Technical Publication

Pressure Part Replacement In-Kind, Upgrade, Redesign

"What are your options and how do you make the right decision?"

by

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ABSTRACT

When replacing pressure parts in today's competitive Power Industry, considerations must include initial costs, reliability and flexibility. Combinations of changes from the original designed operation, changing fuels, extended periods between outages, and operating in excess of capacity are only a few of the issues faced by utilities in today's aging power market. To meet these considerations with an optimized design, it is important to develop an engineered approach when replacing Pressure Parts.

This paper reviews an engineered approach and provides guidance for the replacement of pressure parts.

INTRODUCTION

As part of the continuing effort to improve the replacement of pressure parts, Riley Power Inc. (RPI), a Babcock Power company, is continually working to offer the best replacement options. Based on years of experience, RPI has developed an engineered approach for evaluating and selecting the optimum pressure part replacement option. The initial sections of this paper review the engineered approach as titled the "decision making process".

Also this paper reviews design guidelines on pertinent topics including a) material selection, b) Code issues and c) construction input. The purpose of these sections is to give the reader more knowledge on engineering associated with pressure part replacement projects. The more knowledgeable the owner the more efficient the RFQ (request for quote) process and bid evaluation process.

Lastly this paper reviews scheduling. This section summarizes typical major tasks and associated time requirements. Proper scheduling allows time to optimize the engineering design and optimize costs.

The best projects always seem to have a knowledgeable owner, knowledgeable pressure part designer and a combined willingness to work together.

DECISION MAKING PROCESS

When first initiating a pressure part replacement many questions arise such as: How to approach a pressure part replacement? What are the options? Which is most appropriate: in-kind replacement, an upgraded design or a complete redesign? What "up front" work is required? Are there future considerations to account for?

The first step is to determine the design that best fits your needs. The replacement options include: In-kind, Upgraded and Redesign. It is important to understand each of these options in terms of the evaluation criteria and data requirements needed to make the decision.

Understanding Your Replacement Options

The following reviews the definition of the Pressure Part replacement options and the associated evaluation criteria.

In-kind Replacement

Definition: In-kind replacement, simply defined, is a duplicate surface replacement with tube metals equal or better than the original. In-kind replacement indicates that the fabrication and installation have the same design, fabrication and load transfer configuration as the original part, subassembly or system. This criterion includes the same basic tube bundle configuration, tube diameters, tube wall thicknesses and same surface quantity. Upgrade replacement materials utilized in the same heating surface as the original design are permitted. The National Board Inspection Code treats this as a "Repair".

The evaluation criteria include:

- ❑ Satisfaction with the current heat transfer performance
- ❑ Satisfaction with the current mechanical reliability
- ❑ The future outlook for the boiler has no changes in the operating conditions or fuel(s) fired

Upgrade Replacement — Leading to Alteration Status

Definition: Upgrade replacement utilizing the same heating surface as the original design. Upgraded tube metals and/or supports locations. New tube code wall thickness calculated for new materials. Steam side pressure drop analyzed due to tube wall thickness changes. Possible orificing required to balance tube to tube steam flows. The National Board Inspection Code also treats this as an "Alteration".

Upgrade Replacement evaluation criteria include:

- ❑ Satisfaction with the current heat transfer performance
- ❑ Impact of material upgrades from ferritic to austenitic steels
- ❑ Dissatisfied with the current mechanical reliability
- ❑ Future out-look may have changes in the operating conditions and/or fuel(s) fired

Redesign Replacement

Definition: Changes in heating surface. New heat transfer calculations are required to be performed. Upgraded tube metals, tube diameters and thicknesses and/or support locations. Complete tube metals analysis with new minimum wall thicknesses calculated. Steam side pressure drop analyzed due to tube wall thickness changes. Possible orificing required to balance tube to tube steam flows. The National Board Inspection Code treats this as an "Alteration".

The evaluation criteria include:

- ❑ Dissatisfied with the current heat transfer performance
- ❑ Dissatisfied with the current mechanical reliability
- ❑ Future out-look may have changes in the operating conditions and/or fuel(s) fired

Evaluation Factors to Make the Decision

To select the replacement option that best meets your specific requirements, certain decision factors need to be reviewed and evaluated. The decision factors are categorized as: Performance Criteria, Mechanical Reliability and Future Operating Conditions.

1. Performance Criteria

Is the subject pressure part performance meeting your expectations? Can the performance be improved? Typical performance decision factors to review include:

- ❑ Steam temperatures (high, low and turndown)
- ❑ Spray attemporation flow rate (high, low)
- ❑ Fouling / plugging issues
- ❑ Tube temperature alarms problems
- ❑ Safety valve chattering and/or premature lifting problems
- ❑ High draft loss issues
- ❑ High exit gas temperature problems
- ❑ Low boiler efficiency

2. Mechanical Reliability

Is the subject pressure part reliable? Typical mechanical decision factors include:

- ❑ Tube failure problems
- ❑ Erosion issues
- ❑ Corrosion issues
- ❑ Support issues (alignment, bowing, sagging, expansion)
- ❑ Header ligament cracking
- ❑ Header and piping problems

3. Future Operating Conditions

Are the operating conditions going to change in the future and will these new conditions affect the pressure part design? Typical future operating decision factors include:

- ❑ Fuel changes (main fuel changes and/or co-firing)
- ❑ Operating parameter changes (load ramping/shedding, constant pressure/variable pressure, increased capacity, reheat steam flow changes due to turbine upgrades)

Data Requirements

Up-front data gathering is an important part of this analysis. This includes gathering historical data and analyzing expected future operating conditions.

