

SPE/ASPE Workshop

Downhole Precision Tools in HPHT Applications: Filling the Gaps



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SPE/ASPE Workshop

Innovative Internal Coatings for HPHT Environments – Field Testing for the Future

Robert Deuis, David Waldbillig, Daniel Pilon, Craig Metcalfe and Steve Petrone
Quantiam Technologies Inc., Edmonton, CANADA



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quantiam[®]
technologies inc.

- Advanced materials and coatings company founded in 1998
- Research and commercialization of new products focusing on coatings for internal surfaces; strong manufacturing focus
- **Mission:** commercially exploit matter at the nano-scale to extend the frontiers of advanced materials for extreme environment and energy intensive applications
- **Goal:** develop and commercialize high value, disruptive new products based on nano-scale properties



- Quantiam developed proprietary coating manufacturing process
- Macro-coating: 50 – 4,000 microns (2 - 160 thou) thick
- Metallurgical bond with substrate
- Non-line-of sight deposition enables internal or external surfaces of complex shapes & tubular products to be coated
- Low-cost manufacturing process
- Wide range of coating material formulations can be exploited



Disruptive Coated Products for Extreme Environments

	Coating	Description & Protective Role	Substrate	Environment
Petro-chemical	CAMOL™*	catalytic: lower {coking rate, energy consumption, GHGs} increase throughput & ethane conversion to ethylene	25Cr-35Ni-Fe 35Cr-45Ni-Fe	olefin pyrolysis (ethylene) furnace 1160 C (2120 F), oxidising, carburising, sulfidizing
Oil & Gas	Oil & Gas Series A	wear (abrasion & sliding) and mild corrosion	API 5CT J55 API 5CT L80	downhole field trials in 2014 - tigh oil formation wells
	Oil & Gas Series B	wear & severe corrosion Hastelloy™ & Inconel™-based	API 5CT J55 API 5CT L80	downhole sour gas & dissolved CO ₂
	Oil Sands	wear (abrasion & erosion)	API 5L grade	hydro-transport of bituminous sand slurry
Aerospace & Defence	Defence	wear (abrasion, dry sliding and melt wear) thermal fatigue cracking & high temperature corrosion	AISI 41xx series 416R stainless	weapon barrel coatings ≤1200 C (2192 F), ≤440 MPa (64 ksi)

