Attachment III – Section III

Project Results
Attachment to Final Technical Report

for

Improved Advanced Watertight Door Finalization Program

Prepared under
Subcontract 2013-454

April 16, 2015

Terri Merdes, Principal Investigator
Applied Research Laboratory at the Pennsylvania State University
P.O. Box 30
State College, PA 16804-0030
(814) 863-0652

Table of Contents

Improved Advanced Watertight Door Finalization Program

Performed by The Pennsylvania State University Applied Research Laboratory under Subcontract 2013-454 from Advanced Technology International (ATI) dba SCRA Applied R&D.

Executive Overview

The goal of the Improved Advanced Watertight Door Finalization Project was to advance the highly successful interim advanced watertight door (IAWD) to Technical Readiness Level 8 and full commercial availability at the discretion of the Navy. The finalized design included the following new features:

- Collective Protection System (CPS) latch
- Tubular stainless steel handle for opening and closing
- Slotted frame hinges to facilitate alignment during installation
- Gasket guard plate to prevent excessive gasket wear
- Documented drawing packages for both left-hand and right-hand opening doors

Ten IAWDs were purchased from a commercial fabricator—Begneaud Manufacturing, Inc. of Lafayette LA—and were used to complete all certification tests required that had not previously been performed; also, an installation feasibility demonstration was performed. Under this project, the IAWD passed the following qualification tests:

- MIL-STD 901D Grade A Shock Test on a medium-weight test stand
- MIL-STD 167-1 Vibration Test to 25 Hz (only 15 HZ required)

The following tests were also performed for baseline documentation purposes; they were not pass/fail tests required for certification:

- MIL-STD 3020 Fire Test, N-0 or N-30 requirement
- IEEE STD 299 Electromagnetic Interference (EMI) Test

ARL subcontracted the installation demonstration to Marinette Marine Corporation of Marinette WI. Two IAWDs were welded into a typical *Freedom* Class Littoral Combat Ship (LCS) steel bulkhead, and two into what would be considered a typical LCS aluminum bulkhead.

Contact Information

Terri A. Merdes
Applied Research Laboratory
The Pennsylvania State University
PO Box 30
State College PA 16804-0030
Phone: 814.863.0652 Fax: 814.865.8979
Tam900@arl.psu.edu

Collaborators

The following contributed several hours a month to the final design and qualification testing of the IAWD through the entire duration of this project:

- The NSWCCD - Ship Systems Engineering Station, Philadelphia
- ATI – NSRP with their direct support team
- Begneaud Manufacturing for contribution to the door design
- Our subcontractors: Aero Nav Laboratories, Marinette Marine Corporation, and Southwest Research Institute
- Program Officer of ONR ManTech
- Director of Science and Technology, Program Executive Office Ships

Description of Methodology

At the heart of the IAWD is a rectangular-honeycomb sandwich panel developed under Navy sponsorship and patented by Pennsylvania State University, called LASCELL. It comprised laser-cut, mechanically interlocked stiffeners sandwiched between parallel face sheets. The face sheets are fastened by autogenous laser welds (without filler metal) passing through the face sheets into the stiffeners. To avoid out-of-plane distortion, a process was developed by which massive restraining fixtures held the door panel and frame completely flat during welding of both sides. It was found that this process also introduced beneficial residual stresses, which increased the panel's resistance to localized compression buckling failure under pressure loading. This process was subsequently replaced by a highly automated process, in which the door was held by a rotating fixture.

Flatness and beneficial residual stresses were maintained by the computerized rotational indexing system that systematically balanced residual stresses on opposite sides of the door. Beneath the face sheet are stiffeners with circular holes laser cut along the neutral axes, which reduces weight with negligible loss of stiffness.

To achieve improved watertight integrity, a new bi-directional, hydrostatically actuated seal system was developed; it requires extremely low opening and closing forces, thereby reducing mechanical and gasket wear. The gasket is installed by snapping into place between the containment rods, which are tack welded to the panel rim.

The first goal for this project, was to finalize the IAWD design, incorporating lessons learned from ship installations which occurred in 2010 and 2011. A major objective was the incorporation of the Collective Protection System (CPS) latch into the design. It was decided to use the same CPS latch design (scaled down) as employed by the NSWD, since that design is reliable. Its primary function is to prevent the door from flying open if a pressure differential exists across the door. Its secondary function is to engage the closing assist. To avoid interference with the door handle, a bend in the door handle was introduced. Bending was not feasible with the composite material used for the handle, so it was decided to replace the composite handle with an alloy 304 stainless steel tubular handle—which was bent to clear the CPS latch. The metal handle also confers the additional advantage of increased fire resistance.

The final goal was to fabricate ten door. Four doors were used at ARL Penn State for testing, four were sent to Marinette Marine to be used to develop installation procedures; two were used in following qualification testing:

- MIL-STD 901D Grade A Shock Test/Hydrostatic Test
- MIL-STD 167-1 Vibration Test/Hydrostatic Test
- MIL-STD 3020 Fire Test, N-0 or N-30 requirement
- IEEE STD 299 Electromagnetic Interference (EMI) Test

The IAWD successfully passed the shock/hydrostatic test and the vibration/hydrostatic test. The vibration test was performed at 25 Hz, above the current 15 Hz the Navy Standard Watertight Door qualifies at. The fire and EMI tests are not a pass/fail tests, the data is informational only.