1. Historical Data

- ❑ Summarizing past historical performance data
- ❑ Summarizing past historical mechanical reliability

2. Future Outlook

- ❑ Analyzing expected future fuels
- ❑ Analyzing expected future operating conditions

These tasks are time consuming and tedious but essential when evaluating the optimum pressure part replacement. Establishing procedures to continuously monitor this information during years of operation will make data collection much easier when the time for pressure part replacement occurs.

Engineering Study

If time permits, an Engineering Study should be performed prior to any major pressure part modification. The objective of this study is to perform up-front engineering, review the decision process, and evaluate options. A number of computer modeling programs could be utilized to model the existing boiler geometry and operating conditions. These models would be helpful in quickly generating predicted performance for numerous retrofit options. Typical results are as follows:

- ❑ Evaluates the "total picture" including the effects on other equipment
- ❑ Better defines the project costs
- ❑ Better defines the associated risks and identifies ways to reduce these risks
- ❑ Establishes a firm project direction and action plan
- ❑ Reduces disagreements and misunderstandings during the contract
- ❑ Typically saves money over the total project
- ❑ Installs confidence in approach selected

TUBE METALS SELECTION

Selecting the proper materials to be used during a pressure part retrofit is critical in order to maximize the reliability and life of the pressure part. In recent years the number of retrofits involving material upgrades has increased as utilities strive to improve upon existing material designs. Improperly designed metals can reduce the reliability, life, capacity, and increase EFOR (Equivalent Force Outage Rate) of the boiler.

Design Criteria

The subject of "tube metals" typically refers to the tube material type and minimum wall thickness. The following are the two primary criteria used for boiler tube metals selection:

1. Tube Metal Temperature Limit (Oxidation temperature)

- ❑ The temperature at which metal degradation begins
- ❑ Basis for selection of tube material
- ❑ Typically the maximum tube metal temperature occurs at the crown of the tube

2. Tube Minimum Wall Thickness

- ❑ The tube wall thickness required to operate at the design pressure and temperature
- ❑ Calculated in accordance with Section I of the ASME Boiler and Pressure Vessel Code
- ❑ Allowable stress values are chosen based upon the material type and the average tube metal temperature (mid-wall temperature)

Other design considerations include:

- ❑ Corrosion
- ❑ Thermal Expansion
- ❑ Welded attachments
- ❑ Tube rolling
- ❑ Support Loading
- ❑ Erosion
- ❑ Steam side pressure loss
- ❑ Cost
- ❑ Manufacturing (bending, thinning, ovality, area reduction, etc.)

Common Boiler Tube Materials and Typical Uses

The most common boiler tube materials consist of carbon, low alloy and stainless steels. In addition, special Nickel/Chrome alloys are beginning to enter service in the most extreme service environments. Table 1 lists common boiler materials.

Table 1

Common Boiler Tube Materials

Carbon Steel	Low Alloy Steel	Stainless Steel	Ni-Cr Alloy Steel
SA-178 A	SA-209 T1	SA-213 TP304H	SB-407 800
SA-178 C	SA-213 T2	SA-213 TP310H	SB-407 800H
SA-192	SA-213 T11	SA-213 TP316H	SB-407 800HT
SA-210 A1	SA-213 T12	SA-213 TP321H	
SA-210 C	SA-213 T22	SA-213 TP347H	
	SA-213 T91		

The chemical composition of the boiler materials governs the material's properties. Of particular importance is the material's Chromium, Nickel and Molybdenum content which governs the material's strength and corrosion resistance. Increases in any of these three elements will result in a higher cost of the material. Table 2 summarizes the chemical compositions of the most common boiler tube materials.

