

**Ingalls Shipbuilding**

A Division of Huntington Ingalls Industries



# Expanded Adhesive Outfitting Applications

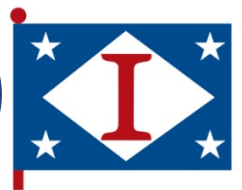


## Joint Panel Meeting Ship Design and Material Technologies

December 8-9, 2015

Mark Losset, Jarrod Gilmore, and John Walks

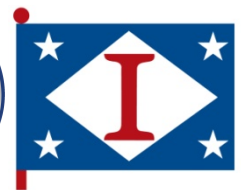
# Agenda



- Project Overview/Status
- Survivability Test Plans
- Environmental (Adhesive) Test Plan



# Expanded Adhesive Outfitting Applications



## Objective:

To expand applications for adhesive outfitting beyond specifically tested and approved items by developing allowable load limits and design rules for adhesively bonded studs

## Technical Approach:

- Determine failure loads through shock and vibration tests
- Qualify adhesives through environmental tests
- Follow NAVSEA adhesive guidelines
- Establish design rules and identify any changes to ship specifications required for implementation





- **Ingalls Shipbuilding – Project Lead**

- Sean Murphy, Jarrod Gilmore, Mark Losset, John Walks, Ronnie Romero, D G McMillion

- **Bollinger Shipyards**

- Dennis Fanguy, Barry Matherne

- **National Technical Systems**

- Mike Poslusny, Tucker Thompson, Conner Smith

- **SCRA**

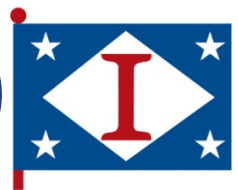
- Mary Saady, Project Manager

- **NASSCO**

- Dan Sfiligoi, Project Technical Representative



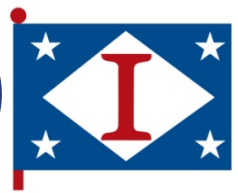
# Project Work Breakdown Structure (WBS)



## Phase I: Development of Technical Requirements for Expanded Adhesive Outfitting Applications

- Task 1.....Project Initiation
- Task 2.....Develop Requirements Matrix
- Task 3.....Develop Environmental and Survivability Test Plans
- Task 4.....Optimize the Adhesive Bonding Process
- Task 5.....Finalize Guidelines for Selecting Adhesive Bonding Applications
- Task 6.....Develop Detailed Test Procedures for Phase II Tests





## Phase II: Execution of NAVSEA Reviewed Testing and Development of Implementation Requirements

Task 7.....Prepare Test Articles / Conduct Environmental Tests

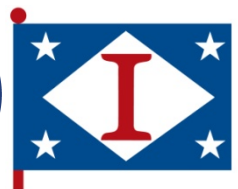
Task 8.....Conduct Survivability Tests

Task 9.....Develop Recommended Changes for Mounting Applications and Specification Requirements

Task 10....Update Implementation Plan for use of Adhesive Design Rules in Outfitting Applications



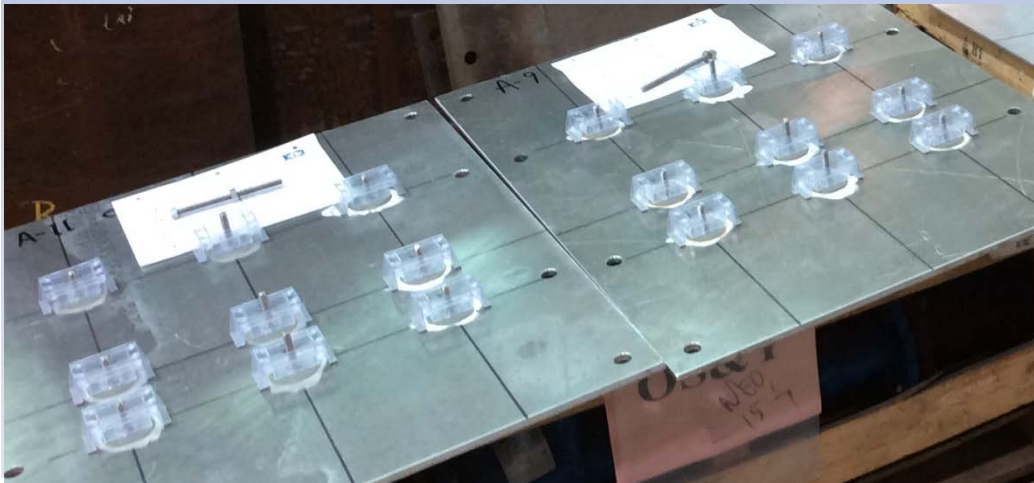
# Project Work Breakdown Structure (WBS)