*catalyst manufacture of olefins

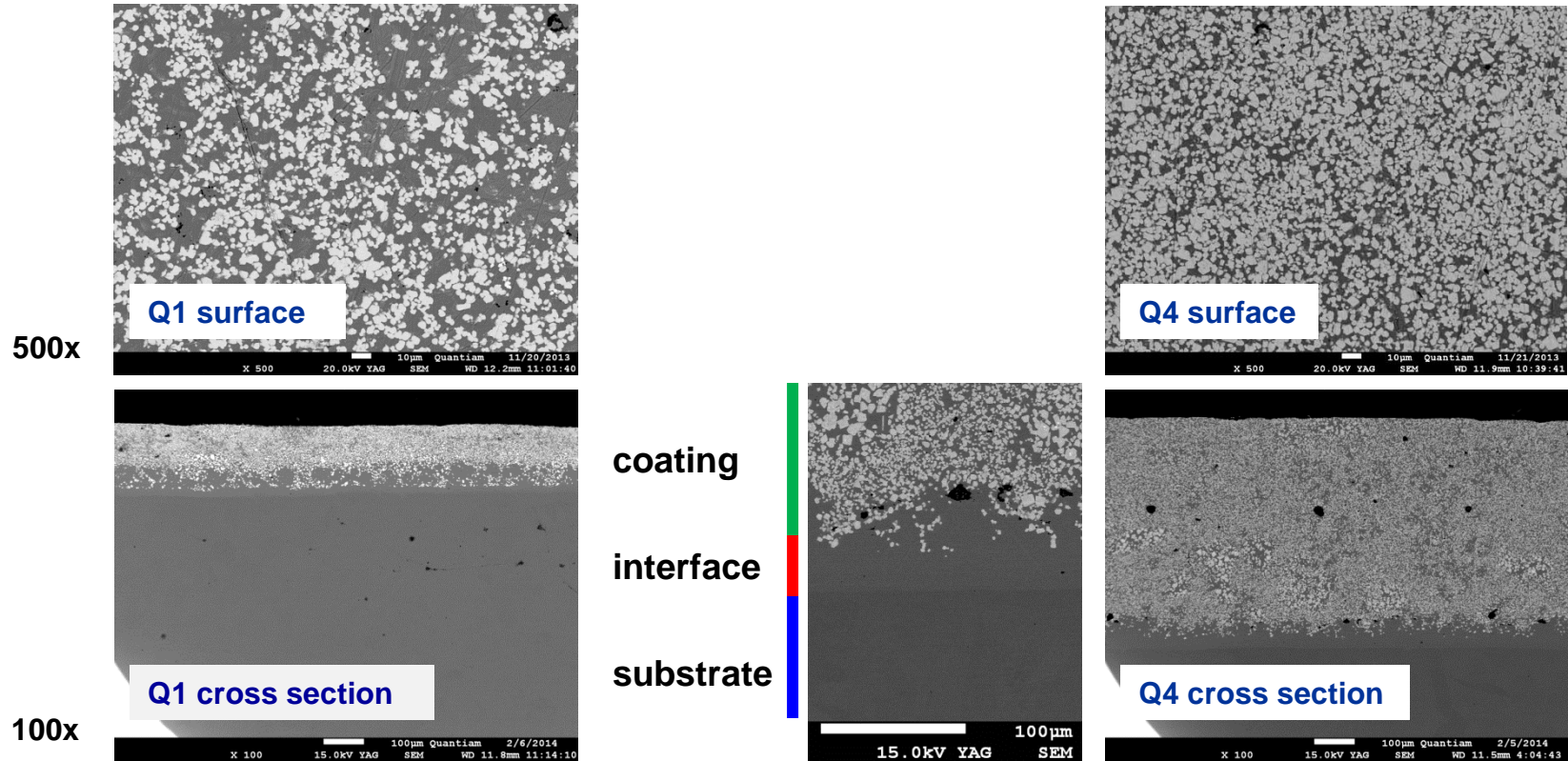


Description		ID	VHN (kg/mm ²)	HR _C
Reference	uncoated tubing	J55	190	9
	sucker rod coupling	N-1	613	56
Series A	wear coatings	Q-1	781	63
		Q-2	896	67
		Q-3	658	58
		Q-4	788	63
Series B	wear & corrosion coatings	Hast-1	754	62
		Hast-2	828	65
		Inc-1	722	61



Microstructures – SEM Micrographs

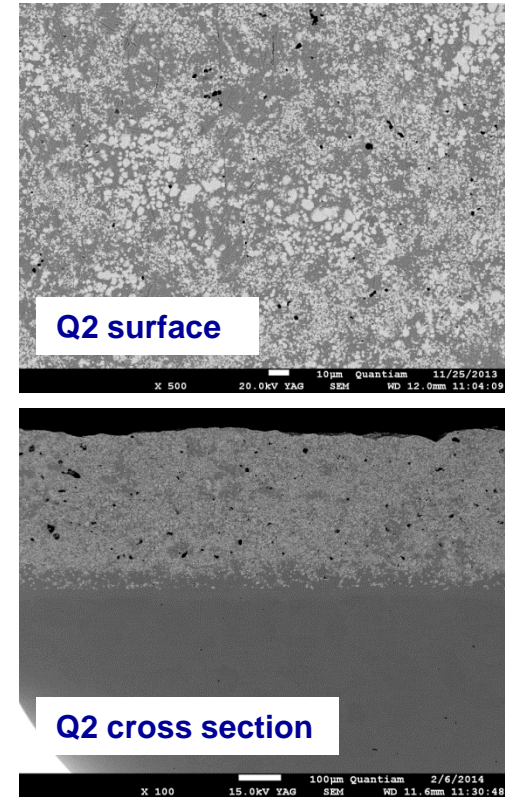
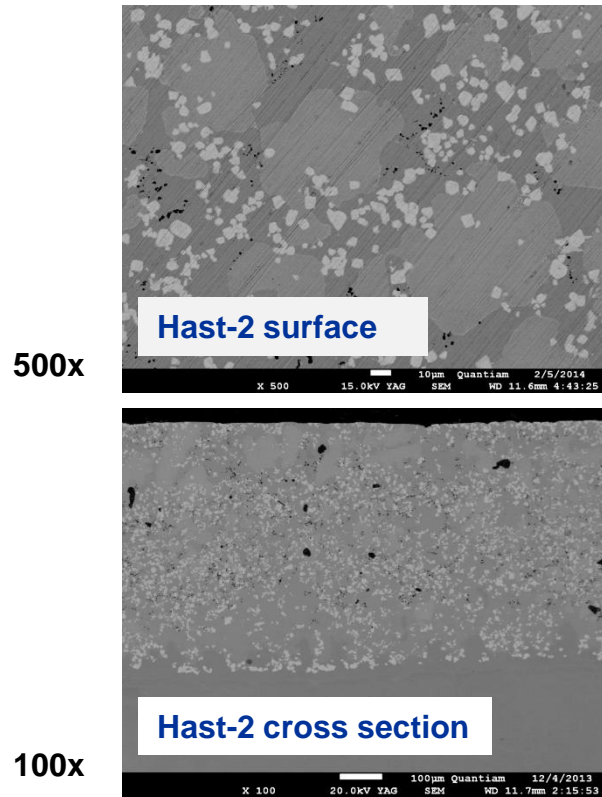
Oil & Gas Series A – Wear Coatings