Table 2

Chemical Composition, % by Weight

<table>
<tr><th>Element</th><th>178 A</th><th>178 C</th><th>192</th><th>210 A1</th><th>210 C</th><th>T1</th><th>T1A</th><th>T2</th><th>T11</th><th>T12</th><th>T22</th><th>T9</th><th>T91</th><th>TP304H</th><th>TP310H</th><th>TP316H</th><th>TP321H</th><th>TP347H</th><th>800 ERW</th><th>800</th><th>800H</th><th>800HT</th></tr>
<tr><td>C</td><td>0.06-0.18</td><td colspan="2">0.35 max</td><td>0.27 max</td><td>0.35 max</td><td>0.10-0.20</td><td>0.15-0.25</td><td>0.10-0.20</td><td colspan="3">0.05-0.15</td><td>0.15 max</td><td>0.08-0.12</td><td colspan="5">0.04-0.10</td><td colspan="2">0.02</td><td colspan="2">0.08</td></tr>
<tr><td>Si</td><td colspan="2">-</td><td>0.25 max</td><td colspan="2">0.10 max</td><td>0.10-0.50</td><td>-</td><td>0.10-0.30</td><td>0.50-1.00</td><td colspan="2">0.50 max</td><td>0.25-1.00</td><td>0.20-0.50</td><td colspan="5">0.75 max</td><td colspan="4">0.35</td></tr>
<tr><td>Mn</td><td>0.27-0.63</td><td colspan="2">0.80 max</td><td>0.93 max</td><td>0.29-1.06</td><td colspan="2">0.30-0.80</td><td>0.30-0.61</td><td>0.30-0.60</td><td>0.30-0.61</td><td colspan="3">0.30-0.60</td><td colspan="5">2.0 max</td><td colspan="4">1.00</td></tr>
<tr><td>P</td><td colspan="5">0.035 max</td><td colspan="7">0.025 max</td><td>0.20 max</td><td colspan="5">0.04 max</td><td colspan="4">0.02</td></tr>
<tr><td>S</td><td colspan="5">0.035 max</td><td colspan="7">0.025 max</td><td>0.010 max</td><td colspan="5">0.03 max</td><td colspan="4">0.01</td></tr>
<tr><td>Cr</td><td colspan="7">-</td><td>0.50-0.81</td><td>1.00-1.50</td><td>0.80-1.25</td><td>1.9-2.6</td><td>8.0-10.0</td><td>8.0-9.50</td><td>18.0-20.0</td><td>24.0-26.0</td><td>16.0-18.0</td><td colspan="2">17.0-20.0</td><td colspan="4">21.0</td></tr>
<tr><td>Ni</td><td colspan="13">-</td><td>8.0-11.0</td><td>19.0-22.0</td><td>11.0-14.0</td><td colspan="2">9.0-13.0</td><td colspan="4">32.0</td></tr>
<tr><td>Mo</td><td colspan="5">-</td><td colspan="5">0.44-0.65</td><td>0.87-1.13</td><td>0.90-1.10</td><td>0.85-1.05</td><td colspan="2">-</td><td>2.0-3.0</td><td colspan="6">-</td></tr>
</table>

The material type is selected based on the material's tube metal temperature limit (oxidation limit) and the maximum expected metal temperature (typically occurs at the crown of the tube). Figure 1 displays the recommended maximum temperature limitation for the common boiler tube materials. Figure 2 displays the general uses for common boiler materials.

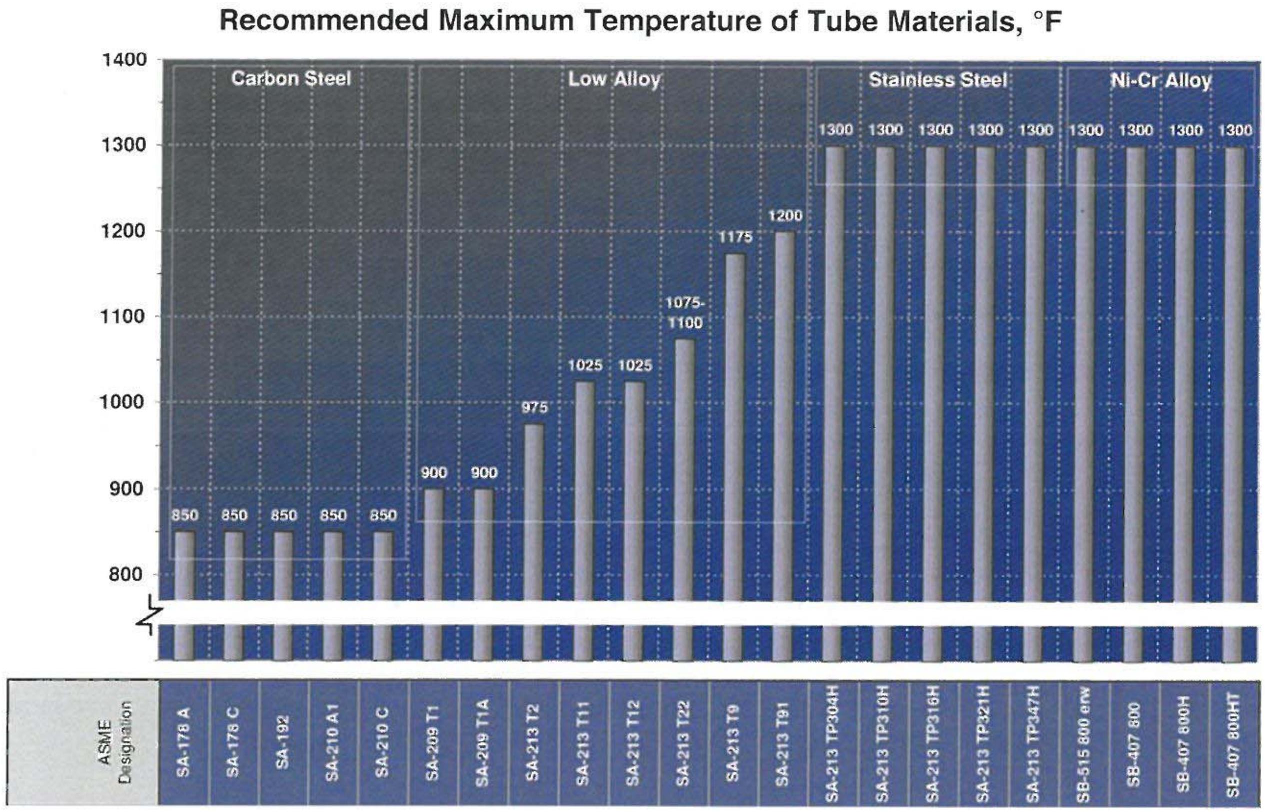

Figure 1.

