The Naval Vessel Rules and GRP Pipe

Certifying New Pipe for US Navy Surface Ships

National Shipbuilding Research Program
Product Design & Material Technologies Panel Meeting
June 15-16, 2010

David McNamara
Principal Materials Scientist

Collaborators

- CTC – Dr. Joseph Pickens, Robert Akans
- ITT Specialty Plastics – Randy Jones, Steve Kirkland, Kevin Schmit
- Gibbs and Cox – Robert Merkle and Larry Gordon
- Naval Surface Warfare Center – Philadelphia Joseph Scharf

and technical experts at

- Naval Surface Warfare Center – Carderock
- Naval Surface Warfare Center – Crane
- Northrop Grumman Shipbuilding

Program Approach

- Establish requirements based on Naval Vessel Rules
- Modify existing piping to meet needs
- Perform qualification testing leading to certification

Objectives

- Achieve same or better performance as Cu-Ni piping (shock, fire, repair, etc.)
- Reduce manpower (Installation & In Service)
- Reduce ship acquisition cost, weight & corrosion

  -Result: Lower system life-cycle cost (LCC)
- How??
  - Adapt and certify lightweight, low-cost composite piping technology (presently serving on Allied naval combatants, commercial ships and oil drilling platforms) to U.S. Navy ships

Potential Advantages of GRP Piping for Naval Ships

- Weight Savings
  - Up to 75% reduction for >10″ nps over CuNi pipe
- Corrosion Resistance
  - No galvanic component and good service history
- Fouling Resistance
  - Similar in performance to CuNi pipe
  - Smooth inner surface lessens fouling under high flow conditions

Royal Navy Experience

New Bulwark class LPD's each used about 1,600 feet of ITT Fiberbond® GRP pipe (ballast system) pipe ranging from 10 to 30-in. O.D.

- Acquisition cost of 10 to 30-in. GRP piping system was roughly half that projected for Cu:Ni pipe

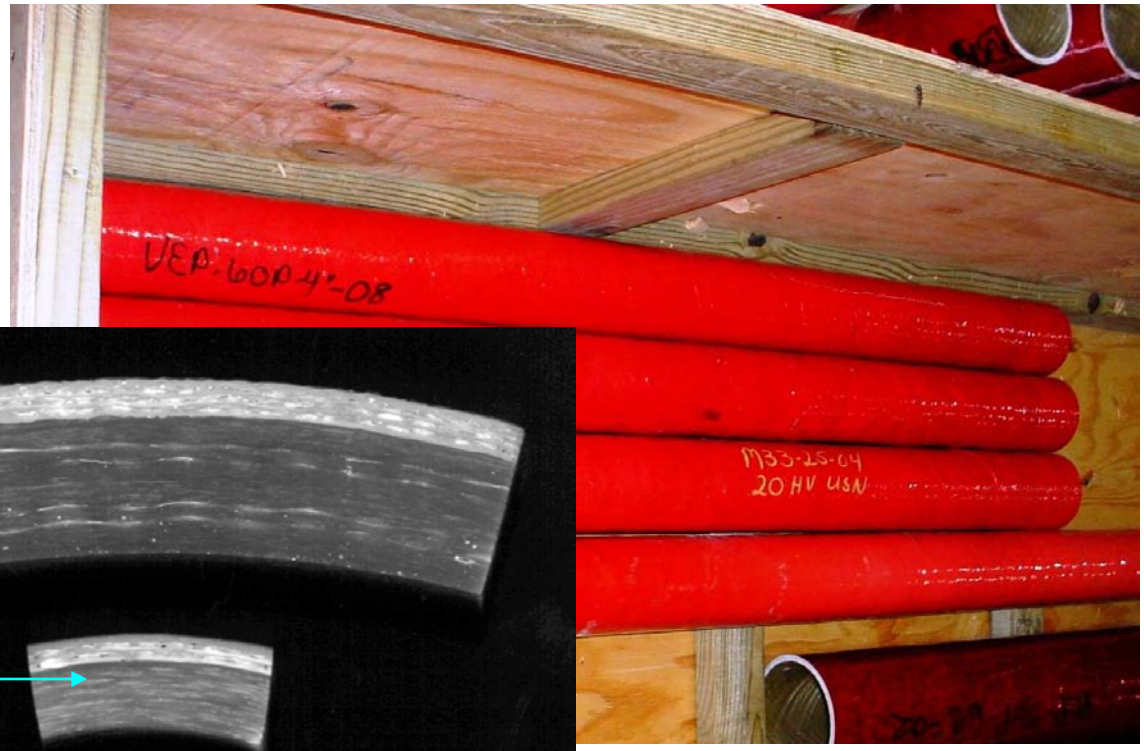
- Use of just 1,600 feet of GRP pipe saved 75 tons (25 vs. 100) and $600,000 per ship

