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NSRP | National Shipbuilding Research Program

Mechanical Property and Fabrication Cost Comparison of Purchased HFRW Structural Shapes vs GMAW Fabricated Structural Shapes

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NSRP All Panel Meeting
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- NSRP program oversight provided by
  - Chad Bryant – NSRP Technical Director
  - Alicia D'Aurora – SDMT Panel Chair
  - Lee Kvidahl – Project Technical Representative (PTR) and Welding Technology Panel Chair

Agenda

- Background
- Benefits and ROI
- Goals & Objectives
- Team
- Technical Approach
- Next Steps

Background

- In the early 1980s, NAVSEA approved Ingalls and Bath Iron Works to use HSLA-80 t-stiffeners designed for high frequency resistance welding (HFRW) and installed them on the CG-47 guided missile cruisers (Aegis Class)
  - CG-47 Cruisers are still in service and there have been no reported failures of the HFRW t-stiffeners in their 30+ years of service
  - After all ship sets were provided for the Aegis Class, the HFRW t-stiffener supplier went out of business
  - After that, the Navy didn't look for another supplier

Background *(cont'd)*

- Electric Boat is looking for alternatives for HY-80 fabricated shapes
- After an industry search, Thermatool was identified as a leader in HFRW structural shape design and production
- Electric Boat is actively engaged with Thermatool to incorporate HFRW structural shapes into the COLUMBIA Class Design

Background *(cont'd)*

- The prior NAVSEA approval to use HFRW t-stiffeners (and all supporting documentation) cannot be located as result of records being moved from one location to another
  - Therefore some level of re-qualification is needed to allow use on existing or planned ship platforms
- Hollow structural shapes ("tube") in high strength steel grades per ASTM A-500 are approved for submarine use; however, high strength low alloy steel grades (HSLA / HY) are not
- Electric Boat is interested in using HY-80 HFRW tube as they are believed to be equivalent in strength to the gas metal arc welded (GMAW) fabricated HY-80 tube currently used in submarine and surface ship construction
  - By replacing a fabricated HY-80 structure with a purchased standard shape, Electric Boat will realize a significant reduction in fabrication costs, decreased fabrication time, and decreased distortion

Background *(cont'd)*

- HFRW tube is designed differently than structural shapes fabricated with GMAW
  - HFRW formed and welded tube is 1 part with 1 weld
  - GMAW fabricated tube is 2 formed "L" shapes with 2 welds

Figure 1. Tube Designed for HFRW

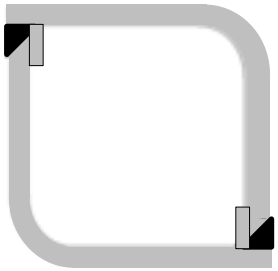


Figure 2. Tube Designed for GMAW

- HFRW tube is also more dimensionally accurate and consistent compared to the baseline GMAW fabricated tube

Background *(cont'd)*

- Shape cross section combined with the geometric characteristics of the welds affect impact, fatigue, and shock performance
- Before HY-80 HFRW tube can be used by the participating shipyards, NAVSEA approval must be once again obtained
- In order to obtain NAVSEA approval, the performance of purchased HY-80 HFRW tube must be compared to the corresponding baseline GMAW fabricated tube in order to demonstrate equivalency of the performance
- This project is the *first step* in the testing continuum that will be required by the Navy

Background *(cont'd)*

- Moving from HSLA / HY grade tube designed for GMAW to HSLA / HY HFRW tube supports the call for improved quality in ship design, construction and repair through continuous improvement of advanced technologies and processes

Background *(cont'd)*

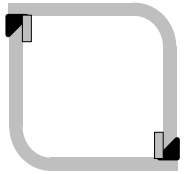
- **Previous and Current Related Work**
  - Electric Boat is currently engaged in several initiatives to implement the use of HFRW structural shapes
    - Fast Fit Cost Reduction Initiative,
    - Design for Affordability for COLUMBIA Class Submarines
    - Process Improvement for VIRGINIA Class Submarines
  - All of these initiatives are in active development
    - Results of this project will be used to leverage/supplement those efforts.