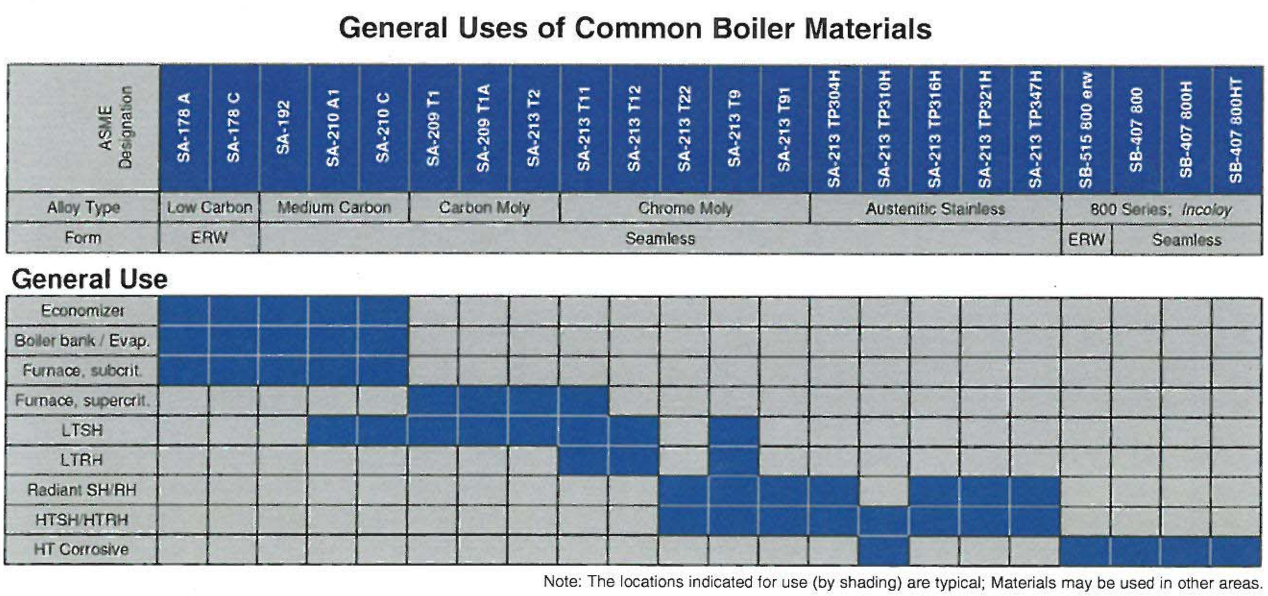

Figure 2.

Minimum Wall Thickness

Once the material type has been selected, the minimum required wall thickness can be calculated. The minimum wall thickness is calculated in accordance with Section I (Power Boilers) of the ASME Boiler & Pressure Vessel Code (BPVC) and is a function of the tube O.D., the design pressure of the boiler (Maximum Allowable Working Pressure, MAWP), and the allowable stress of the chosen material. The allowable stress is evaluated at the design temperature using the tables included in Section II, Part D, Tables 1A and 1B of the ASME B&PV Code. The design temperature of the material is evaluated at the tube mid-wall. Figure 3 displays the maximum allowable stress as a function of temperature for common boiler materials. The stress values summarized in Figure 3 are taken from the 2005 Addendum to the 2004 Edition of the ASME B&PV Code.