- Installation cost savings of $900 per lineal foot with GRP

Comparison of GRP and Cu-Ni Key Properties

	Nominal Pipe ID (in.)	Outside Diameter (inches)	Wall Thickness (inches)	Weight (lb per lineal foot)	Service Temp. Limit (ºF)	Pressure Rating (psi)
ITT VEP II	4	4.9	0.45	4.7	200	232
70:30 Cu:Ni	4	4.5	0.11	5.8	1000	200
ITT VEP II	12	13.4	0.69	21.2	200	232
70:30 Cu:Ni	12	12.75	0.25	38.1	1000	200

Vinyl Ester Phenolic II (VEPII) Fiberbond® Pipe Construction



Filament wound vinyl ester resin body, glass reinforced phenolic resin outer layer

The Naval Vessel Rules and GRP Piping

- ABS Guide for Building and Classing Naval Vessels – 15 July 2004
- Part 5 Auxiliary Machinery Systems, Section 1C Reinforced Plastic Piping
- A full range of mechanical, fire performance and physical behavior tests
- Additional testing mandated to conform to earlier Mil-P-24608 GRP piping standard

NVR Test Requirements – Mechanical Properties

NVR Section	Test Type	Standard	Test Specimen
MIL-P 3.6.1.1	Long Term Hydrostatic Pressure	ASTM D2992 Procedure B	Pipe or Assembly, L/D >5x nps
MIL-P 3.6.1.2	Cyclic Pressure Strength	10,000 cycles to 400 psig	Hybrid Test Article
MIL-P 3.6.1.3	Hydrostatic Collapse Strength	ASTM D2924	Pipe, L/D >10x nps
MIL-P 3.6.1.4	Ultimate Tensile Strength	ASTM D2105	Pipe
MIL-P 3.6.1.5	Joint Strength	ASTM D2105 modified	Pipe with center butt joint
MIL-P 3.6.1.6	Hydrostatic Strength	Hold 400 psig for 5 minutes, repeat with 800 psig	Hybrid Test Article

NVR Test Requirements – Mechanical Properties

NVR Section	Test Type	Standard	Test Specimen
MIL-P 3.6.1.7	Hydrostatic Strength	300 psig for 5 min (ASTM D1599)	Pipe, L/D > 5x nps
MIL-P 3.6.1.8	Impact	2.23 ft-lb steel ball (ASTM D2444)	Pipe
5.1.1C.3.1	Hydrostatic Failure Pressure	Test or calculation	ASTM D1599
5.1.1C.3.2	Collapse Test Pressure	Test or calculation	ASTM D2924
5.1.1.C.3.3	Longitudinal Strength	Test or calculation	ASTM D1599
5.1.1C.3.4	Heat Distortion Temperature	ISO 75 Method A	ASTM D648
5.1.1C.3.5	Impact Resistance	ASTM D2444	Modified Test Protocol

Longitudinal Strength Testing

Whole pipe fails by spiral fracture at 6000 psi
Jointed pipe and flanges fail at same strength level in connecting pipe

