Sense & Nonsense of Welding Procedure Qualification

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ARC Specialties Engineering & Consulting Services
Chair, AWS Technical Activities Committee
Experience

• ‘73 graduate of TOSU
• Employment experience
  – 35+ years at three different consulting companies in Columbus, Ohio including 11 years at EWI
  – Currently Senior Welding Engineer of ARC Specialties Engineering & Consulting Services
• Joined first AWS committee in 1978
  – Member: Education, A2, B1, D1, D14, and TAC
  – Currently Chair of A2b (Terms & Definitions) and TAC
AWS technical committees

• Technical Activities Committee (TAC)
  – Guides development and maintenance of all AWS technical standards
  – Consists of the Chairs of all AWS technical committees plus 6 at-large members
  – Assures that the AWS standards comply with ANSI standards
    • Developed by a “balanced” committee membership
    • Reviewed and either revised or reinstated in compliance with the ANSI 5-year renewal rule
Introduction

• Most of this presentation was originally presented at AWS Codes & Standards Conference in Orlando in July

• Original plan was to discuss the Technical Activities Committee’s efforts over the past 10+ years to standardize the manner in which welding procedures are qualified
  – And to bring attention to AWS B2.1, Standard for Welding Procedure and Performance Qualification
• What has evolved however is a more global look at the qualification activity we are all engaged in at one time or another

• For this presentation, I have provided a local flavor by discussing the Houston way of qualifying procedures for corrosion-resistant overlays (CROs)
More than 10 years ago, upon the urgings of Walt Sperko, TAC sought to minimize the differences among AWS fabrication standards with regard to welding procedure qualification

– More than a dozen standards addressed procedure qualification

– All the same but different

Standards committees urged to embrace AWS B2.1
AWS B2.1

• AWS’s version of ASME Section IX
• Desirable features
  – M-number groupings (comparable to P-numbers)
  – Position **not** an essential variable
  – Means of qualifying fillet welds for both strength and soundness in a single testpiece
  – Simplified, standardized testing requirements
• A concentration on essential variables affecting metallurgical characteristics of a welding procedure
One of the most powerful extensions of AWS B2.1 is the Standard Welding Procedure Specification (SWPS)

- Based on multiple previously qualified procedure qualification records (PQRs)
- SWPS limitations are the most stringent of all those PQRs
- The Navy is developing a series of SWPSs for use by contractors and their suppliers
- This same approach has been suggested for future nuclear construction
D14 — Leading the charge

- D14 standards provide fabrication requirements for a variety of equipment, including: cranes, presses, construction & agriculture equipment, and rotating elements of equipment
  - In D14.3, the base metal groupings portion of the document was bigger than the rest of the document
  - The 2005 edition of D14.3 specified B2.1 as the qualification standard and allowed the use of Standard Welding Procedure Specifications (SWPSs)
  - B2.1-BMG published as separate document and is available as a free download on AWS website

Houston AWS Section—9.18.13 - 9
Status of this harmonization effort

• Those accepting procedures qualified per B2.1
  – D14.1 through D14.8
  – D1.1 and D1.3 (with Engineer’s approval)
  – D1.6 (if conflicts exist, D1.6 requirements prevail)
  – D9.1

• Those specifying B2.1 for qualification
  – D14.3
  – D17.1

• Success???
Lessons learned

• Too busy looking for differences to see the common aspects
• Legacy is powerful
• Often people expect more than a welding procedure can provide
  – The manner in which a procedure is qualified becomes insignificant if it isn’t followed
What is a welding procedure?