Background *(cont'd)*

- The tangible output from this project is guidance for shipyards looking to replace higher cost HSLA / HY grade GMAW fabricated tubes
- The project will generate data to determine that the benefits of using purchased HSLA / HY grade HFRW hollow structural shapes outweighs using GMAW fabricated structural shapes and can be used as a starting point to pursue NAVSEA approval for using HFRW structural shapes

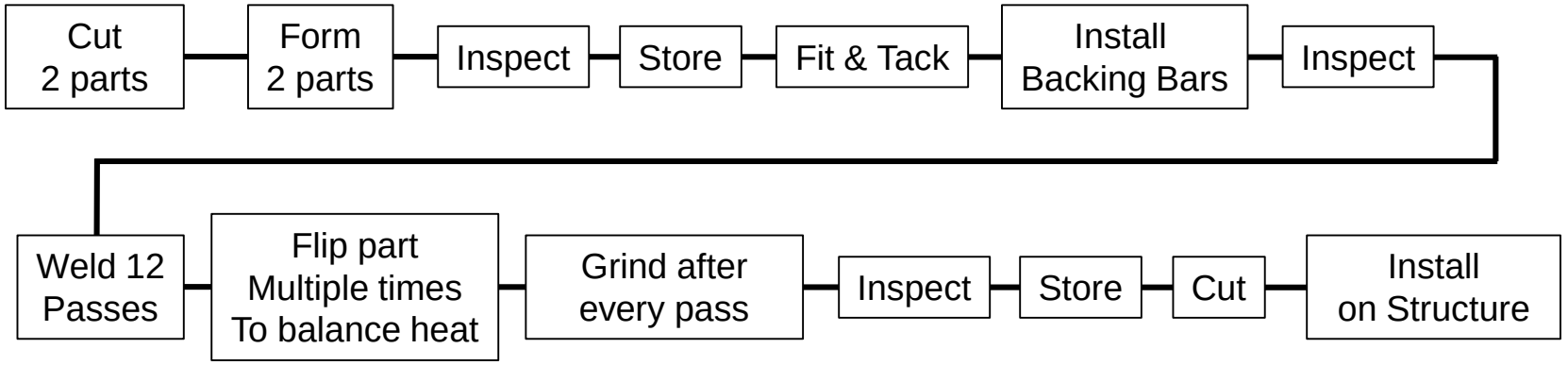
Benefits and ROI

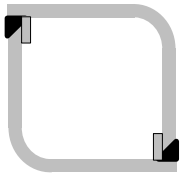
- HFRW process is highly automated
  - Structural shapes produced at rates upwards of 100 feet per minute
- Productivity comparison for 6-ft. by 8-in. square tube with a 0.75-in. nominal wall thickness
  - HRFW = 3.6 minutes to weld
  - GMAW fabricated tube = 108 minutes to weld
    - 12 weld passes required to balance heat input



Benefits and ROI *(cont'd)*

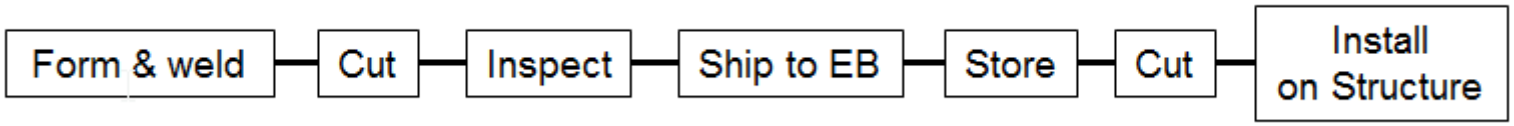
- Processing steps for GMAW tube fabrication is complicated and challenging as it involves multiple formed piece parts and is highly reliant on skilled workmanship





Benefits and ROI *(cont'd)*

- Processing steps for purchased HFRW tube is much less complicated



Benefits and ROI *(cont'd)*

- Obvious benefits of using purchased HFRW tube
  - Expected to hold a tighter exterior corner radius, which simplifies the joining of attachments to the tube
  - Reduced piece parts also simplifies the material acquisition and planning processes
  - Improvement in product geometric consistency is expected to reduce downstream labor used to fit and weld tubes to other structures

Benefits and ROI *(cont'd)*

- Other benefits of using purchased HFRW tube
  - Ability to use a smaller, but stronger cross section when the design permits
  - Use of corrosion resistant grades of HSLA material
  - Alternative to fabricated HSS tube when HSS per ASTM A-500 tube cannot be used

Benefits and ROI *(cont'd)*

- Elimination of the GMAW fabrication steps allows the shipyard to re-allocate skilled resources and floor space for more productive use
- The results of this project will generate data that shipyards can use to determine that the benefits of using structural shapes designed for HFRW outweighs using current fabricated structural shapes welded with GMAW
- This data can be used as a starting point to pursue NAVSEA approval for using HFRW structural shapes

Project Goals

- Demonstrate equivalency between a purchased HY-80 HFRW tube vs. the corresponding fabricated GMAW tube by comparing
  - Physical strength
  - Fabrication costs

Project Objectives

- Demonstrate and compare impact strength of HFRW vs GMAW
- Demonstrate and compare fatigue strength of HFRW vs GMAW
- Quantify purchased HFRW tube cost
- Quantify fabricated GMAW tube cost
- Compare purchased HFRW tube cost to fabricated GMAW tube cost