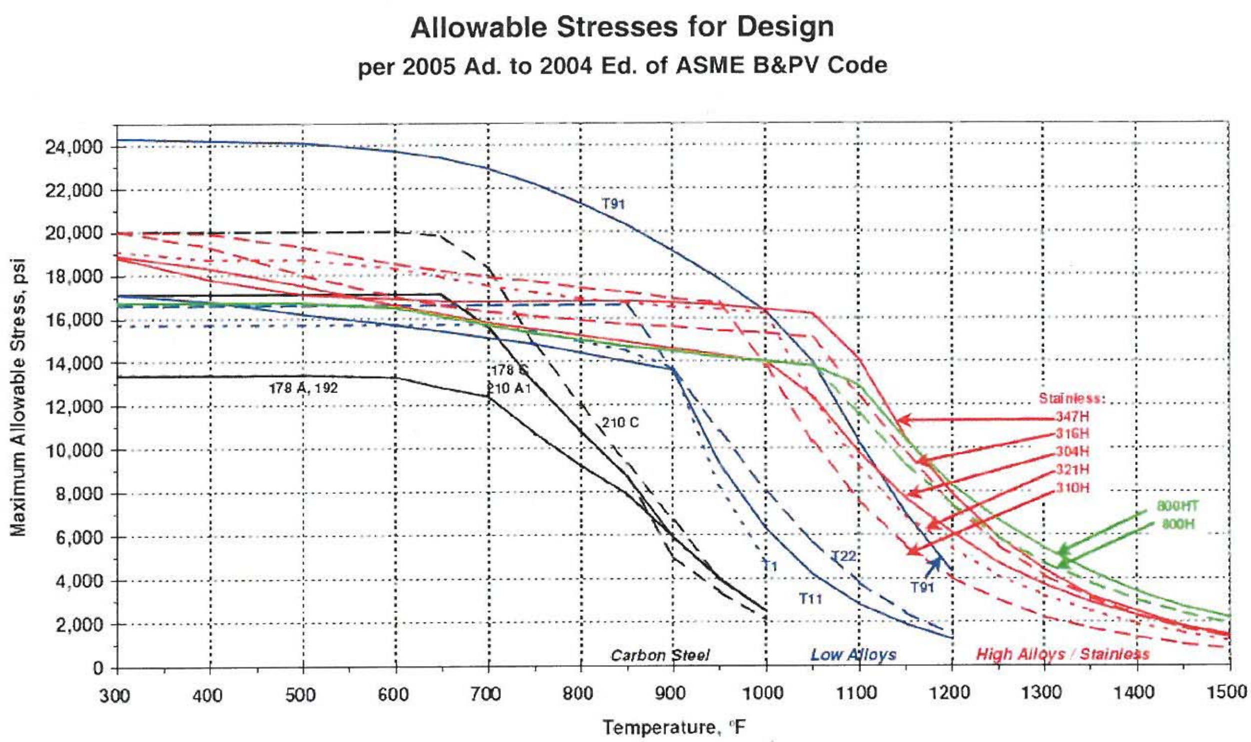

Figure 3.

New Products

New products are being used in the industry in an attempt to reduce the material costs and increase the reliability and life of the pressure parts. Two examples of new products now being used in pressure part retrofits include hot finished tubing and weld overlay.

1. Hot Finished Tubing

Hot finished tubing as opposed to cold finished tubing is tubing formed to final size and surface finish in the initial, hot extrusion process, with no additional cold drawing process. The elimination of the cold drawing process results in increased dimensional tolerances and inside surface roughnesses as compared to cold finished tubing. Consequently, hot finished tubing is a lower cost alternative to cold finished tubing when increased dimensional tolerances and increased inside surface roughness are acceptable. (Refer to ASTM A450 for tolerance specifications.)

In certain applications, the increased dimensional tolerances and increased inside surface roughness are not acceptable. In these instances, "tight tolerance" hot finished tubing can be selected, still resulting in a cost savings compared to cold drawn tubing. "Tight tolerance" hot finished tubing implies hot finished tubing to cold finished tolerances. This is often times specified as HF=CF, or by various trade names including Super Hot Finished and Close Tolerance Hot Finished.

2. Weld Overlay

Weld overlaid tubing is used today for the mitigation of corrosion and erosion in many fossil fuel and waste to energy boilers. After applying weld overlay to straight lengths of tubing, the weld overlaid tubing can be bent to suit almost any boiler application. Weld overlay is used in place of tube shields for erosion protection in sootblower lanes and in areas of high flue gas velocities. Weld overlay is used for corrosion protection on the furnace waterwall tubes of waste to energy units and fossil fuel boilers firing high sulfur coal and utilizing staged combustion. Weld overlay is also used as an alternative to stainless steel for corrosion protection on superheater and reheater tubes.

Commonly used weld overlay materials include nickel and stainless alloys including Inconel 625 or 622 and 309 or 310 stainless steel. Typical weld overlay deposition thickness ranges from less than 0.050 inches to 0.070 inches depending on the application.

New Materials

As power plant designers strive to increase the plant efficiencies, the boiler operating conditions continue to be increased beyond the limits of the common boiler materials. As a result new materials are being developed for use in these more advanced power stations. Several new materials are discussed below.

1. SA-213 T91

T91 is a 9% chrome 1% molybdenum ferritic alloy steel that has been successfully used in the power industry since the early 1990s. As a result, long-term operational data and feedback is now becoming available. Due to its strength at elevated temperatures and its increased corrosion resistance compared to T22, T91 is ideal for high temperature superheater and reheater tubing and piping (SA-335 P91) applications.

The advantages of T91 include:

- ❑ Cost effective, intermediate material used between T22 and stainless steel
- ❑ Thermal expansion is similar to carbon steel and ferritic steels
- ❑ Higher strength as compared to T22 allowing for less wall thickness and less weight

Of particular importance when selecting T91 is that the material does present difficulties when welding. All T91 welds, whether of similar or dissimilar base metal composition, require strict adherence to pre-heating and post weld heat treating procedures. As a result, welding T91 in the field should be avoided when possible.

2. SA-213 T92 (ASME Code Case 2179)

T92 is a similar material to T91; however, tungsten is utilized as an alloying element with a resulting reduction in molybdenum content. The resulting T92 alloy has an increased strength at elevated temperatures compared to T91. T92 is an appropriate selection for superheaters and reheaters on boilers designed with steam temperatures 1050-1110°F.