Task 7.....Prepare Test Articles / Conduct Environmental Tests

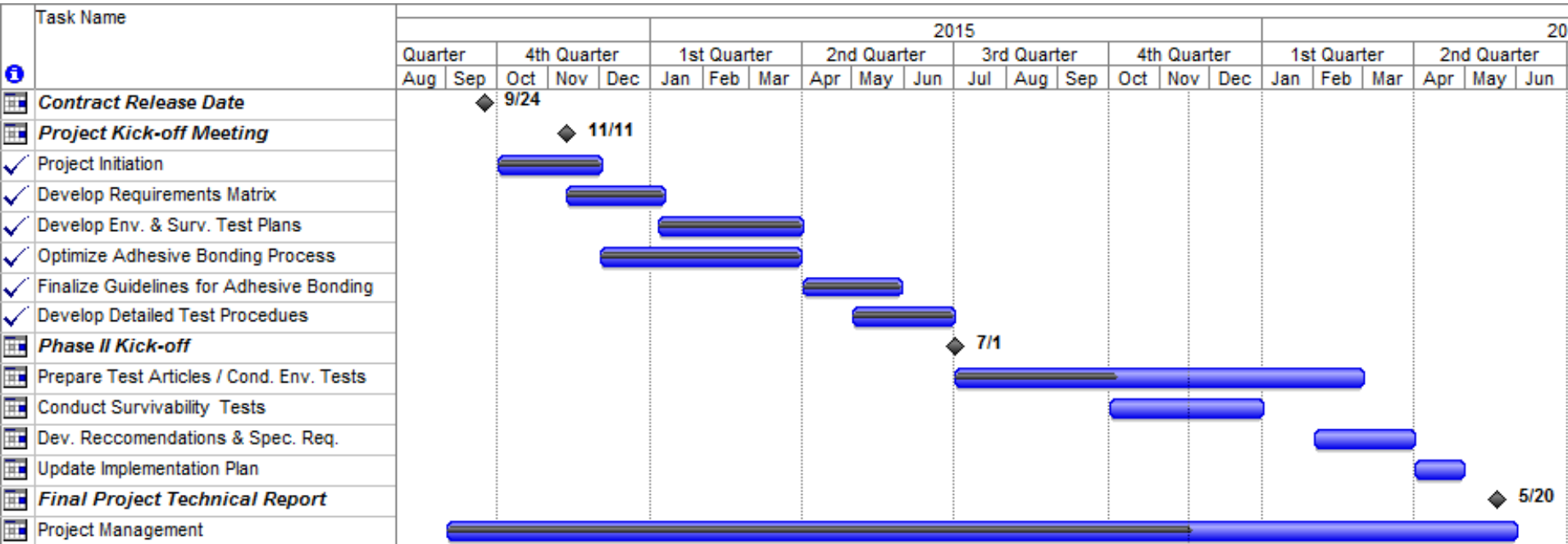
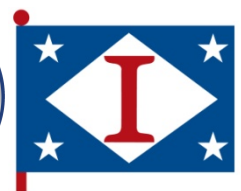
Task 8.....Conduct Survivability Tests