Metal matrix composite coating alloyed to substrate - diffusional interface
Hard phase for enhanced wear resistance and ductile matrix phase
Excellent hard phase/matrix bonding - high load bearing ability and fracture toughness

Microstructures – SEM Micrographs

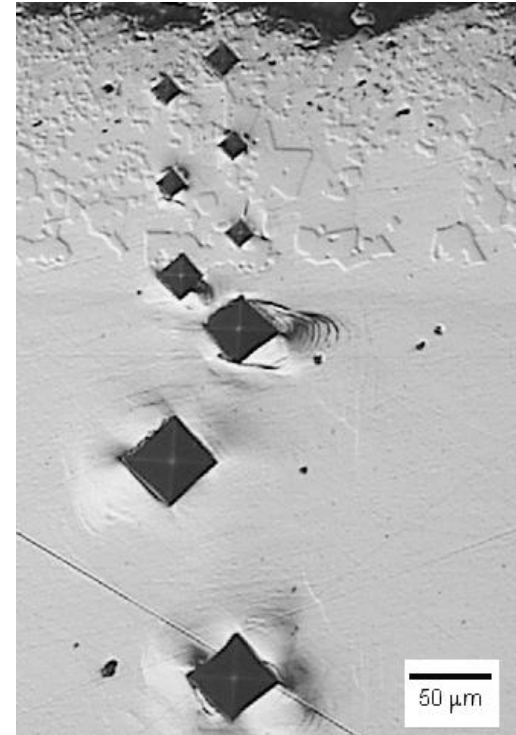
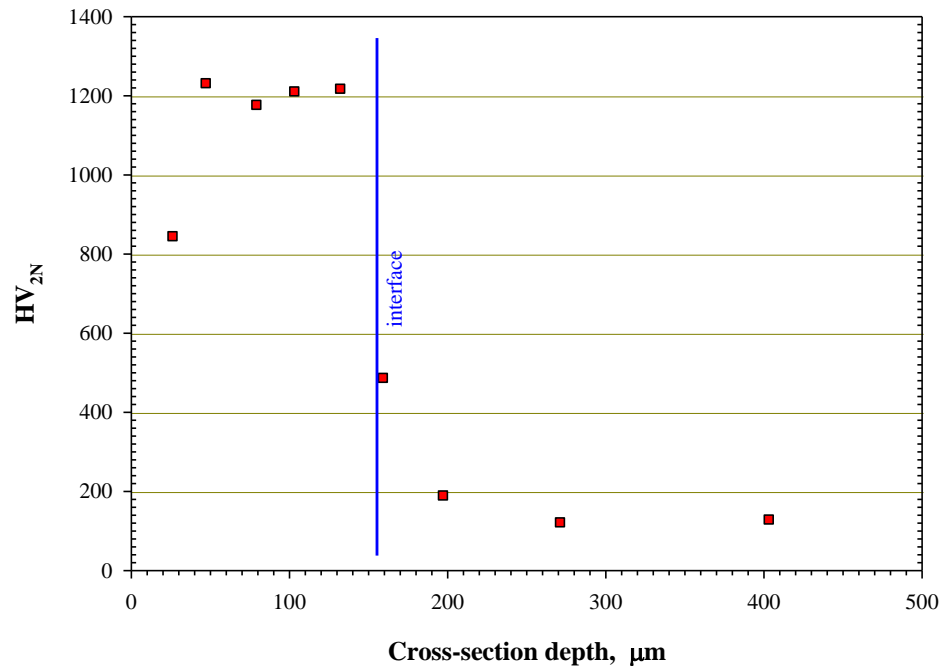
Oil & Gas Series B – Wear & Corrosion Coatings



