STANDARDIZED WELDING CURRICULUM AND TESTING FOR SHIPYARDS

Technology Investment Agreement 2005-337

Deliverable for Task 1

SHIPYARD EDUCATION SURVEY REPORT

Revision 1

Submitted by Huntington Ingalls Incorporated

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Introduction

The National Shipbuilding Research Program (NSRP) project entitled "**Standardized Welding Curriculum and Testing for Shipyards"** is a collaborative and sustainable optimization process on weld size control and production process improvement. Ingalls Shipbuilding (Ingalls), a company element of Huntington Ingalls Incorporated (HII), is pleased to provide leadership for this project. It is intended to significantly reduce the cost of lightweight steel production across the U.S. shipbuilding and ship repair industries. This project is applicable to a major labor cost driver across all shipbuilding and ship repair programs. The team expects the results of the project to be applied to Ingalls programs such as the DDG 113, LHA, LPD, and USCG NSC Programs, and to be transferred to all Navy, Coast Guard, and Repair Programs upon completion of the project.

In recent years, ship designers have been forced to incorporate lighter, thinner steel structures to reduce topside weight, improve fuel economy, and enhance mission capability. Over the past decade, the production ratio of thin-steel (10 mm or less) to thick-plate structures for some vessels built at Ingalls has risen up to 90% per ship. At the same time, military and commercial customers have tightened the design requirements in strength, stiffness, and fitness to meet more stringent performance specifications.

Understandably, the development of technology, facilities, and processes to build thin steel ships efficiently has not kept pace with the rate of change in the designs. Shipbuilding facilities and equipment are large, costly, and expected to have a long service life. Thin steel requirements affect facility issues from the spacing of conveyor rollers, to the type of magnet cranes used, to the way steel is stored, cut, moved, welded, and assembled. The heavy machinery and support structures that are part of the steel fabrication facility cannot be changed overnight. The rapid shift in the use of thin steels from small percentages a decade ago to the high levels of today poses a major cost challenge to the U.S. Navy, to Ingalls, and to other U.S. shipyards that build these ships.

Project Background

Shipyard training programs for welders are varied in their methods and in the metrics they use to qualify welders, and welders are not always trained on each type of weld (butt, fillet, lap, etc.) they may make before going out into the field and performing them. As naval ship designs continue to incorporate a rising amount of thin steel, the demand for a standardized training program to address the requirements for welding this thinner material is increasingly apparent. In many programs, little attention is given to distortion-reducing practices, including welding to design sizes in an effort to reduce overwelding.

Funded by NSRP in October 2012, this project will investigate what is currently taught in the U.S. shipyard training programs in order to determine where change is most-needed. Then, working with shipyard instructors, a new program will be drafted and tested at shipyards with the goal of training welders who are able to make sound welds to design sizes and who are capable of performing welding procedures needed for thin steel designs in order to reduce rework and downstream costs. An "as-is" analysis of the current state of weld training and curriculum given to new hire welders and re-training

for current welders employed at Ingalls has been performed. Investigation of the current state at Ingalls and other US shipyards has led to affirmation of the need to fully develop and implement a new training strategy to address the issues faced by welders in today's ship designs and production limitations. A preliminary new training database is currently being developed. It's expected that the benefits the standardized weld curriculum will bring to cost savings at Ingalls Shipbuilding and across all other U.S. shipbuilders will be substantial.

Deliverable Overview

HII-Ingalls developed a training questionnaire based on current needs for thin steel welding and through investigation and documentation of proven distortion control techniques. Ingalls then sent a survey questionnaire to 11 US shipyards regarding their current welder training programs to determine where curriculum focus would be most beneficial. The project team has received formal survey responses from Ingalls, Bollinger, BIW, Newport News, and Vigor. The compilation of these results are being incorporated into the course outline. Focusing the training modules based on the survey feedback allows the project team to address areas that are most needed and training that will generate the greatest benefit to the US shipbuilding industry.

The survey results show that the current weld training programs across the US shipbuilding industry have significant deficiencies in welder and fitter training curriculum. In addition to the written responses to the survey questionnaire, shipyard educators at several other yards provided verbal feedback. The consensus from these yards was that no formal training on thin steel welding techniques exists in their respective organizations. The training personnel at these shipyards expressed a desire and need for a standardized curriculum to address the welding issues present in the majority of today's ship designs. Information was obtained from these shipyards on current welding processes and production areas where issues are generated due to a lack of adequate training.

In most cases, only limited supplemental guidance on specific distortion control techniques is available for welders. In addition to an overall lack of formal training on thin steel and distortion control, several specific areas were isolated as particularly needed for inclusion in the curriculum. Examples of these module topics include: tack quality, root gap tolerances, minimizing overwelding caused by gouging processes, insert fitting procedures, weld sequencing, and achieving design specified weld sizes. These topics will be investigated in depth and adequate training procedures will be developed and included in the modules.

The shipyard training questionnaire that was sent to the major US shipyards as well as the responses received from participating yards is included in the remaining sections of this report.