- Steel and Aluminum test plates have been cut
- Aluminum Test plates have been outfitted for tests
- Steel Plates are currently being prepped and painted



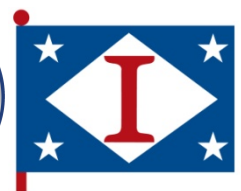


# Project Schedule





# Deliverables from Phase I



## Test Plans

**Environmental Test Plan  
For  
Expanded Adhesive Outfitting Applications  
SCRA Contract No. 2015-404  
Rev -  
June 30, 2015**

**Survivability Test Plan  
FOR  
Various Adhesive Mounted Configurations  
  
Ingalls Procedure No. SHK/001/2015  
Revision A  
2 September 2015**

## Bonding Procedure

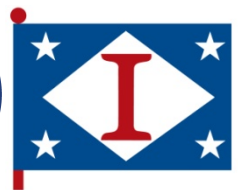
**Adhesive Bond Process Optimization Report  
For  
Expanded Adhesive Outfitting Application  
SCRA Contract No. 2015-404  
Rev -  
March 30, 2015**

**Adhesive Stud Bonding Procedure  
For NSRP Project  
Expanded Adhesive Outfitting Applications  
SCRA Contract No. 2015-404  
Rev -  
March 30, 2015**

## Guidelines

**Guidelines for Lightweight Adhesive Outfitting  
For  
Expanded Adhesive Outfitting Applications  
SCRA Contract No. 2015-404  
Rev -  
June 30, 2015**



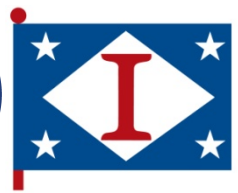


## Overall Shock Test Series Objective

- The main objective of all the shock testing is to determine the shock adequacy of various adhesive mounted stud configurations. This objective can be broken into 2 main categories:
  - Test various configurations to failure to determine the typical failure modes of the adhesively mounted studs during shock.
  - Test various configurations per the standards of MIL-S-901D for shock approval
- In general, the test series are developed to mitigate the risks of the numerous variables that are involved in stud mounted equipment.

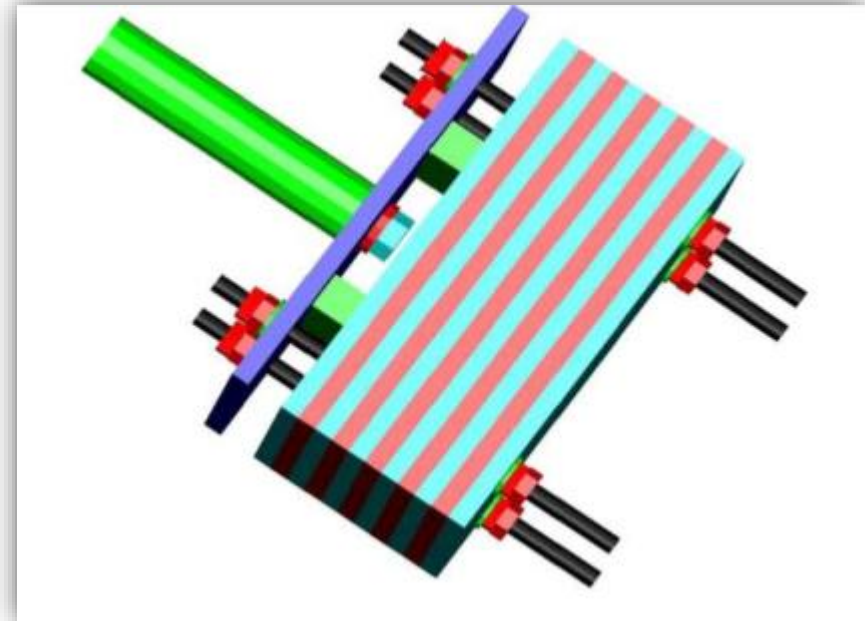


# Survivability Test Plan

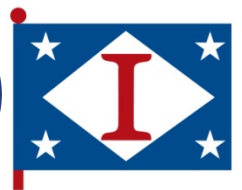


## LWSM Test Description

- This figure is an example of the dummy weight fixture that will be used on the single stud test specimens. A similar approach will be used on the two stud configurations. Test specimen studs will be attached using standard manufacturing guidelines. The full details of the adhesive manufactured guidelines will be included in the detailed Series A and Series B Test Procedures.