Metal matrix composite coating alloyed to substrate - diffusional interface
Hard phase for enhanced wear resistance and ductile matrix phase
Selective constituent design – minimize galvanic corrosion within the coating



Hardness Profile for Series B Wear & Corrosion Coating



Micro-hardness Profile and OM of a Modified Hastelloy coating formulation on L80 Steel Substrate

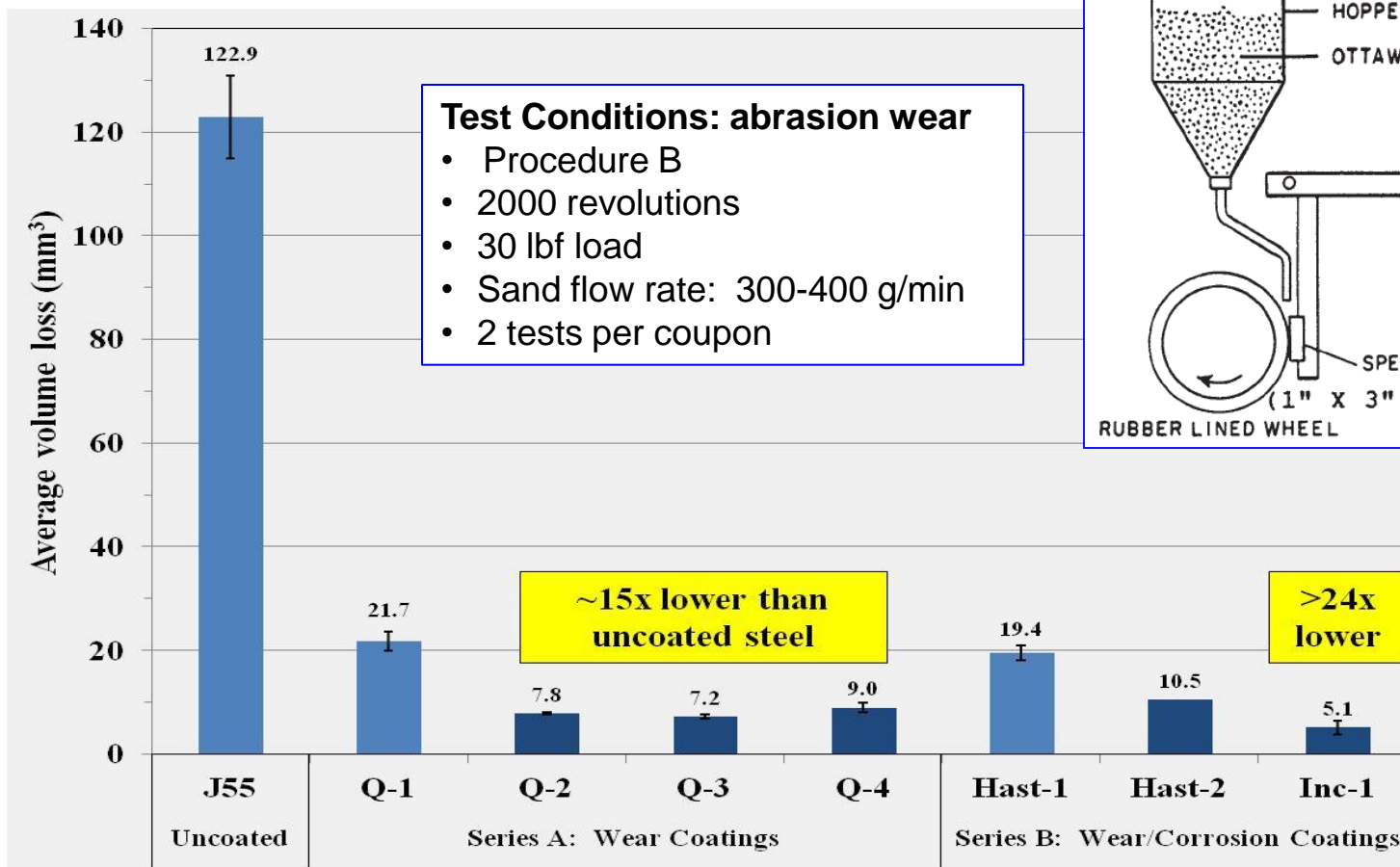


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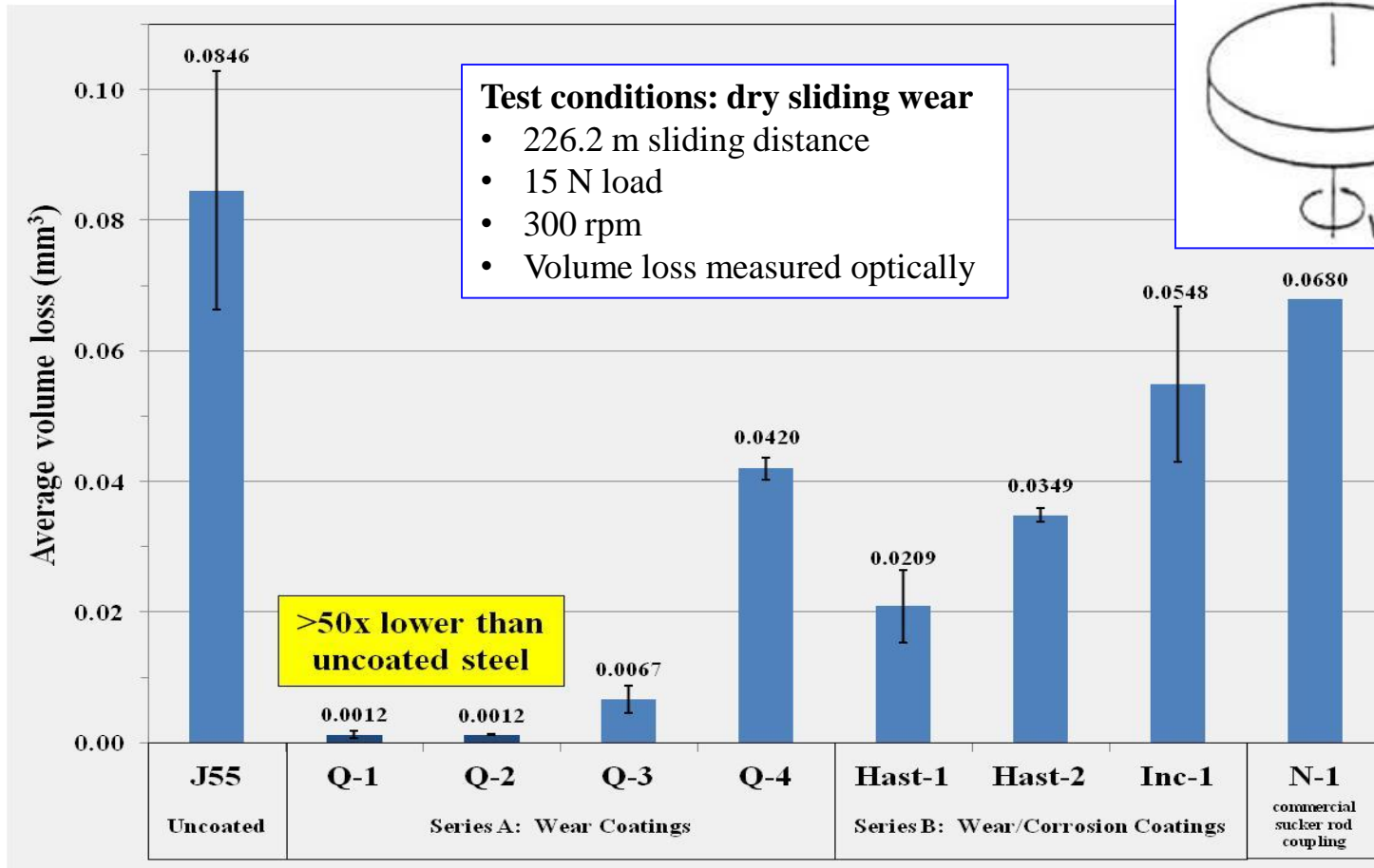
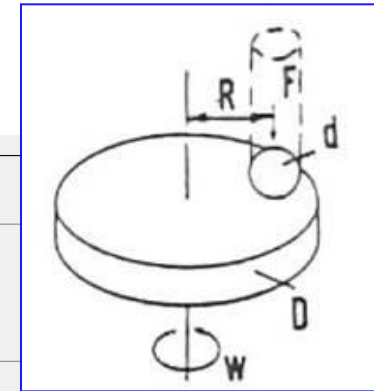