Because T92 is also a 9% chrome material similar procedures as to T91must be followed when making similar and dissimilar T92 welds

3. T23 (ASME Code Case 2199) & T24

T23 and T24 are being developed for use as waterwall tubing for high temperature, high pressure applications required in Ultra-Super Critical (USC) furnaces. T23 and T24 modify the T22 alloy by reducing the carbon and molybdenum content and adding tungsten (T23) or titanium (T24). Both have a higher strength and creep resistance compared to T22 and neither T23 nor T24 require post-weld heat treatment of furnace waterwall panels. Post weld heat treatment is required for T22 waterwall panels to reduce the hardness in the heat affected zone. Post weld heat treatment of waterwall panels is difficult due to the size of these components and the potential resulting distortion.

Results from initial tests have shown that T23 may be susceptible to weld cracking. This cracking appears to be avoided with the use of T24.

4. Super 304H (ASME Code Case 2328)

Super 304H is an austenitic stainless steel with 18% Chrome and 9% Nickel (compared to 8% Ni for SA-213 TP304H). The increased nickel content increases the oxidation limit and corrosion resistance of Super 304H compared to SA-213 TP304H. In addition, Super 304H is stronger at elevated temperatures than both SA-213 TP304H and TP347H. As a result, super 304H is applicable for USC boilers with steam temperatures in excess of 1200°F.

Interesting Notes

- ❑ The higher the material grade (higher chrome and nickel content) the higher the cost
- ❑ If the steam side pressure drop is high, upgraded materials with increased strength can be used which in-turn allows the wall thickness to be thinned. Reducing the tube wall thickness results in an increased ID and lower pressure drop
- ❑ Tubing normally is manufactured in forty foot lengths but can be special ordered longer. This is important when designing for reduced welded joints

BOILER CODE DISCUSSION

The subject of codes is fairly extensive since there are numerous codes to consider when replacing boiler pressure parts. It is important that all codes associated with pressure part replacements are fully comprehended and adhered to. The following lists the "national" Codes typically associated with pressure part replacement.

1. ASME Boiler and Pressure Vessel Code

- ❑ Section I
- ❑ Section II
- ❑ Section IX

2. ASTM Material Specifications

3. AMBA Industry Standards

4. ANSI

❑	B16.25	Buttwelding Ends
❑	B16.5	Steel Pipe Flanges and Flanged Fittings
❑	B31.1	Code for Pressure Piping, Power Piping

5. National Board Inspection Code

Based on the the writer's experience, this section will discuss interesting areas of the Codes that come-up frequently during a pressure part replacement project.

- ❑ Local Codes — State/Local Jurisdictional Requirements
- ❑ ASME BPVC, Section I — Power Boilers
- ❑ National Board Inspection Code
- ❑ EPA, New Source Review

Local Codes

One item that comes up on many customer RFQ's is when the specification document lists the applicable national codes and also has the statement that all local codes apply. The problem is that many of the Pressure Part manufacturers are not local to the subject boiler and may not be knowledgeable of local codes and special jurisdictional requirements. If there are local codes that deviate or are in addition to the national codes, it is recommended that these differences be listed in the RFQ. A good example of this is prior to the incorporation of Code Cases 2290 and 2284 into the ASME BPVC regarding the reduction of the factor of safety on tensile strength from 4.0 to 3.5. Being certain of the local Code ensures that the design meets all of the customer's desires during the contract phase.

ASME BPVC (Boiler Pressure Vessel Code), Section I

The majority of the boiler and pressure components in the United States today are designed and manufactured in accordance with the ASME Codes. ASME BPVC Section I, Rules for Construction of Power Boilers, is termed a New Construction Code but is also applied to boiler repairs, as it is applicable to the materials, design, fabrication, examination, inspection, testing, certification and pressure relief of a power boiler in accordance with a specific Code edition and addenda. The ASME process requires that the manufacturer of a boiler or the pressure components complete and sign the applicable ASME Data Reports to verify that the construction meets all the requirements of the Code. Upon the completion of the boiler — including hydrostatic testing and the stamping and installation of the nameplate — the applicable data reports are filed with the National Board. Permanent files are maintained at the National Board to ensure that records of the details of the original construction of the boiler are available.

Code Revisions

The requirements of the ASME BPVC's are not retroactive, however, there have been revisions to the Code, which have improved the reliability in the fabrication of pressure components. When making repairs or replacement parts the consideration of the current Code requirements should be carefully examined.

An example of this is Section PG-19 of the Section I Power Boiler Code. Prior to the 1999 Addenda of the 1998 Edition of Section I, the heat treatment of highly strained austenitic materials, such as those which have been cold formed, had not been a Code requirement. The Code has been revised and the heat treatment for the cold forming of highly strained austenitic materials is now a requirement. This has improved the Code and should be considered for all such austenitic pressure part replacements regardless of the boiler vintage. In reality, most of the original equipment manufacturers (OEMs) recognized the need to perform the heat treatment of austenitic fabrications with high strains and heat treating was part of the OEMs standard manufacturing practice. In contrast, the heat treatment process of highly strained cold-formed pressure parts was largely overlooked by non-OEMs prior to the Code revision.

National Board

Registration of the manufacturer's data report forms with the National Board is now mandatory in all the US States, and all the Provinces of Canada. A basic advantage of National Board registration is that the process provides a design record of the boiler pressure parts. When repairs or alterations are made to the boiler, these records are important in determining original design data of the pressure component.