**Single Adhesive Mounted Stud Test Dummy Weight**

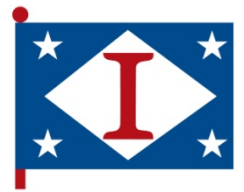


- Shock Testing Planned

- Test Series A
  - Testing to failure
- Test Series B
  - MIL-S-901D Standard LWSM test

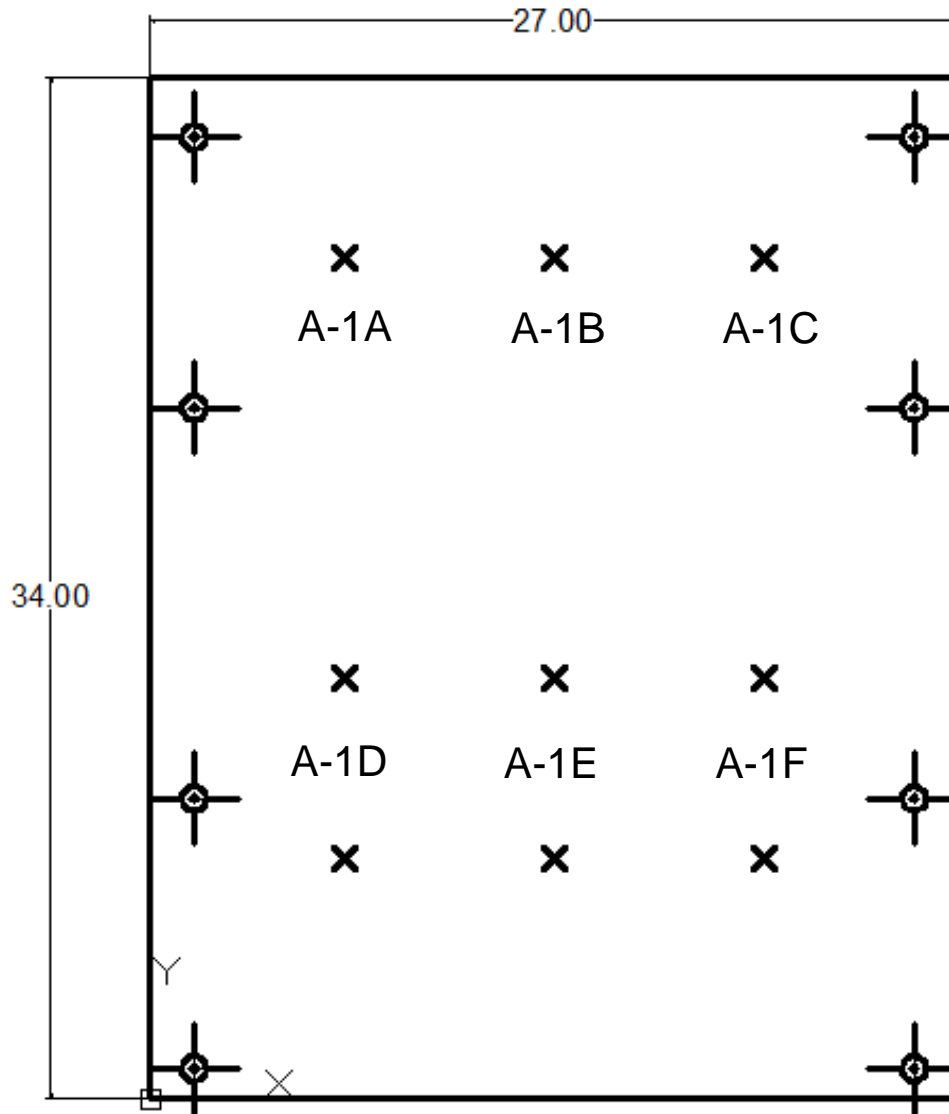
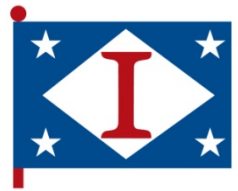


