Image Cover Sheet

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TITLE

Novel Materials for Improved Fire Safety of Naval Platforms

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Novel Materials for Improved Fire Safety of Naval Platforms

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ABSTRACT

Fire at sea has been called "the ultimate nightmare." Ships' damage control teams must respond to fire at sea rapidly and contain or extinguish the fire as soon as possible often under very difficult situations exacerbated by the dense smoke and toxic fumes released as materials burn. Ships carry a considerable mass of combustible materials including interior furnishings, electrical cables and painted bulkheads and deckheads to name a few. Moreover, fire can spread rapidly throughout the ship from one compartment to another along burning electrical cable pathways. The use of construction materials, which are inherently fire resistant, can provide a measure of protection against fire but this is often costly or impossible to do owing to unavailability of fire resistant products. It follows, then, that materials vulnerable to fire will inevitably be present on ships and that any measure that can be used to reduce their vulnerability thus minimizing fire growth would be beneficial to surviving a fire at sea, and, in the case of a warship, possibly critical to mission success. This briefing will describe some of the studies that have led to the development of novel, non-toxic, non-combustible, inorganic intumescent coatings that can be used to retrofit a variety of vulnerable substrates and provide an increased measure of fire resistance. Further, the presentation will describe some products of commercial initiatives that have grown out of this basic technology in Canadian industry.

NOVEL MATERIALS FOR IMPROVED FIRE SAFETY OF NAVAL PLATFORMS

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Defence Research Establishment Atlantic

DEFENCE R&D DÉFENSE

Outline

- Background
- Approach: Intumescent Coatings
- Organic versus Inorganic Systems
- Experimental Work and Evaluations
- Commercialization Opportunities
- Summary

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Background

- Fire at Sea "The Ultimate Nightmare"
- Aim to Minimize Spread of Fire
- Protection of Vulnerable Substrates
- Non-combustible Coatings
- Low Cost and Retrofit Capability
- Dual Use

Intumesce

- To Expand as from the Action of Heat
- The Bubbling Up of a Molten Mass

Organic Coatings

- Can Add to Fire Load
- Rapid Release of Blowing Agent
- Produce Smoke and Toxic Gases
- Ablation of Surface Char
- Good Environmental Resistance
- Expensive

Inorganic Coatings

- Non-combustible
- No Added Fire Load
- No Toxic Gases or Smoke
- Strong Rigid Foamed Structure
- Inexpensive
- Poor Environmental Resistance

Inorganic Compositions

- Na - Silicate
- K - Silicate
- Li - Silicate
- Na / K / Li - Silicate Mixtures

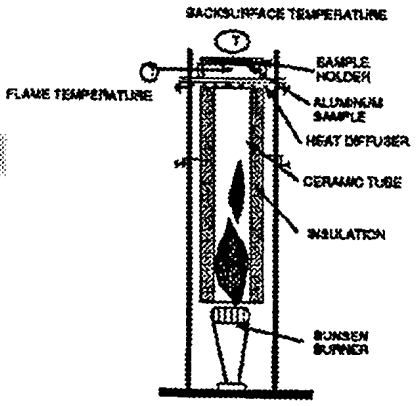
Formulations

- From Solution as Liquid Coatings
- Powdered Granules in Silicate Solution Binder

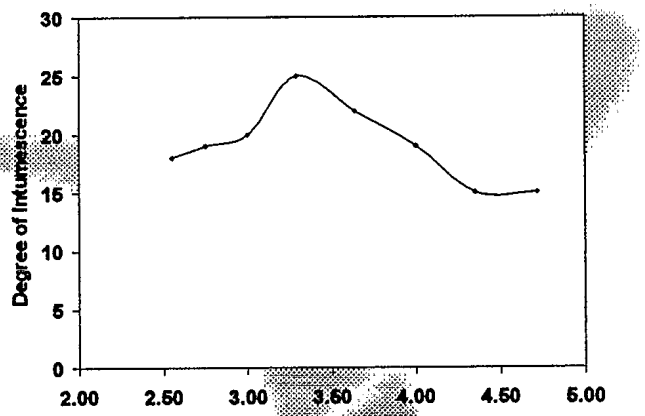
Mechanism of Intumescence

- Heat Liberates Water of Hydration
- Inorganic Coating Softens
- Escaping Water Vapour Causes Softened Coating to Expand
- Expanded Porous Structure Re-solidifies