Project Team

Chad Bryant – NSRP Technical Manager (ATI)
Lee Kvidahl – Project Technical Representative (Ingalls)
Alicia D'Aurora – SDMT Panel Chair (Newport News)

Allen Manuel - Retired Tech Warrant Holder

Joe Blackburn – Tech Warrant Holder
Matt Sinfield - NSWCCD 05P TA
Kevin Mendala – NSWCCD 05P TA

GENERAL DYNAMICS
Electric Boat

Mimi Vymola – NSRP Program Manager
Bob Gillies - Project Technical Lead
Pete D'Napoli - Manager

Nancy Porter – Senior Project Manager
Dave Workman – Welding Engineer

Jeff Pierson
Mick Nallen
Dr. Lesley Frame

Technical Approach

- Task 1 - Produce Test Specimens
- Task 2 - Business Case Analysis
- Task 3 - Mechanical Testing
- Task 4 - Technical Warrant Holder Feedback

Task 1 – Produce Test Specimens

- The goal of this task is to create specimens for testing, to determine advantages/disadvantages of each process, and to obtain productivity data.
- Based on current production data, Electric Boat will identify a HY-80 GMAW fabricated tube for the project to baseline
- EWI will determine the design of impact and fatigue test coupons
- Team will determine the size, shape, and quantity of test specimens that need to be produced to generate the required number of test coupons for impact and fatigue testing
- Electric Boat will weld the baseline HY-80 GMAW shapes
- Thermatool will supply the HY-80 HFRW structure shapes

Task 2 – Business Case Analysis

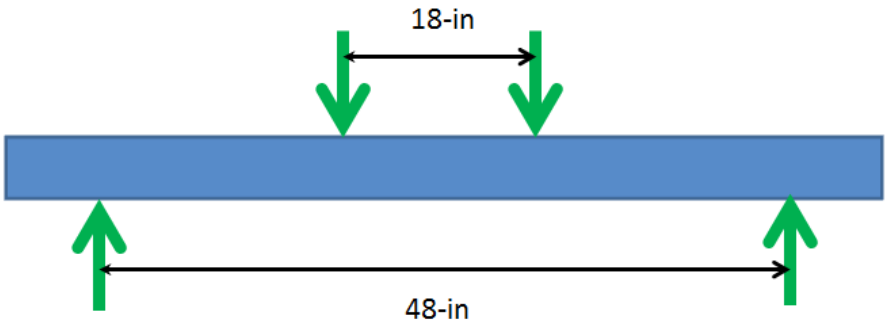
- The goal of this task is to conduct a limited business case analysis to establish the relative costs for both purchased HY-80 tube and fabricated HY-80 tube
- Electric Boat will conduct the business case analysis
- For each process, Electric Boat will document differences in
  - Processing steps
  - Cost
- Electric Boat has already obtained HY-80 GMAW fabricated tube production costs
- Thermatool to provide price for HY-80 HFRW tube

Task 3 – Mechanical Testing

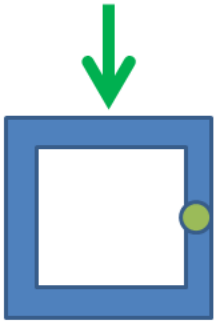
- The goal of this task is to conduct limited mechanical testing to establish the relative strength of the two tube designs.
- EWI will conduct Impact testing and Fatigue testing
- EWI will document the performance comparison of baseline GMAW coupons to the HFRW coupons

Task 3 – Mechanical Testing

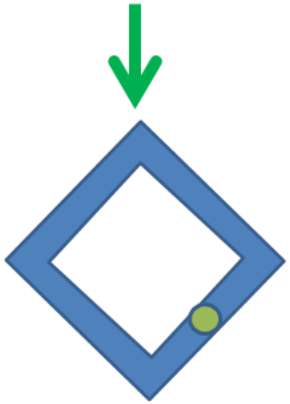
- Fatigue Testing Approaches



Shear Loading Predominately



Complex Loading with Tube Crushing



It is not possible to get the weld joint into Mode 1 loading in a fatigue test of a beam

- 4 point bend test for beams
- R=0.1
- 3 pcs each weld type

Task 4 – TWH Feedback

- The goal of this task is to obtain feedback from the current and former NAVSEA Technical Warrant Holders regarding the potential for pursuing the qualification of structural shapes for submarine applications
- Team will seek feedback from
  - Current Welding TWH Joe Blackburn
- Team will also seek feedback from
  - Former NAVSEA TWH Allen Manuel, who approved the previous use of HFRW t-stiffeners on the Aegis Class cruisers

Next Steps

- Prepare test coupons
- Complete mechanical testing
- Complete business case analysis

Questions?