# Example of Shock Tests



Lightweight  
Shock Testing  
from NSRP  
Cost  
Reductions for  
Late Stage  
Outfitting

# Test Panel A-1 – 3/16” Steel Plate



A-1A – Single Stud Attached with AO420  
(Starting Weight: 3.5 lbs)

A-1B – Single Stud Attached with AO420  
(Starting Weight: 3.5 lbs)

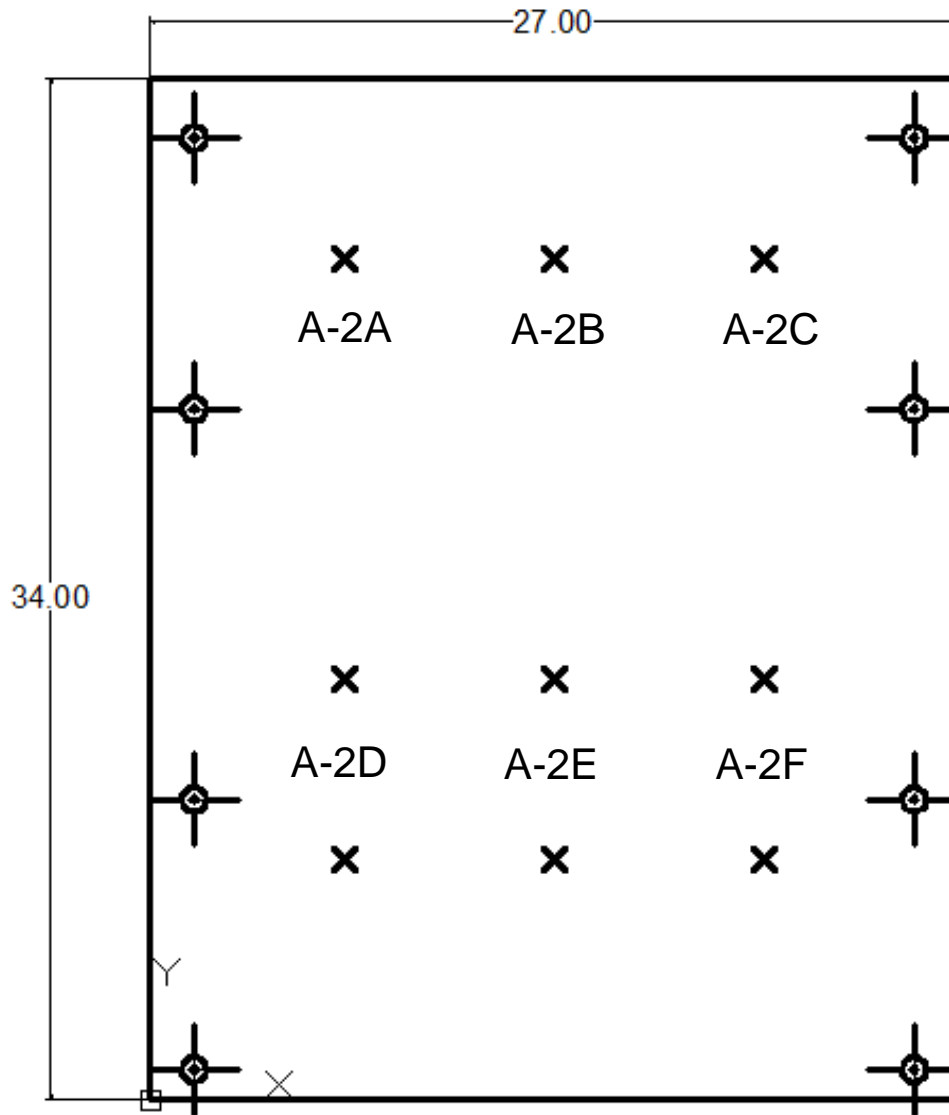
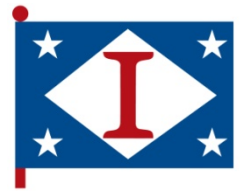
A-1C – Single Stud Attached with AO420  
(Starting Weight: 3.5 lbs)