Laboratory Test Apparatus



Effect of Molar Ratio on Intumescence



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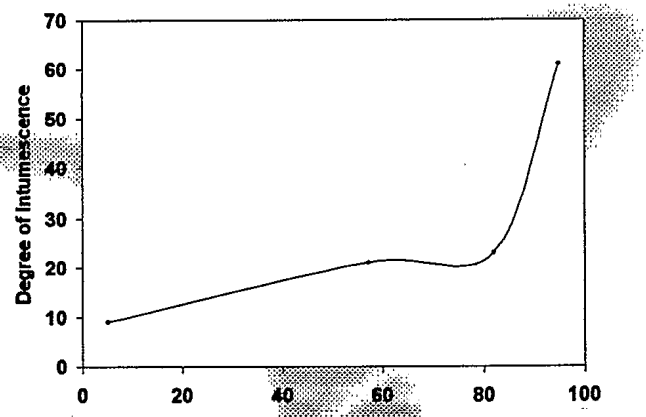
Effect of Humidity on Intumescence SiO2:K20 Molar Ratio 3.3



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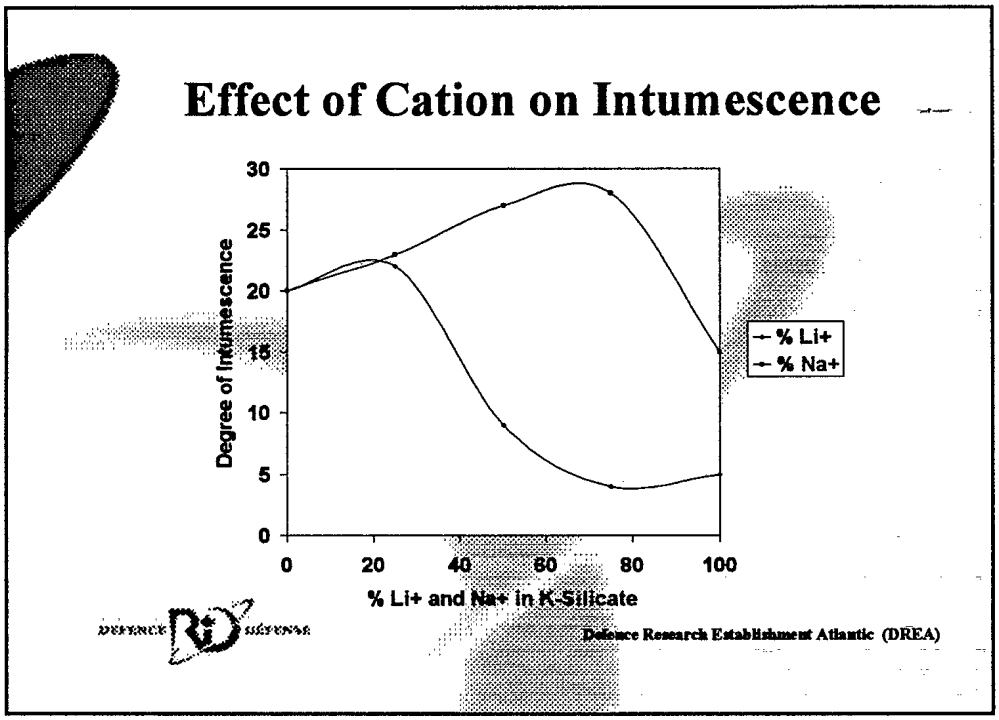
Effect of Cation on Intumescence
Degree of Intumescence
30
25
20
15
10
5
0
0
20
40
60
80
100