It is also a role of the National Board Inspection Code [NBIC] to establish the rules of safety governing the repair, alteration and inspection of pressure-retaining items for existing boilers. Within the NBIC there is an important distinction made between the words "repair" and "alteration". There appears to be a great deal of latitude taken by the industry interpreting the definition of these two words. To this purpose, the NBIC also provides examples in order to guide the user in the replacement of boiler components in an effort to distinguish between repairs, replacement parts, upgrades and alterations.

Repair

Repair is defined as the process of restoring a boiler component(s) to a safe and satisfactory condition such that the existing design requirements are met. Often times, an existing pressure component cannot be repaired by the methods outlined in the NBIC and it is more economical to replace the component.

Replacement In-kind

The term "replacement in kind" and "replacement in kind to the latest Code" often appear in Customer specifications. Replacement in kind indicates that the fabrication and installation of pressure component shall have the same design conditions and appurtenances as the original pressure component, part, subassembly or system. Certain substitutions and changes to the original design are permissible and these variations are defined within the NBIC. "Replacement in kind to the latest Code" allows the ASME pressure part manufacturer to fabricate to today's Code. This allows the use of higher allowable stress values in certain cases; however, there shall be no physical alterations or design condition changes from the original design of the pressure component, part, subassembly or system.

Alteration

An "alteration" as related to pressure components is any change in the item described on the original equipment manufacturer's data report which affects the pressure containing capability of the pressure-retaining item. In addition, there are a number of non-physical changes, which denote an alteration. Such changes include increases to the design pressure (MAWP) of a pressure component and increases / decreases in design temperature.

The question then becomes "how do you differentiate between a repair / replacement and an alteration?" A basic rule of thumb should lead to the following questions to be asked when assessing an RFQ for existing pressure components, parts, subassemblies or systems.

1. For pressure components, their parts, subassemblies or systems thereof — is there a requirement to perform Code calculations?

2. Did you change any listed entry on the original ASME Data Report for any existing pressure component, part, or subassembly?

If the answer to any of the above questions is "yes", then there is high probability that the request is an "alteration" per the NBIC rules.

Documentation

As required by the NBIC, there are specified forms, which should be processed as the result of any repair, replacement or alteration of an existing pressure component, part, subassembly or system. These forms should also be filed with the National Board in order to insure that the changes and history associated with existing pressure components parts subassemblies or systems of an existing unit are known and maintained. It is the responsibility of the "R" Certificate holder performing the repair / replacement / alteration to prepare and file these forms with the National Board.

NBIC Form R-1 is for the repair / replacement of an existing pressure component, part, subassembly or system. NBIC Form R-2 is used for the alteration of an existing pressure component, part, subassembly or system. It should be noted that Form R-2 also requires a design certification by an company holding a "R" stamp / ASME certification which attests to the alteration of the pressure component, part, subassembly or system being in accordance with the NBIC and ASME Codes. Therefore a coordination effort must be considered by the "R" Stamp holder performing the alteration to obtain sign-off in the design certification portion of the R-2 form.

EPA, New Source Review

This is an environmental issue that is in much debate in the industry today. It is recommended that all redesigned pressure part replacements be reviewed with the local EPA authority for potential triggering of New Source Review. The basic rule is: Any physical or operational change to an existing facility that results in an increase in any pollutant initiates a New Source Review.

CONSTRUCTION

Construction input into the design is often forgotten during the initial design process but is critical for a successful project. The term "constructability" is commonly used in the industry today when referring to the "ease of construction". It is highly recommended that the erector have a direct input into the design of the replacement pressure part.

Pressure part replacement on existing boilers is more difficult than installing pressure parts on a new boiler. This is due to demolition, access around existing equipment, support of existing equipment, ambient conditions (cleanliness) and condition of remaining pressure parts.

It is also important to note that the existing equipment may not be in the same alignment as when new (due to bowing, differential thermal expansions, etc.) and the replacement part design may need to be flexible to account for possible field adjustments.

Constructability

The most common constructability inputs to the final pressure part design include element size, modularization, field weld locations, types of field welds and design features to allow flexibility for field adjustments.

1. Element Size

Element size is normally dictated by access space for installation. The objective is to design the pressure part as large as possible to reduce the number of field welds.

2. Modularization

Modularization is also controlled by access space. The objective is to shop assemble as much as possible to reduce field costs. When shop assembling, typically quality improves due to the controlled shop conditions. Of course, if the modules get to large, shipping and weight limitations may take precedent.

3. Field Weld Locations

Field weld locations go hand-in-hand with module sizes and access. The objective is to minimize the number of field welds and locate the field welds for accessibility.

4. Types of Field Welds

For quality reasons, ferritic to austenitic dissimilar welds are preferred to be done in the manufacturing facility opposed to in the field. Quality of ferritic to austenitic dissimilar welds improves in the shop due to the controlled environment. If this type of dissimilar weld is required at a field weld location, a shop installed "safe-end" is recommended so that the field is welding similar materials. A safe-end is a short tube section that has the dissimilar weld done in the shop.

