holding pressures up to 2500 psi
- Includes numerous safety suggestions
- New: expanded materials to include duplex SS

Article 3.3: Damaged Threads in Tapped Holes

- Options include:
  - Drilling damaged holes to larger size for tapered bolts
  - Drilling damaged holes to larger size for helical coil thread inserts
  - Filling w/ weld metal, redrilling & retapping

Article 3.4: Flaw Excavation and Weld Repair

- Covers surface or embedded flaws that exceed code allowances
- Flaws may be removed by excavation and filled with weld metal or left as-is as appropriate
- Includes grinding, machining, lapping, honing, flapping, or thermal gouging

Article 3.5: Flange Repair and Conversion (formerly Flange Refinishing)

- Covers refinishing/repair/revision of flange faces to:
  - Repair mechanical imperfections
  - Restore material lost due to corrosion or other damage
  - Change flange face finish or enable use of different gasket
  - Includes machining with or without weld metal build-up

Article 3.6: Mechanical Clamp Repair

- Split bolted fittings to enclose leaking components/reinforce damaged components
- Std catalog items or custom designed
- With or without injectable sealant
- Reinforced to resist pressure end thrust
- May be non-structural (pressure tight) or structural (reinforcement)

Article 3.7: Pipe Straightening or Alignment Bending

- Provides requirements and cautions for correcting a bent metallic pipe using hot or cold bending
- Can be used to improve fit-up or misalignment
- Does not cover systems that include mechanical joints (flanges, threaded joints, expansion joints, compression fittings, etc.

Article 3.8: Damaged Anchors in Concrete

- Covers repairs to column base anchors in concrete
- Includes anchors installed by mechanical or chemical means
- Includes extension of existing anchor bolts when appropriate

Part 4: Nonmetallic and Bonded Repairs (3 existing)

- **Article 4.1 Nonmetallic Composite Repair Systems for Piping and Pipework: High Risk Applications**
- **Article 4.2 Nonmetallic Composite Repair Systems For Pipelines And Pipework: Low Risk Applications**
- **Article 4.3 Nonmetallic Internal Lining for Pipe: Sprayed Form for Buried Pipe**

Article 4.1: Nonmetallic Composite Repair Systems for Piping and Pipework: High Risk Applications

- Repair system consisting of glass, aramid or carbon fiber reinforcements in a thermoset resin matrix
- Intended for piping/pipelines to B31 systems
- May be used for Metallic or Nonmetallic systems
- Can repair:
  - *External corrosion where structural integrity is compromised*
  - *External dents, gouges, fretting, wear*
  - *Cracks if properly prepared (see Article 3.4 on flaw excavation)*
  - *Internal corrosion/erosion which may or may not be leaking*
  - *Leaks*
  - *Manufacturing/fabrication defects*

Article 4.2: Nonmetallic Composite Repair Systems For Piping And Pipework: Low Risk Applications

- Repair system consisting of fiber reinforcements in resin matrix
- Intended for low risk piping/pipeline apps
- Can repair:
  - *External corrosion/damage*
  - *Internal corrosion/erosion*
  - *Leaks*
  - *Manufacturing/fabrication defects*
- Deleted B31.4 as an example/reference to reflect low risk applications.
- Clarified qualification data and validation testing requirements.

Article 4.3: Nonmetallic Internal Lining for Pipe: Sprayed Form for Buried Pipe

- Covers thermosetting polymers sprayed as protective or structural lining to buried pipe
- Can provide structural strength, chemical/ abrasion resistance, leakage barrier, improve flow
- Limited to buried pipe
- Most effective for diameters > 24 inch
- Can be applied manually or with a “spray rig”
- Minimum temperature restrictions added.

Part 5: Examination and Testing

- **Article 5.1 Pressure and Tightness Testing of Piping and Equipment**

Article 5.1: Pressure and Tightness Testing of Piping and Equipment

- Provides recommended practice for determining:
  - *Type of test*
  - *Test pressure*
  - *Test procedure*
- Provides general info on application of types of tests, benefits, and limitations
- Addresses hydrostatic, pneumatic, tightness and leak testing
- Does not address isolation of parts of system for testing purposes or vacuum testing
- Explains five specific reasons for testing

Ten New Articles in PCC-2, 2nd edition

- **Part 1:** Scope, Organization and Intent
- **Part 2:** Welded Repairs (7 New)
- **Part 3:** Mechanical Repairs (2 New)
- **Part 4:** Nonmetallic and Bonded Repairs
- **Part 5:** Examination and Testing (1 New)

Part 2: Welded Repairs (7 New)

- **Article 2.8** Alternatives to Welding Preheat
- **Article 2.9** Alternatives to PWHT
- **Article 2.10** In-Service Welding onto Carbon Steel Pressure Components or Pipelines
- **Article 2.11** Weld Build-up, Weld Overlay, and Clad Restoration
- **Article 2.12** Fillet Welded Patches
- **Article 2.13** Fillet Welded Patches with Reinforcing Plug Welds
- **Article 2.14** Threaded or Welded Plug Repairs

Article 2.8: Alternatives to Welding Preheat

- Provides guidance on alternatives to preheating when it may be inadvisable or impractical to apply preheat.
- Six alternative strategies are discussed along with their benefits, limitations and workmanship issues, including:
  - *Changing groove geometries*
  - *Changing welding processes and techniques,*
  - *Using different welding consumables*
  - *Evaluating the carbon equivalent*
  - *Evaluating the cracking parameter*
  - *Doing controlled deposition welding*
- Where preheating is needed, effective methods of applying and monitoring the preheat are discussed.