% Li+ and Na+ in K-Silicate
% Li+
% Na+
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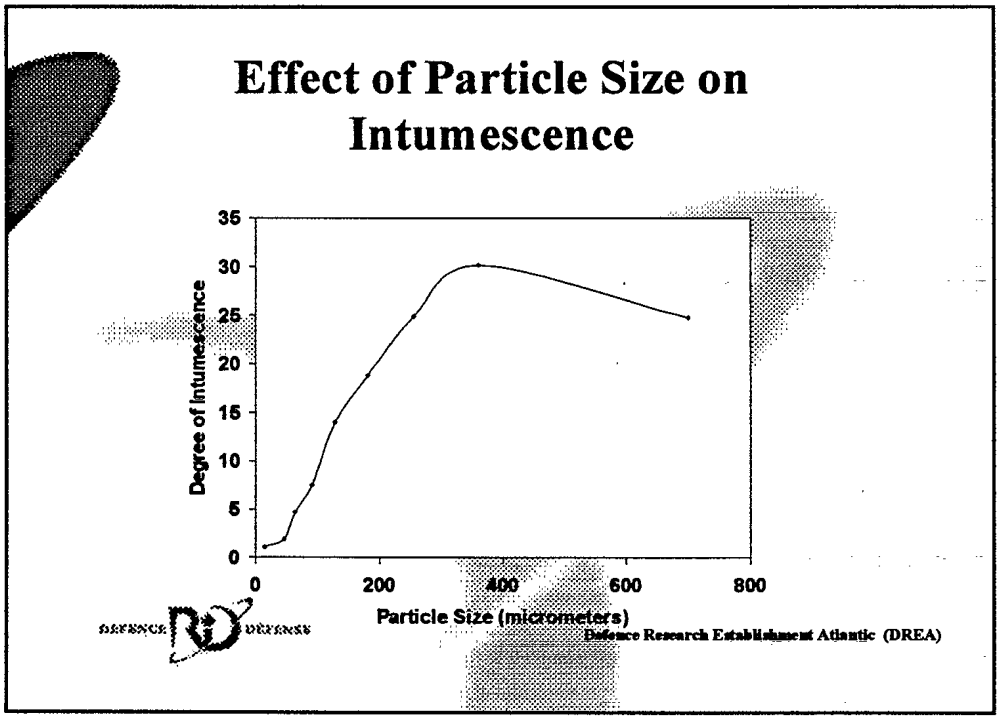
Effect of Particle Size on Intumescence
Degree of Intumescence
35
30
25
20
15
10
5
0
0
200
400
600
800
Particle Size (micrometers)
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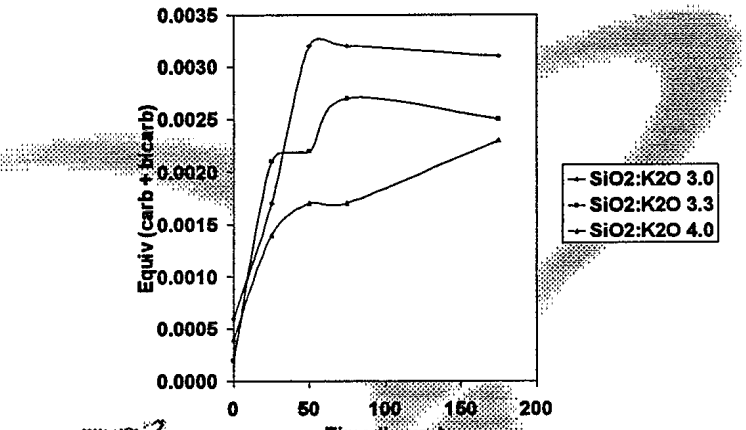
Effect of Molar Ratio on Efflorescence K-Silicate