Collapse Pressure Testing

‘Buckling’ failure at 3900 psi overpressure

Salient Mechanical Properties

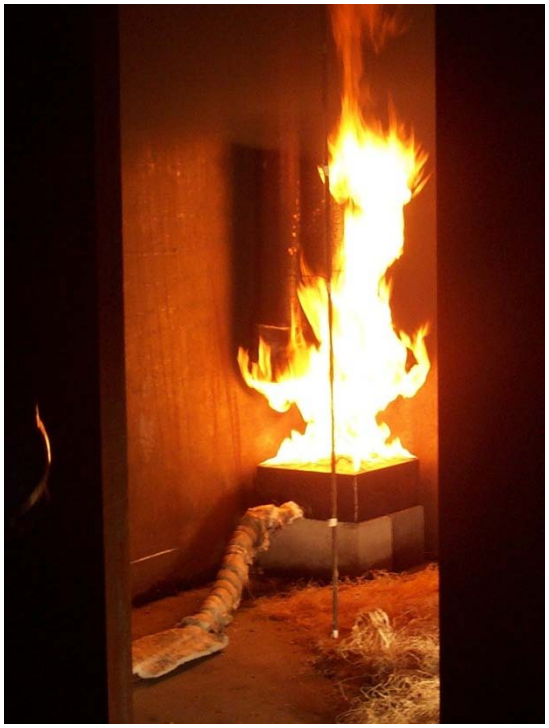
Test	Result	Comment
Tensile Strength	6024 + 307 psi	1.54 msi modulus
Internal Pressure	> 4000 psi	>32,000 psi hoop stress
Collapse Strength	3930 psi	
Long Term Hydrostatic Pressure	574 psi	20 year (95% confidence)
Impact Resistance	> 25 ft-lb	Impacter geometry dependent
Heat Deflection Temperature	260 °F	

NVR Fire Performance Tests

NVR Section	Test Type	Standard
5.1.1C.3.6.1	Shock Test	Mil-S-901d
0.3.8.1.1	Vibration Test	Mil-Std-167-1
5.1.1.C.3.6.2	USCG Modified ISO Fire Endurance Test	IMO A.753
5.1.1.C.3.6.3	USCG Modified ISO Flame Spread Test	IMO A.653
5.1.1C.3.6.4	Smoke Evolution Test	ASTM D668
5.1.1.C.3.6.5	Fire Gas Toxicity Test	ASTM D800
5.1.1.C.3.6.6	Room Corner Fire Test	EB4013

Fire Endurance Testing

Room Corner Fire Test



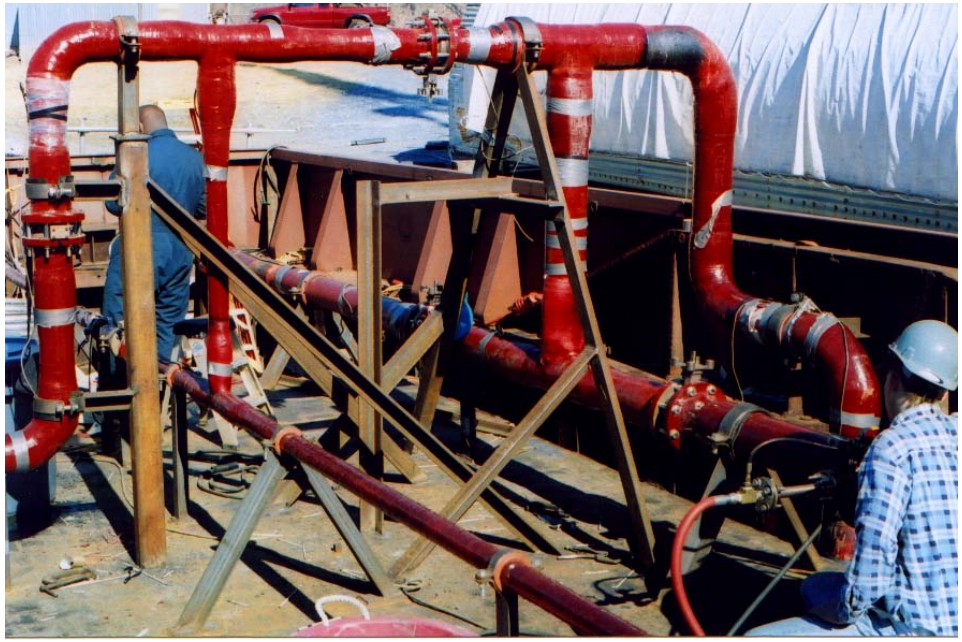
Fire Performance Test Results

Test	Criteria	Result
Vibration	No leakage	Passed
Shock	No leakage	Passed
Level III Fire Endurance	Hold pressure after 30 min. test	Passed
Room Corner Test	Limited heat evolution/smoke	Passed
Smoke Density	Smoke density	Passed
Fire Gas Toxicity	Toxic gas levels	Passed
Flame Spread	Heat evolution	Fails total heat evolution criteria