Shipyard Training Questionnaire for Fitters and Welders

Question No. 1: Does your shipyard training program include training on distortion control? (Y/N)

SHIPYARD 1: Yes
Comments: Weld sequence plans developed by Welding Engineering to control distortion.

SHIPYARD 2: Yes
Comments: As discussed in our meeting last week, we do not have a formal training effort on distortion control, but as seen in other NSRP projects the training materials provided are used periodically to address these issues as they arise.

SHIPYARD 3: No
Comments: Welding Engineering issues Welding Engineering Instructions (WEI's) for products that are problematic as well as products that have flatness and alignment requirements.

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: Sequence of work, restraint and over-welding are covered.

Question No. 2: Does your training program include specific processes for fitting/welding thin plate with plate thickness equal to or less than 3/8"? (Y/N)

SHIPYARD 1: Yes
Comments: Training on thin plate is only to the extent required by workmanship regulations.

SHIPYARD 2: No
Comments:

SHIPYARD 3: No
Comments:

SHIPYARD 4: No
Comments:

SHIPYARD 5: No
Comments: We currently do not use much thin plate (≤3/8"). If we do then we will train folks.

Question No. 3: Is distortion considered when training on tacking procedures? Is there focus on tack quality AND size to reduce final weld size and ensure adequate incorporation into final weld? (Y/N)

If yes, what guidelines or limitations are welders trained on to limit cap size or improve quality of tacks?

SHIPYARD 1: No

Comments: Training only specifies producing a tack of a quality that allows facilitation into the final weld

SHIPYARD 2: No
Comments:

SHIPYARD 3: No
Comments:

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: All tacks ½" to 1" long and minimal size to allow full consumption into final weld.

Question No. 4: Are fitters specifically trained on how their craftsmanship affects the quality and process time of the welders who receive their work? Are they educated on the challenges that welders face from certain fitting practices? (Y/N)

If yes, what training is given to facilitate communication between fitters/welders?

SHIPYARD 1: Yes
Comments: Fitters are trained on First Time Quality but more direct instruction and focus on communication between fitters and welders is needed

SHIPYARD 2: Yes
Comments: As mentioned in my first response, we do not have a formal training effort in place but use the training materials provided in the Weld Shrinkage project to address issues and have refresher trainings as needed.

SHIPYARD 3: No
Comments:

SHIPYARD 4: Yes
Comments: First Time Quality training

SHIPYARD 5: Yes
Comments: Our crews meet each morning to communicate job essentials.

Question No. 5: Are employees trained / issued tolerances for root gap size on inserts (thick to thin transitions within a plate)? Are inserts simply trimmed until they can be forced into the cutout or is there a target gap that fitters aim to achieve? (Y/N)

If yes, what are the root gap tolerances that are targeted?

SHIPYARD 1: No

Comments: Fitters and Welders are trained and issued tolerances on gap offset but no training or tolerances are issued on insert root gaps.

SHIPYARD 2: No
Comments:

SHIPYARD 3: Yes
Comments:

Location	Target Gap
Panel Line Joints	0 – 1/16"
Erection Joints	3/16" to 7/16"

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: 1.) We fit tight then scarf preps on inserts 2.) We cut parts with 3/8" gap for ceramic backing. Note: Depending on situation, contract.

Question No. 6: Are fitters trained on when and how to properly apply edge beveling? (Y/N)

If yes, is edge beveling called out in construction manuals or is it left to the discretion of the fitter?

SHIPYARD 1: No
Comments: Instruction on when and how much beveling is required is relayed to fitters on the drawing and unit construction manuals.

SHIPYARD 2: No
Comments: The information for edge beveling is simply placed on the drawing.

SHIPYARD 3: No
Comments:

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: Contract, drawings. Not fitter's discretion

Question No. 7: Are fitters trained on gouging procedures and the effect they have on the final weld size/quality? (Y/N)

If yes, what type of gouging (arc, flame, etc.) procedure is used?

SHIPYARD 1: No
Comments:

SHIPYARD 2: No
Comments:

SHIPYARD 3: No
Comments: IJT

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: Plasma, carbon, arc.

Question No. 8: Are welders trained to use a specific weld procedure depending on insert thickness and/or location? (Y/N)

If yes, please describe some of the situations covered:

SHIPYARD 1: Yes
Comments: General procedures issued that account for material thickness and proximity to panel edge.

SHIPYARD 2: Yes
Comments: This is done by the use of OJT and drawing callouts for weld procedures.

SHIPYARD 3: Yes
Comments: Generic procedures are issued for the preferred welding sequence.

SHIPYARD 4: No
Comments: No formal training on insert distortion control

SHIPYARD 5: Yes
Comments: Our WPS covers unlimited thickness. Sequencing welds is done.

Question No. 9: What (if any) training is given to welders on the use of clamps/restraints when welding thin plate? (Y/N)

If yes, are welders trained on when to apply and remove restraints? Are restraints used before fit-up?