5. Design Flexibility

Allowance for field adjustments. The design may require special features for constructing flexibility in the field. Common special features include:

a) If the cut-points are not consistent or fully known, add extra tubing material so that the field can "cut to fit"

b) Slit the membrane allowing for field flexibility when aligning tubes for welding

6. Construction Sequence

Construction sequence is important at times for the structural integrity of the boiler during erection. A plan needs to be established to either temporarily support existing equipment or sequence the construction to maintain the structural integrity.

SCHEDULE

Plan ahead, be prepared

As part of the any project, the schedule needs to be fully evaluated. For guidance when developing a schedule, typical components and timing of a pressure part replacement schedule from inception to completion include the following:

	Duration
1. Decision Making Process	
a) Up-front data gathering	8 weeks
❑ Historical performance and mechanical reliability	
❑ Future outlook	
b) Engineering study (if time permits)	6 weeks
c) Establish replacement option (in-kind, upgrade, redesign)	2 weeks
2. Order Preparation by Utility	
a) Write specification	4 weeks
b) RFQ process	6 weeks
c) Bid Evaluation	2 weeks
3. Initial Engineering (long lead materials)	3 weeks
4. Material Procurement	
a) Domestic	3-14 weeks
b) Foreign w/ shipment to United States	6-18 weeks
5. Constructability Study	2 weeks
6. Engineering	3-12 weeks
7. Manufacturing	
a) Domestic	12-14 weeks
b) Foreign	
8. Shipment	
a) Domestic (shipment within the United States)	1 week
b) Foreign (shipment to the United States)	4-5 weeks
9. Construction	6 weeks
10. Startup	1 week

Many of the above components will run in parallel so that the component time is not cumulative. The result is a schedule of 12 to 14 months; refer to Figure 4, a depiction of the potential schedule. Since we do not live in a "perfect world" there will be times that require an accelerated schedule. Being knowledgeable on normal major scheduling tasks, a shortened schedule can be better developed and the implications better understood.

Pressure Part Replacement Schedule

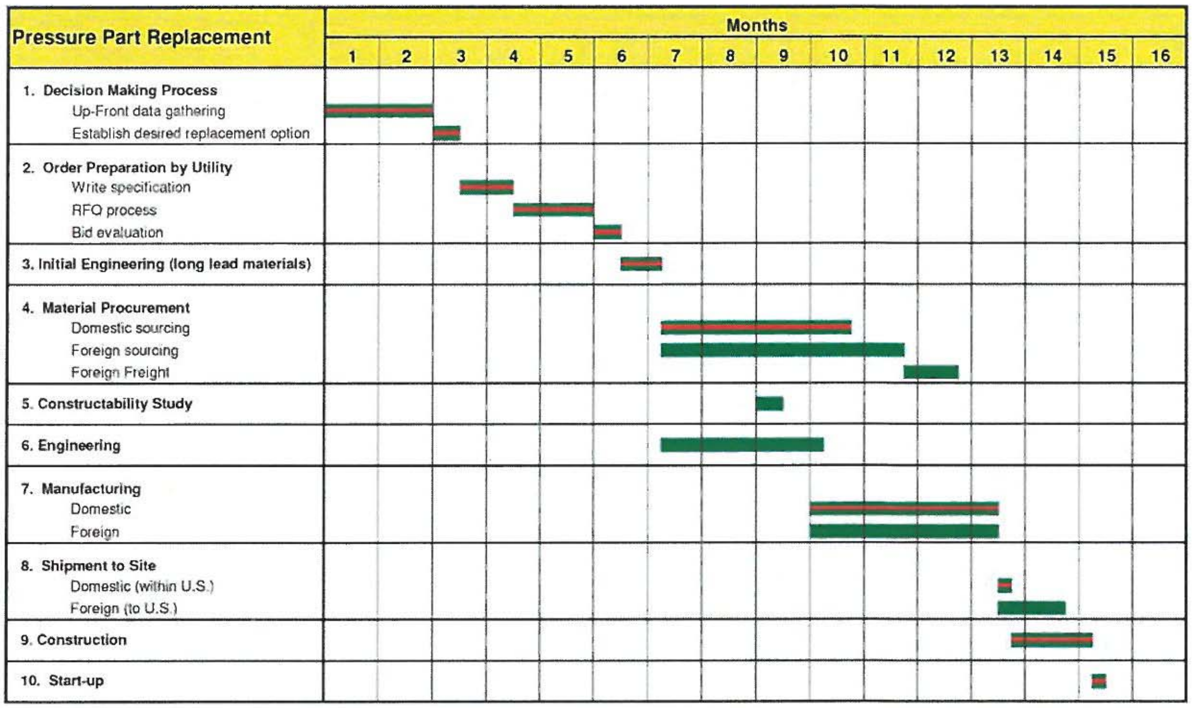

Figure 4.

CONCLUSION

In summary, this paper addressed a recommended engineering approach for pressure part replacement, pertinent engineering topics and scheduling. The writers sincerely hope that this information is both useful and helpful on future projects.

There are other great topics to discuss concerning pressure part replacement but were not included due to the length constraints of such a paper. These topics include:

- ❑ Support and Alignment Mechanical Design
- ❑ Sourcing Options (domestic, foreign)
- ❑ Quality
- ❑ Transportation

Future papers will address these topics.