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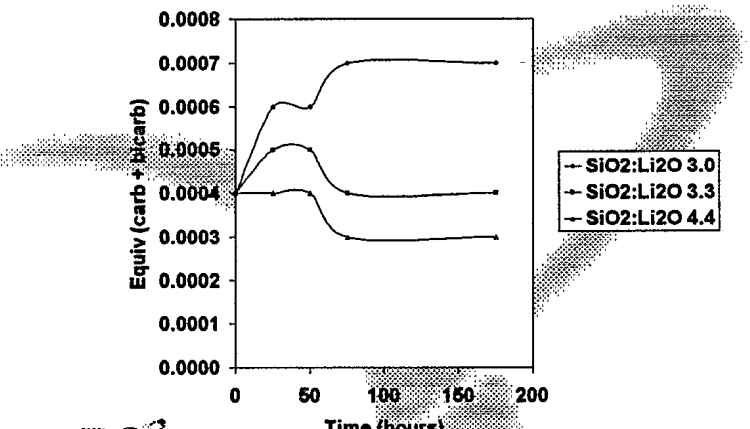
Effect of Molar Ratio on Efflorescence of Li-Silicate



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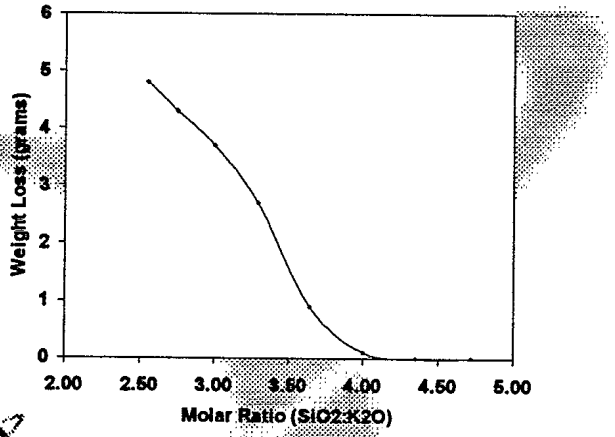
Effect of Molar Ratio on Solubility of K-Silicate



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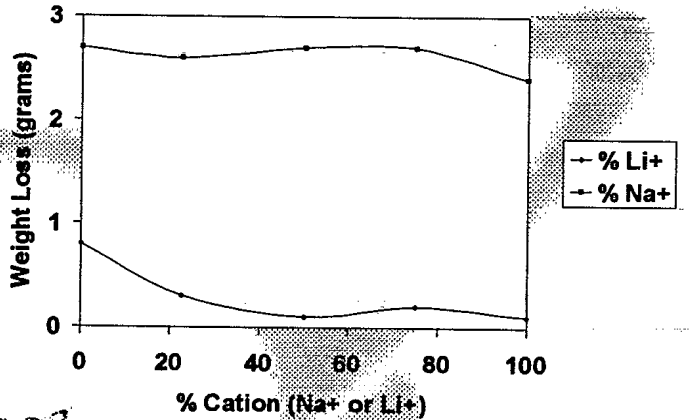
Effect of Cation on Solubility of K-Silicate



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Fire Rated Property Testing

- U. S. MIL - STD - 2031 Required Tests
- ASTM E 162 Flame Spread Index
- ASTM E 662 Smoke Density
- ASTM E 1354 Heat Release
- U. S. Navy Quarter Scale Test

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MIL-STD 2031 Results

Test Characteristic	MIL-STD-2031	Coated GRP
Flame Spread Index	20 max	1
Smoke Density @ 300 s	100 max	4
Max Smoke Density	200 max	258
Time to Ignition @100 kW/m^2 (s)	60 min	224
Time to Ignition @ 75 kW/m^2 (s)	90 min	382
Time to Ignition @ 50 kW/m^2 (s)	150 min	No Ignition
Peak Heat Release @ 100 kW/m^2 (kW/m^2)	150 max	143.8
Peak Heat Release @ 75 kW/m^2 (kW/m^2)	100 max	65.6
Peak Heat Release @ 50 kW/m^2 (kW/m^2)	65 max	No Ignition
Heat Release 300 s @ 100 kW/m^2	120 max	67.02
Heat Release 300 s @ 75 kW/m^2	100 max	35.32
Heat Release 300 s @ 50 kW/m^2	50 max	No Ignition