SHIPYARD 1: Yes
Comments: Workmanship requirement documents specify use of strong backs as a means of restraining plate from buckling distortion when specific plate design elements are present. The number of circumstances which require these restraints is limited and training is the responsibility of the shop supervisors. Suggested guidelines for clamping have been issued but are not part of training and are largely unenforced.

SHIPYARD 2: Yes

Comments: The fabrication table has slots that are spaced to accommodate the proper clamping and once again we use OJT and the use of the Weld Shrinkage training template to reinforce proper techniques.

SHIPYARD 3: Yes
Comments: Flatness and alignment critical products are the only products where restraint may be required. Guidance is given to the welder/fitter via the Welding Engineering Instruction (WEI) as far as restraint is concerned. Welders and fitters always have the option to use restraint if they think it is necessary. The type of restraint is also called out on the WEI. For instance (use dogs and wedges –Do Not Tack)

SHIPYARD 4: No
Comments:

SHIPYARD 5: No
Comments: At fit-up, removed after welding is completed.

Question No. 10: Are welding sequence sketches used as a part of welder training? (Y/N)

If yes, what sequencing approach is used? (I.e. progressing weld steps from center of the work outward)

SHIPYARD 1: Yes
Comments: General instruction is given to begin welding at the center of the work piece and moving outboard. Unit specific weld sequences were developed by Welding Engineering and are issued as part of the work package. Hands-on training is given on the general sequence plan via instructor welded examples.

SHIPYARD 2: Yes
Comments: We use a weld handbook for the thin steel projects to assure proper sequencing.

SHIPYARD 3: No
Comments: Covered in WEI's

SHIPYARD 4: Yes
Comments: Generalized sequences provided to craft in construction manuals

SHIPYARD 5: Yes
Comments: Sequence sketches are occasionally used for critical weldements.

Question No. 11: Is overwelding (excessive welding above design size) addressed in employee training? Are there requirements or tolerances put in place to limit overwelding? (Y/N)

If yes, please explain:

SHIPYARD 1: Yes

Comments: Training on limiting overwelding is given in new hire course material. Students are taught to aim at welding no larger than 1/16" greater than design size.

SHIPYARD 2: No
Comments:

SHIPYARD 3: No
Comments: It is an issue that we are addressing.

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: Cost and Distortion are covered; QA/QC checks weld size.

Question No. 12: Are welders trained on the back-step welding process? Are there rules set that require or suggest its use in a given application? (Y/N)

If yes, please explain:

SHIPYARD 1: Yes
Comments: New hire training includes the procedure for back-step welding. Training on when to apply the process is not included.

SHIPYARD 2: Yes
Comments: As mentioned above, we use a weld handbook for the thin steel projects to assure proper sequencing.

SHIPYARD 3: Yes
Comments: Covered in WEI's as well as in the WE-20 (HII 5310).

SHIPYARD 4: Yes
Comments:

SHIPYARD 5: Yes
Comments: Suggested often, not always required. Required occasionally for critical weldments.

Question No. 13: Are welders trained on temporary attachment welding? Are there weld size limitations put in place for temporary attachments? (Y/N)

If yes, please explain:

SHIPYARD 1: Yes
Comments: Temporary attachment size is developed and trained according to material thickness. In training, the students are given mock-up activities that generally specify ¼" weld pass all around.

SHIPYARD 2: No

Comments:

SHIPYARD 3: No
Comments:

SHIPYARD 4: No
Comments:

SHIPYARD 5: Yes
Comments: We require certain amounts and types of welds for various attachments.

Question No. 14: Are welders trained on attaining certain weld sizes prior to production work? Is there a size tolerance they must be able to achieve consistently before they are released to production? (Y/N)

If yes, please explain:

SHIPYARD 1: Yes
Comments: Welders must perform weld sizes ranging from 3/16" to ¼" and 3/8" welds are incorporated in the mock-up activities.

SHIPYARD 2: No
Comments:

SHIPYARD 3: No
Comments:

SHIPYARD 4: No

SHIPYARD 5: Yes
Comments: Prior to WPQ test, a fillet test is given. At hiring, fillet gauges are issued. QA/QC monitors weld sizes. Correct size + 1/32" is required. Over sized welds are not allowed when 1/16" or greater over design size.

Question No. 15: What performance qualifications must the welder/tacker achieve prior to course completion?

SHIPYARD 1:
Comments: Pass requirements outlined in NAVSEA Technical Publication S9074-AQ-GIB-010/248. These requirements are achieved in Workmanship Training, New Hire Assessment and Mock-up Training.

SHIPYARD 2:
Comments: Once again we have no formal training although we do require welders to pass on D1.1 qualification test as a pre-employment qualification.

SHIPYARD 3:

Comments: Pass the required welding qual.

SHIPYARD 5: Yes
Comments: 3G, 4G full pen test w/ back gouge. Bend tested (For all welders). 1F, 2F break test for tackers (very few).