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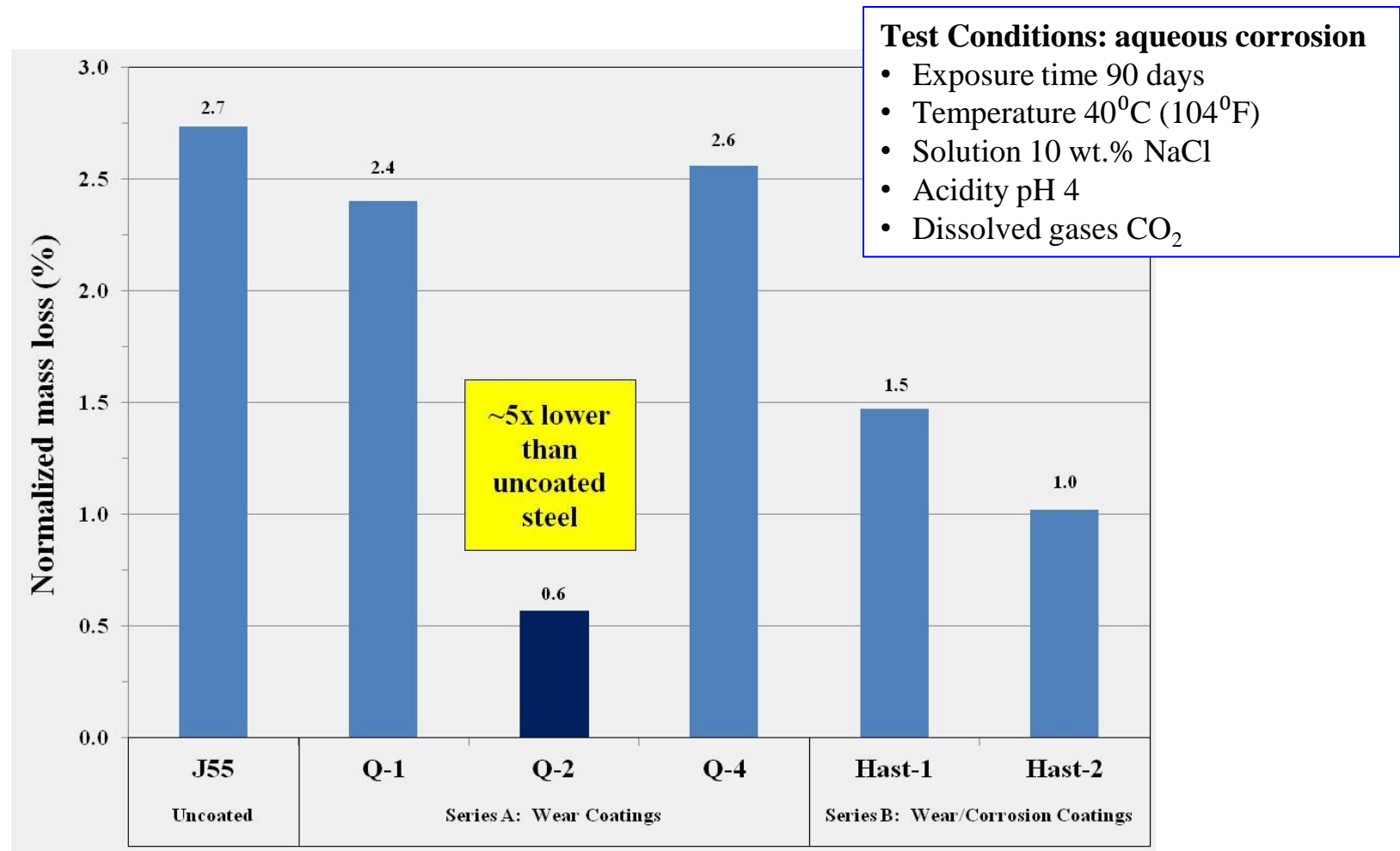
ASTM G65: Standard test for measuring abrasion using the dry sand rubber wheel apparatus