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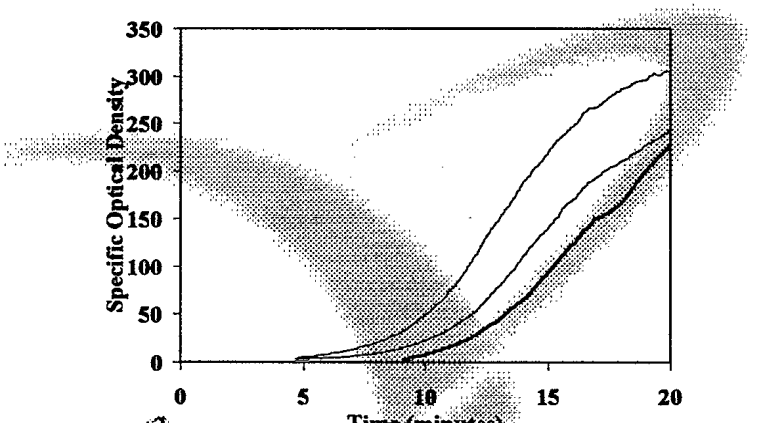
Smoke Density of Coated GRP (ASTM E 662)



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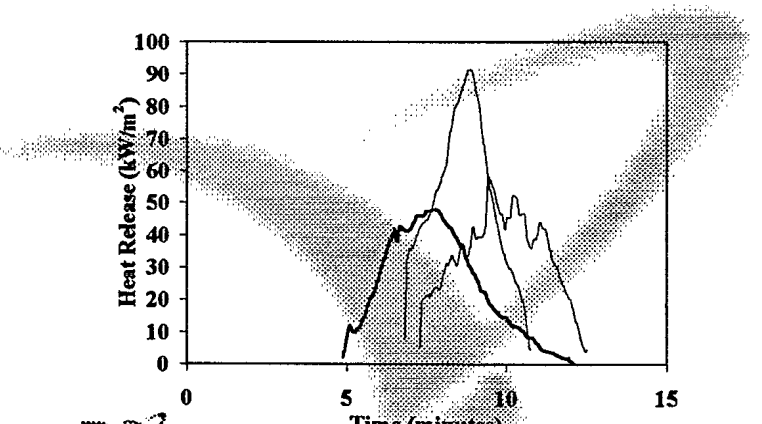
Heat Release of Coated GRP ASTM E 1354 @ 75 kW/m²



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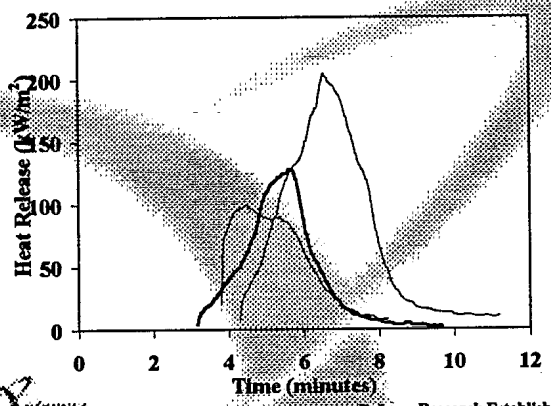
Heat Release of Coated GRP ASTM E 1354 @ 100 kW/m²



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United States Navy Quarter Scale Test

- Arranged Through TTCP with NSWC
- Vinyl Ester GRP Substrate
- Inorganic Powder / Binder Coating
- Spray Application to 20-40 mil Thickness
- Adhesion