Resources Needed

To manufacture IAWS, the organization must have following capabilities and expertise:

- Capability to fabricate one IAWD from the drawings provided.
- Be prepared to host an inspection by NAVSEA representatives ascertaining compliance with all specifications.
- Upon successful completion of the on-site inspection, submit one IAWD to a certified, independent testing laboratory with capability to perform
  - MIL-STD 901D Grade A Shock Test/Hydrostatic Test
  - MIL-STD 167-1 Vibration Test/Hydrostatic Test

The organization requires facilities and expertise in automated laser welding. The number of personnel required is indeterminate.

Evaluation and Analysis Methods

The IAWD has been renamed the Navy Standard Pressure Actuated Door (NSPAD) by NSWCCD as a step towards transition. NSPAD offers clear advantages over the Navy Standard Watertight Door and it is anticipated that once approved by the Technical Warrant Holder, it will become an interior watertight 26" x 66" door-of-choice for acquisition managers and fleet maintenance managers across the fleet.

Eight prototypes of the IAWD have been successfully deployed: two on the *USS Porter* (DDG-78), two on the *USS Monterey* (CG-61) and four doors on the *USS Wasp* (LHD-1) since 2010. Only one door that has over 2,000 openings a day, has required any maintenance to-date.

Time Estimate

This project took 18 months to complete. A competent organization with access to our report and drawings should be able to fabricate and qualify a door in 12 to 18 months, depending on their expertise with laser welding of stainless steel.

Installation of an IAWD into a steel bulkhead is estimated to take approximately 1 day. This includes cutting out the bulkhead using a template and welding in the frame. Panels are interchangeable with the frames and can easily be removed with minimal re-alignment. The IAWD can also be installed into an aluminum bulkhead using Detacouple®. This installation time will depend on if the doors are prepared by the fabricator or on-site.

Limitations or Constraints

This is a 26" x 66" (10 psi) interior door. This size door was selected by the Navy when the IAWD was a research and development project, since it is a commonly sized door found across the surface fleet. This door can be fabricated or purchased, and can be installed by any shipyard.

Major Impacts on Shipyard

- Shipyards will have the ability to fabricate the IAWD or purchase from a qualified fabricator.
- Lift-hand and right-hand stainless steel 26" x 66" (10 psi) IAWD will become available as an alternative to the Navy Standard Watertight Door (NSWD).
- The IAWD requires less time to install into a steel bulkhead then the NSWD, and requires minimal installation alignment.
- Panels and frames are interchangeable.
- Reduced maintenance & repair burden.
- Improved performance, easy to open and close.
- Reduced requirement for on-hand material & supplies.

Cost Benefit Analysis/ROI

	NSWD	IAWD Projected
Reduced maintenance costs (Man-hours per year per door)	1,280 hrs	100 hrs
Reduced Replacement Costs	Frames/panels must stay manufactured set	Frames/panels are interchangeable
Baseline weight savings (Without CPS Latch) (with CPS Latch)	 292 lbs 322 lbs	 214 lbs 231 lbs
Sealing gasket	Knife edge (gap can exist at joint)	Hydrostatically actuated seal (continuous loop)

Lessons

- Installation of the IAWD into a bulkhead is straight forward and uses common welding practices.
- To successfully fabricate a IAWD, requires a facilities for automated laser cutting and welding processes along with knowledge of shrinkage behavior of stainless steel.

Technology Transfer

The transition event for the project will be NAVSEA 05Z44 Technical Warrant Holder (TWH) certification of the IAWD for USN watertight door applications. NAVSEA TWH approval will be based on successful completion of all certification testing and successful at-sea installation and evaluation. Upon certification, the IAWD design would then be added to the existing list of approved watertight door designs, and would thereby become an available option for USN ship acquisition program managers, as well as in-service ship maintenance managers. Similar to the existing Navy Standard Watertight Door, it could be specified for competitive procurement. It should be noted that the selection of a particular certified watertight door design for new construction applications and backfit applications, from the list of TWH certified options, is ultimately up to the platform acquisition program manager and/or ship maintenance managers in accordance with budget, schedule, and technical performance requirements.

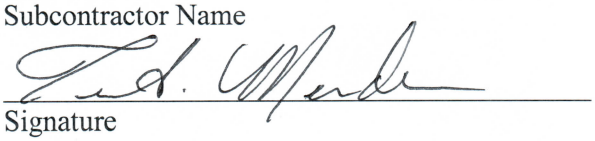
Implementation

While the net effect of the IAWD on shipboard damage control personnel will be to reduce their maintenance requirements considerably, they will need to be trained in new maintenance protocols. This has been demonstrated on the *USS Wasp (LHD-1)*, *USS Porter (DDG-78)* and *USS Monterey (CG-61)* over the past five years. NSWCCD Philadelphia will determine the necessary revisions to maintenance protocols and training materials.

An IAWD was installed at Newport News, VASSIC facilities in May 2015 as a display for discussion while this door is waiting for final approval by the TWH, this door is allowing the shipyard to acquire knowledge on how to weld the door into a bulkhead, ability to compare the operational differences between the IAWD and the NSWD.

The undersigned Subcontractor representative states that he/she has prepared the above information and that the facts and data set forth are complete and accurate to the best of the undersigned's knowledge and belief. Questions regarding this report should be addressed to _Terri A Merdes_____ of the Subcontractor's organization at telephone number 814-863-0652.

_The Applied Research Laboratory_____
Subcontractor Name



Signature

__Terri A. Merdes_____
Typed or Printed Name

_April 16, 2015_____
Date