ASTM G99: Standard test for wear testing with a pin-on-disk apparatus



Immersion corrosion test

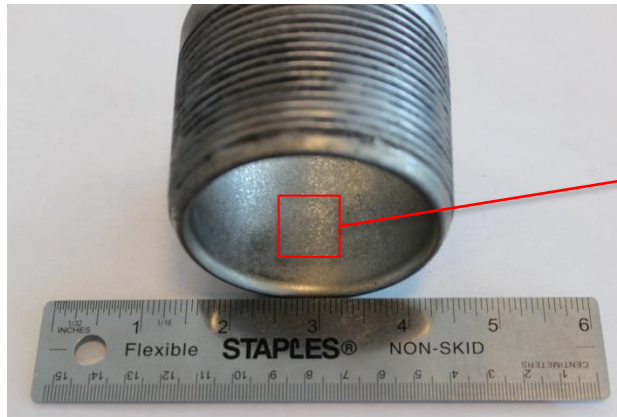


- **Manufacturing facility located in Edmonton CANADA**
 - 34,000 ft² primarily advanced manufacturing
 - Internal tubing coating capacity for 1.5” to 6” ID tubulars at 3M-in²/y (~32,000 linear ft/year) – adaptable to 2 7/8” OD J55 tubing
 - Plan to increase capacity to ~12M-in²/y (~127,000 ft/year); enable J55 & L80 tubing to be coated

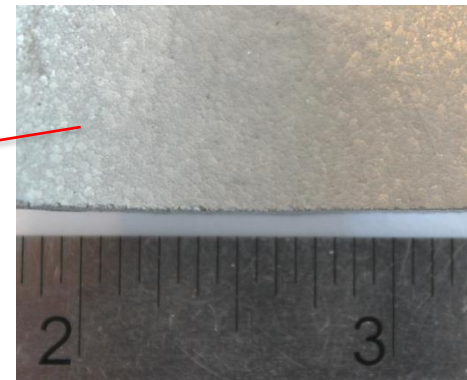


- **Trial manufacturing (2014 – 2015)**

- 1-2 field trials per year, 2 7/8 inch OD J55 10 ft pups, (500 - 1,000 ft)
- 2014 trial 1: (Series A) wear coating
- 2015 trial 2: (Series B) wear & corrosion coating
- Installation - Bakken region
- Placement directly above rod pump



Coated pup joint



Coating surface

- Adhesion
 - Metallurgically-alloyed
 - Not cladded or mechanical bond
- Substrates
 - Carbon steel
 - Stainless steel (300s, duplex, HTAs)
- Pitting Resistance
 - Series A **PREN** 64-120
 - Series B **PREN** 40-69
 - Duplex Steel **PREN** ≥40
- Future Plans
 - Laboratory HPHT testing
 - Combine loads (tension & compression)
 - Tensile, HPHT grade steel (y.s. ≥125 ksi)
 - Stress corrosion (NACE MR0175)



- **Development of two Oil & Gas coating systems:**
 - **Series A** - wear with mild corrosion
 - **Series B** - wear & severe corrosion
 - **Coating properties**
 - 50x improvement - sliding wear resistance (J55 ref.)
 - 15x improvement - abrasion resistance (J55 ref.)
 - 5x improvement - corrosion resistance (J55 ref.)



- **Commencement of trial manufacturing: Series A**
 - 1-2 trials of 500 - 1,000 ft of 2 7/8 inch OD J55
 - Installation - Bakken for field evaluation in 2014 - 2015
- **Scale-up manufacturing process and coating capacity: (2015)**
 - Increase capacity - range 1 tubing (J55 & L80)
 - Utilize existing coating capacity of 32,000 ft/y in 2015
 - Expand up to 127,000 ft/y in 2016 – as warranted



Thank-you for your Kind Attention!