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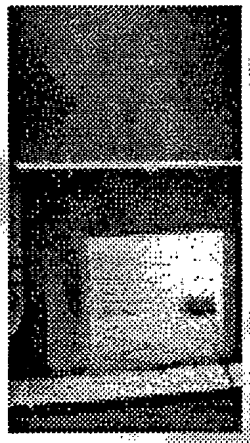
United States Navy Quarter Scale Test Set-Up During Exposure on Coated GRP



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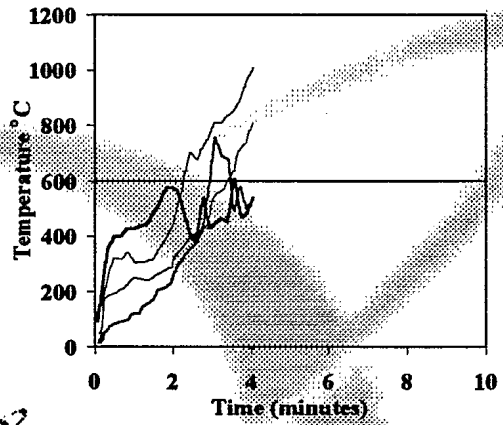
U. S. Navy Quarter Scale Test of Uncoated GRP



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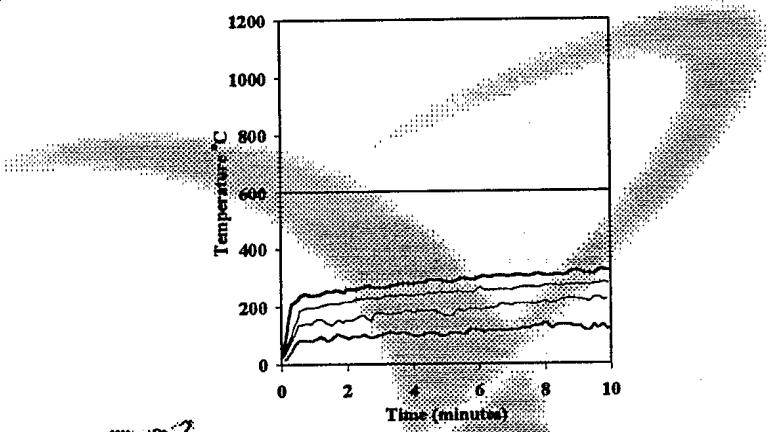
U. S. Navy Quarter Scale Test of Coated GRP (337.5 kJ/min)



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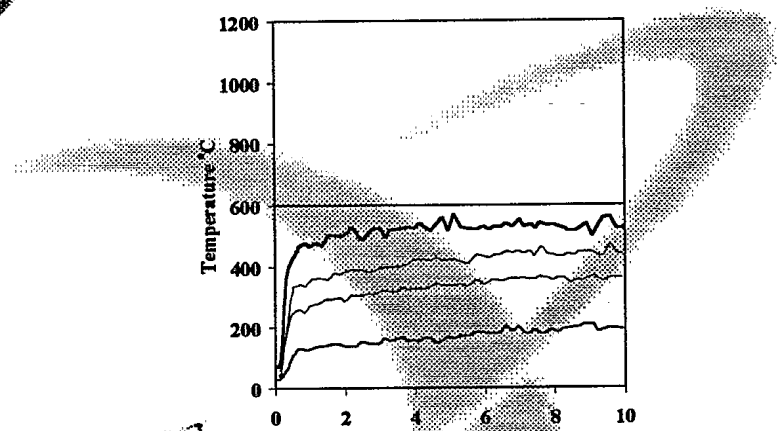
U. S. Navy Quarter Scale Test of Coated GRP (675 kJ/min)



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Commercialization

- J. O. Bernt and Associates, Limited
- Fire Rated Coatings
- Interior Core for Wood Fire Doors
- Penetration Sealant
- Fire Safe Bulkheads / Siding

Summary

- Inorganic Intumescent Coating Developed
- Passed U.S. Navy Quarter Scale Test
- Technology Transferred to Canadian Industry with DIR Support
- Commercialization Opportunities Growing
- Penetration Sealant Approved for Naval Use