A-1D – Pair of Studs Attached with AO420  
(Starting Weight: 7.0 lbs)

A-1E – Pair of Studs Attached with AO420  
(Starting Weight: 7.0 lbs)

A-1F – Pair of Studs Attached with AO420  
(Starting Weight: 7.0 lbs)

# Test Panel A-2 – 3/16” Steel Plate



A-2A – Single Stud Attached with CB200  
(Starting Weight: 3.5 lbs)

A-2B – Single Stud Attached with CB200  
(Starting Weight: 3.5 lbs)

A-2C – Single Stud Attached with CB200  
(Starting Weight: 3.5 lbs)

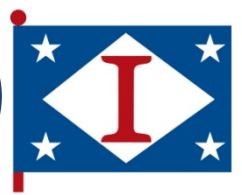
A-2D – Pair of Studs Attached with CB200  
(Starting Weight: 7.0 lbs)

A-2E – Pair of Studs Attached with CB200  
(Starting Weight: 7.0 lbs)

A-2F – Pair of Studs Attached with CB200  
(Starting Weight: 7.0 lbs)



# Survivability



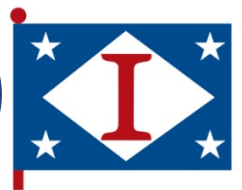
LWSM at Ingalls



Vibration Table at NTS



# Environmental Test Plan Summary



The test plan is designed to measure bond performance under a variety of conditions outlined by NAVSEA. The main parameters are:

- Materials - Steel, Aluminum, Corrosion Resistant Steel (CRES) Honeycomb
- Bond Strength - Tensile and Shear
- Adhesives - Plexus AO420 and Click Bond CB200
- Attachments - Click Bond CB3200 Studs
- Conditions - Baseline, Corrosion / Aging, Elevated Temperature
- Variability - Lot to lot based on 3 lots



# Environmental Test Matrix



Test Description	Bonding at:	Timing	Test Article (Materials)	Replicates	Cure Time (Hr)	Cure Temp (F)	Exposure Time (Days)	Exposure Temp (F)	Exposure Conditions	Test Type	Testing Temp (F)	Plates Steel	Plates Al
Baseline Adhesion	Ingalls	Batch 1	Studs (S/Al)	5	24	70	N/A	N/A	N/A	(Mod) Tensile / Shear	70	4	2
Corrosion	Ingalls	Batch 2	Studs (S/Al)	5	24	70	30 days	95F	B117 Salt Fog	(Mod) Tensile / Shear	70	4	2
Corrosion	Ingalls	Batch 3	Studs (S/Al)	5	24	70	60 days	95F	B117 Salt Fog	(Mod) Tensile / Shear	70	4	2
Accelerated Aging	Ingalls	Batch 2	Studs (S/Al)	5	24	70	30 days	158F	N/A	(Mod) Tensile / Shear	70	4	2
Immersion in Water	Ingalls	Batch 2	Studs (S/Al)	5	24	70	30 days	120F	Immersion	(Mod) Tensile / Shear	70	4	2
Immersion in Detergent	Ingalls	Batch 2	Studs (S/Al)	5	24	70	30 days	120F	Immersion	(Mod) Tensile / Shear	70	4	2
Immersion in Hydrocarbon	Ingalls	Batch 2	Studs (S/Al)	5	24	70	30 days	120F	Immersion	(Mod) Tensile / Shear	70	4	2
Curing Time at Low Temp	NTS Lab	Batch Special	Studs (S)	5	Note 1	40	Note 1	Note 1	N/A	(Mod) Tensile	40	10	
Curing Time at Room Temp	NTS Lab	Batch Special	Studs (S)	5	Note 1	70	Note 1	Note 1	N/A	(Mod) Tensile	70	10	
Lot Variability B	NTS Lab	Batch Special	Studs (S)	5	Note 2	70	Note 2	Note 2	N/A	(Mod) Tensile	70	2	
Lot Variability C	NTS Lab	Batch Special	Studs (S)	5	Note 2	70	Note 2	Note 2	N/A	(Mod) Tensile	70	2	
Curing Time at High Temp	NTS Lab	Batch Special	Studs (S)	5	Note 1	90	Note 1	Note 1	N/A	(Mod) Tensile	90	10	
Elevated Temperature (250F)	Ingalls	Batch 1	Studs (S)	5	24	70	N/A	N/A	N/A	(Mod) Tensile	250	2	
Elevated Temperature (400F)	Ingalls	Batch 1	Studs (S)	5	24	70	N/A	N/A	N/A	(Mod) Tensile	400	2	