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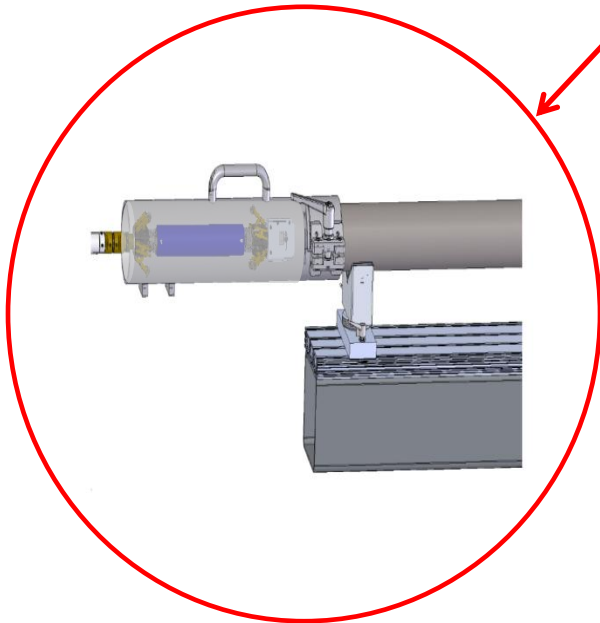
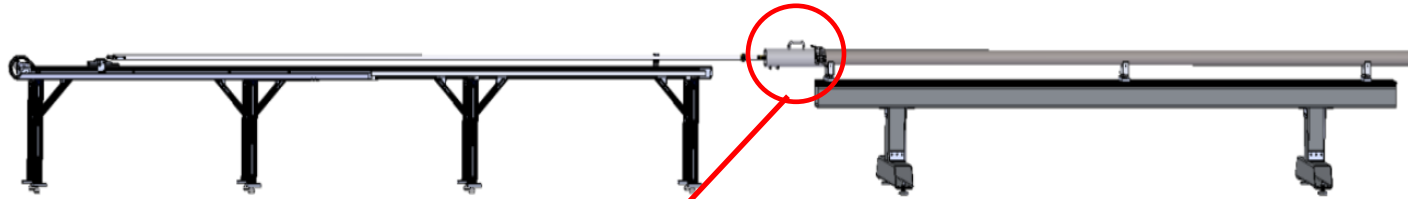
Appendix for Q&A



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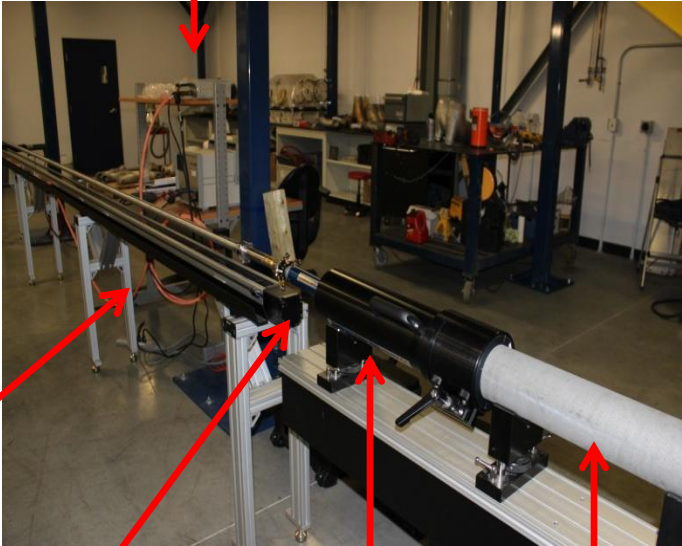


Non-destructive Analysis

- As Received Assessment
- Coating Assessment
- Surface Assessment

Overview

Controller and Analysis System

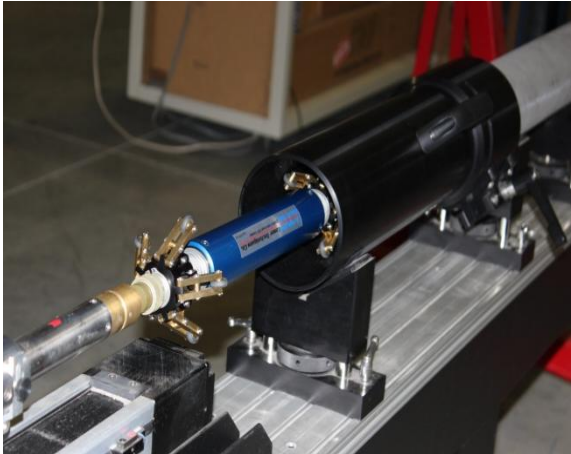


Delivery System

Scanning Head

Guide Tube

Analysis Tube



As Received Assessment

- ID variability
- Surface defects
- Surface Roughness (?)
- Eddy-current for inclusions (future?)

Coating Assessment

- Thickness & variability (radial & longitudinal)
- Defects

Surface Assessment

- Oxide Thickness
- Coverage & Defects