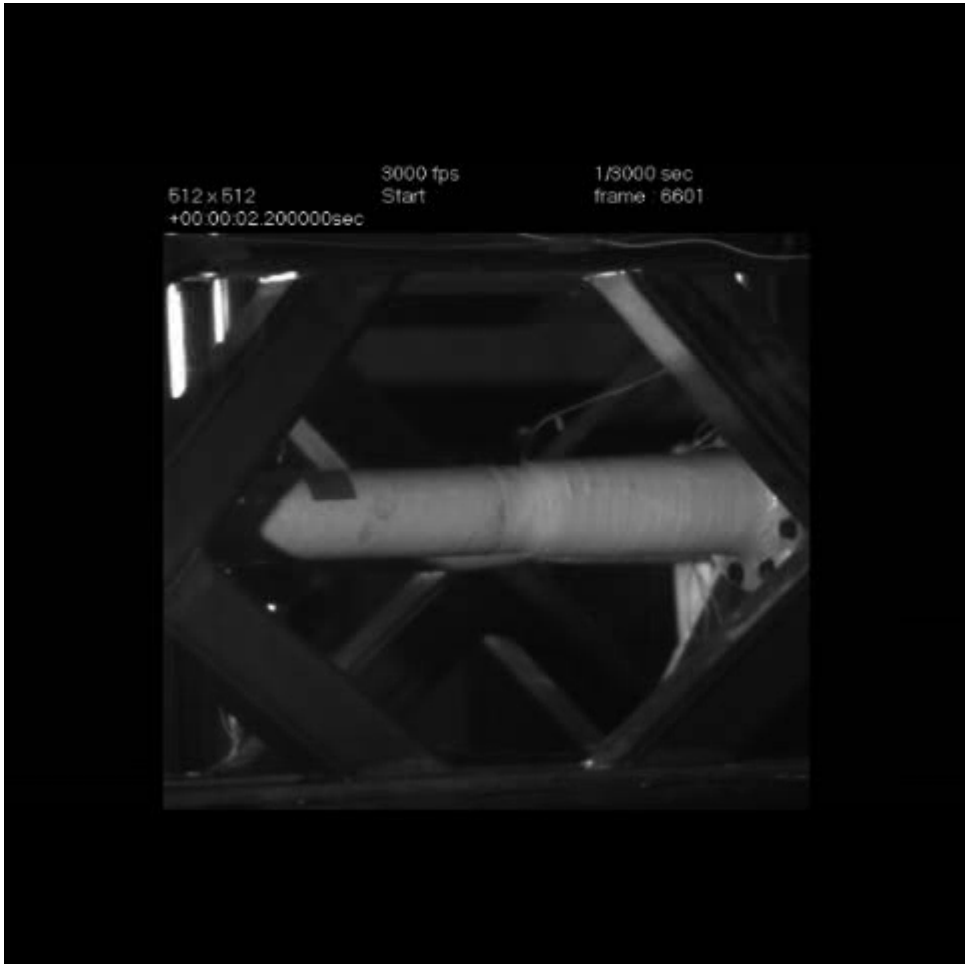
Additional Confidence Tests

Test	Test Specification	Result
Flange Strength		Flange is stronger than pipe wall
3pt Bending		12,000 psi
Floating Shock Platform	Mil-S-901	Flange failures only

FSP Test Article During Construction / Testing



High Speed Video During Medium-Weight Shock Testing



Conclusions

- GRP piping has been developed that is close to passing all the NVR mandated tests.
- Shock and mechanical tests have demonstrated the fitness of GRP piping; no evidence of any significant failure with only minor weeping of piping during testing.
- Fire performance meets most criteria. All tests that use intact pipe have been successful.

Concurrent
Technologies
Corporation

Putting ideas into action.SM

David McNamara
814 262-2320
mcnamard@ctc.com