Article 2.9: Alternatives to PWHT

- Provides guidance for alternatives to conducting a PWHT when doing a PWHT may be inadvisable or impractical.
- Primary alternatives include elevated preheating and controlled deposition welding techniques.
- Special considerations may be required where stress corrosion cracking, hydrogen cracking, stress cracking or loss of toughness could be issues.

Article 2.10: In-Service Welding (ISW) of Carbon Steel Pressure Components

- Provides guidance and precautions for welding on components while they are still in-service.
- The two primary welding issues that need to be dealt with are the potential for burn-through and hydrogen cracking.
- Three types of ISW covered include ISW for filet welds, attachment welds, and weld metal build-up
- Eleven essential variables are covered for an ISW WPS, including weld type, cooling rate, carbon equivalence, consumables, heat input, current, preheat and postheat
- Recommendations for ISW procedure qualification include types of destructive property tests, macro-sectioning tests, and hardness tests

Article 2.11: Weld Build-up, Weld Overlay, and Clad Restoration

- As the name implies, guidance is provided on weld build-up (loss of base metal), weld overlay (loss of corrosion resistant overlay) and clad restoration where clad thinning has occurred.
- Covers numerous special considerations for welding, including: numbers of weld layers to be applied, effective depth of corrosion resistant restoration needed, surface preparation, back cladding, welding on low-alloy steels, heat treatment, chemical testing of overlay and NDE.

Article 2.12: Fillet Welded Patches

- Covers the requirements for applying fillet welded patch repairs (including pipe sleeves) where permitted by In-Service Codes, such as API 510 & API 570.
- Provides guidance on upper and lower service temperatures for fillet welded patch repairs.
- Provides formulas for design of filet welded patches of various types and contours, including the allowable loads on the perimeter fillet welds.
- Patch fabrication guidance includes: edge preparation, shaping, tolerances, WPS's, WQR's, patch plate venting during welding, NDE, and leak testing.

Article 2.13: Fillet Welded Patches with Reinforcing Plug Welds

- Covers all the same things as the previous article on fillet welded patches, plus provides design and fabrication guidance on how to transfer some of the pressure load to reinforcing plug welds included within the patch

Article 2.14: Threaded or Welded Plug Repairs

- Provides guidance on restoration of integrity of a component by insertion of a solid or threaded plug where a flaw has been removed or other through-thickness opening has been created, including applying a seal weld for leak tightness,if desired.
- Design and fabrication guidance includes: opening reinforcement, material properties, material removal, dimensions, flaw removal, seal/strength welding, examination and testing.

Part 3: Mechanical Repairs (2 New)

- **Article 3.11** **Hot Bolting and Half Bolting Removal Procedures**
- **Article 3.12** **Inspection and Repair of Shell and Tube Heat Exchangers**

Article 3.11: Hot and Half Bolting Removal Procedures

- Covers the issues involved for the sequential removal and replacement of bolts while the joint is still in service (hot bolting); and the issues involved with the removal of every other bolt (half bolting) during system depressurization
- Specific attention is provided to evaluating the risks and safe work practices of using either procedure, including 25+ different issues that might affect the risks.
- Guidance is also provided during the execution phase including: tightness checking, sequencing, cleaning, lubrication, baseline readings, torquing and cutting out seized bolts.

Article 3.22: Inspection and Repair of Shell and Tube Heat Exchangers

- Covers inspection, testing and repair techniques for S/T HX's, including the tube bundle, tubesheet, shell and other components.
- Considerable guidance is provided on what design issues should be evaluated, based on the findings from inspection.
- Covers different repair considerations for leaking tube to tubesheet joints, including: rolling, plugging, seal or strength welding, retubing, and various methods of T/S repairs.
- Various tubular cleaning methods are discussed, including water blasting, chemical cleaning and abrasive blasting.
- The pros/cons of various common types of tubular inspection techniques are covered including: IRIS, EC, RFEC, PSEC, MFL, VT, RT, along with an appendix that provides guidance on how to select the minimum number of tubes to inspect.

Part 5: Examination and Testing (1 New)

- **Article 5.3** **NDE in Lieu of Pressure Testing for Repairs and Alterations**

Article 5.3: NDE in Lieu of Pressure Testing for Repairs and Alterations

- Covers issues to consider (pros/cons) when a pressure test (PT) may not be practical or when NDE can be shown to be more effective or safer than a PT.
- Supplements article 5.1 which covers guidance on safe and effective methods of PT.
- Starts with several valid reasons why PT is advisable in the first place, but then lists several good examples of when pressure testing may be inadvisable or impractical.
- Includes an overview table of 14 NDE methods that may be useful in lieu of PT, listing what each can do along with advantages and limitations.
- Also includes a list of typical repairs or alterations that generally to not need pressure testing.

ASME Post Construction Committee (PCC-2) Repair and Testing

Closing Comments:

- PCC-2 is a standard that describes and documents "*recognized and generally accepted good engineering practice*" for the repair of pressure equipment and piping after being placed in service
- First edition (2006) contains 17 R&T articles
- Second edition (2009) contains 10 more R&T articles
- Work continues on 10-12 additional articles to be included in the next edition
- All stand-alone articles are designed to integrate with and be referenced by existing codes and standards on In-Service Inspection and Repair Codes
- Ideas for additional articles, and company repair procedures to consider, are needed and welcome
- Committee members willing to attend meetings, prepare more articles, and comment on ballots are needed and welcome

Those are the Highlights of ASME PCC-2: Repair of Pressure Equipment and Piping

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Questions and Comments?

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