Note 1 - Fixtures pulled at 30 min, 1, 2, 24, and 48 hours at test temp

Note 2 - Repeat Room Temp, 24 hour pull only with 2 alternate batches

Total	66	14	80
-------	----	----	----

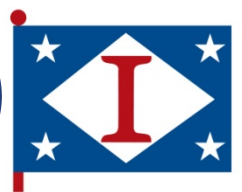




- Environmental conditions:
  - Baseline: Room Temperature Dry (simulates interior, conditioned spaces)
  - Corrosion / Aging: Extended exposure in salt fog and elevated temperature
  - Fluid Immersion: Extended exposure at elevated temperature (water, cleaning fluid, lubricating oil)
  - Elevated Temperatures:– Adhesive upper limit and elevated temperature corresponding to an N-30 class boundary backside thermal rise)
  - Curing Times: Curing curve at lower and upper application temperature limits
- Specific procedures / methods for fabricating test plates, bonding studs, and performing are included in the plan or appendices.



# Environmental Test Articles

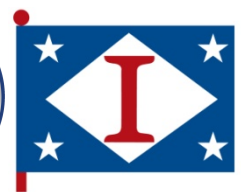


- Test Plates – 5 Replicates per Plate

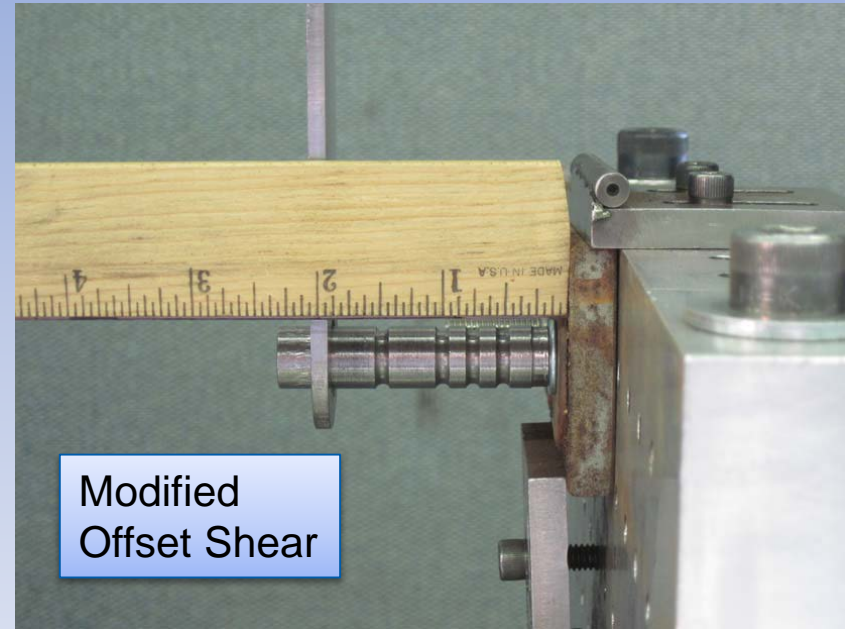
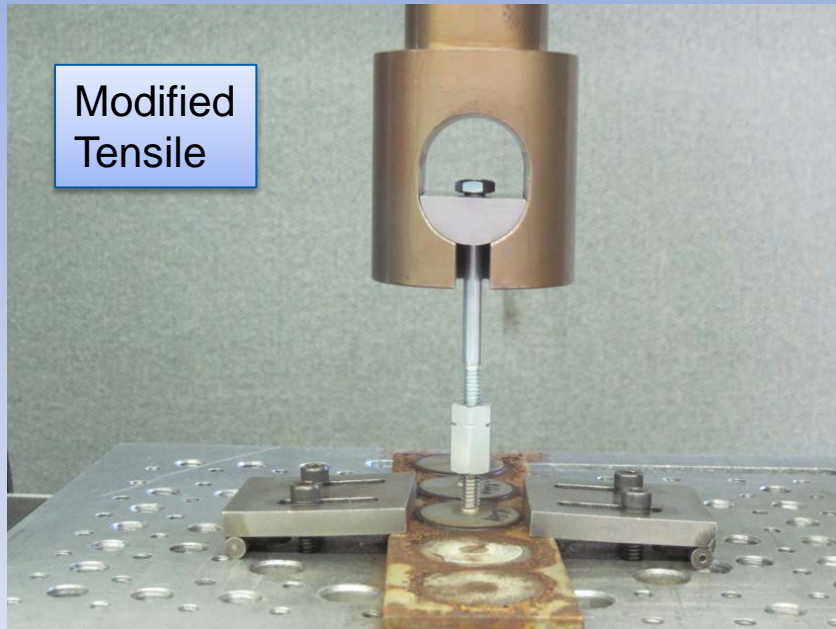


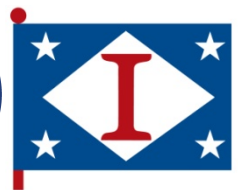


# Environmental Test Types



- Bond Performance – Tensile and Shear





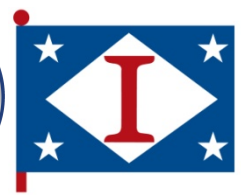
Guidelines for the use of adhesively bonded studs are as follows:

1. Shall use NAVSEA approved adhesive (currently ClickBond CB200 [7])
2. Shall use NAVSEA approved surface preparation and adhesive bonding procedures [8]
3. Shall apply to steel and aluminum substrates only
4. Maximum item weight is 20 pounds or less (loaded), provided applicable shock requirements are met.
5. Shall only be used in fire protected spaces (i.e., spaces protected with sprinklers)





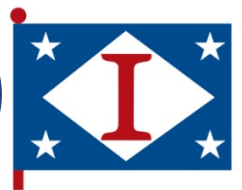
# Adhesive Use Guidelines



6. Shall not be used for fastening safety equipment such as fire extinguishers, stokes litters, axes, emergency breathing apparatus, and shall not be used for flammable materials storage containers and heat and fire detectors.
7. Shall not be used higher than six feet above the deck level.
8. Shall not be used to support hanging or swinging weights.
9. When employed for hanging or supporting cables, at least every third hanger shall be welded.
10. Shall not be used to mount electrical equipment or boxes unless a separate NAVSEA approved ground is incorporated in the box/component design.
11. Shall conform to other requirements established by NAVSEA, as applicable.



# Phase II Plans Through Year End



1. Complete Test Articles
2. Begin Environmental Tests
3. Complete Shock Survivability Tests



# Questions?