• It’s a “recipe” for the creation of an acceptable weld
  – It specifies the “ingredients” and instructions how they are combined

• The essential variables for welding procedures should be those factors that can affect the metallurgical result of the welding process
  – We are trying to establish weldability
Excessive essential variables

• Specifying essential variables that have no effect on the metallurgical properties of the weld just add cost
  – Examples include:
    • Position of welding
    • Base metal specivity
    • Industry/application specivity

• AWS B2.1 levels the playing field and, like ASME Section IX, pays attention to the variables that matter
  – Provides a means of addressing production constraints that could reduce the potential for success of a procedure
  – Provides a means of qualification that is not application-specific
Practical benefits of AWS B2.1

- Procedures recognized by multiple AWS standards, as well as ASME
- Flat position qualifies all positions
- Plate qualifies pipe without diameter limitation
- Base metal groupings (consistent with ASME Section IX)
- \( \frac{3}{4} \) in weld thickness with 1\( \frac{1}{2} \) in test coupon qualifies up to 8 in thick
Overcoming the roadblocks

• D1.1 is the elephant in the room
  – It’s all about what’s different
  – Don’t want to require their customers to buy another book
  – Major stumbling blocks
    • Position ⇒ essential variable for toughness applications
    • Material grouping ⇒ use B2.1-BMG
    • Essential variables ⇒ use existing Table 4.5
• Too much emphasis on qualification, but too little attention given to the control and performance of a WPS
  – Deficiencies in the control and verification of production welding is what can easily lead to weld rejects
  – Monitoring the performance of a qualified WPS in the production environment is critical to assure that the process can be operated successfully
Invest wisely

- Rather than requalifying a procedure, perform auxiliary testing to enhance the procedure
  - Verify the specified ranges of an existing procedure
    - Like D1.5 min-max heat input rate (HIR)
  - Verify the ability of a qualified procedure under production conditions
    - Use mock-ups to simulate specific joint configurations and/or inaccessibility
    - Recommended as alternate qualification approach by B2.1, D14.3 and D17.1
B2.1 Summary

• Let’s take advantage of the flexibility offered by procedures qualified in accordance with B2.1
• Let’s quit wasting our money retesting the same procedures over and over again
• Requalification of a procedure does not guarantee success as much as careful monitoring of existing procedures
• Since entering the Houston market, have been re-educated regarding qualification
• ARC E&C works with its customers to develop and qualify welding procedures for use on their equipment
  – Both overlay and “strength” welds
Qualification requirements

• Must satisfy ASME, API, and NACE requirements
  – Plus the variations and interpretations of the OEMs
  – To develop an effective qualification program, must consider of all of these requirements
  – Finding materials, especially welding filler materials, to meet these requirements is a challenge
Qualification issues

• **Use of *boutique* test materials**
  – Pretested materials can be purchased for qualification
  – Heat-treated to withstand long PWHT times
  – No concern for Carbon Equivalent (CE)
  – More importantly, no limitation for CE of production materials

• *CE should be included on PQRs and become a limitation of WPS*
• Chemical composition determines how a steel will react to heat treatment and preheat
  – CE = %C + (%Mn+%Si)/6 + (%Cr+%Mo+%V)/5 + (%Ni+%Cu)/15
  – Higher the CE ⇒ higher preheat temperature

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Hardness testing

• NACE MR0175 requires hardness testing
  – Max HAZ hardness = 250 HV\textsubscript{10}
    • “As close to fusion line [weld interface] but no more than 1mm away”
  – Some cases allow the use of HR\textsubscript{C}
    • 22 HR\textsubscript{C} maximum
    • No more than 2mm away from fusion line
    • 22 HR\textsubscript{C} is too close to the point where the HR\textsubscript{C} scale is no longer accurate (20 HR\textsubscript{C})
      – Recommend using Rockwell A-scale
ASME allows WPS preheat temperature to be up to 100°C less than PQR temperature.

For CROs, WPS heat input rate (HIR) permitted to be 10% higher than PQR.

- Permissible to list amps, volts and travel speeds that would result in a higher HIR if the maximum amps & volts and minimum travel speed used.

Use of 32h PWHT for PQR allows for up to 40h WPS limit.
Summary and recommendations

• Develop a consensus qualification standard with consistent, and realistic, requirements
  – Eliminate the “moving target” for suppliers
  – Get input from the ultimate users

• Make CE an essential variable

• Develop a hardness testing requirement that allows for consistency

• Put the emphasis on control of production welding
  --- not procedure qualification!