Baker Oil Tools

Solid Expandable Systems & CRA Qualification Techniques

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Baker Oil Tools

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Overview

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- BOT Expandable Systems
  - Current metallurgy available
  - Additional CRA metallurgy being evaluated
- CRA Qualification Techniques
  - Physical Properties
  - Corrosion & Environmental Limitations

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BOT Solid Expandable Systems

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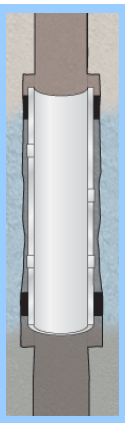
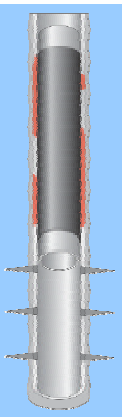


drillEXX
Isolate open hole problem zone, continue drilling w/o reducing hole size

AISI 316L Austenitic SS
22% Cr Duplex SS
Nickel Alloy 25

linEXX
Expandable liner system providing ability to drill monobore wells

Low Alloy Steel
AISI 316L Austenitic SS
22% Cr Duplex SS
Nickel Alloy 25



EXPatch
Repair damaged or corroded casing, isolate perfs to shut-off water

Low Alloy Steel
AISI 316L Austenitic SS
22% Cr Duplex SS
Nickel Alloy 25

sealEXX
Improve open hole inflow profile or isolate water production

AISI 316L Austenitic SS
22% Cr Duplex SS
Nickel Alloy 25

EXPress
Expandable sand screen using solid pipe for open hole zonal isolation

AISI 316L Austenitic SS
22% Cr Duplex SS
Nickel Alloy 25

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CRA Qualification Techniques

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Physical Properties

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Post-Expanded Property Determinations

Previously:

- Isotropic Hardening
  Tensile Y.S = Compressive Y.S
- Conventional API 5C3 Calculations
- BOT Aware of Bauschinger Effect – No Commercial Testing Technique Available
- Compliant Expansion Provided Improvements in Collapse Rating

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Physical Properties

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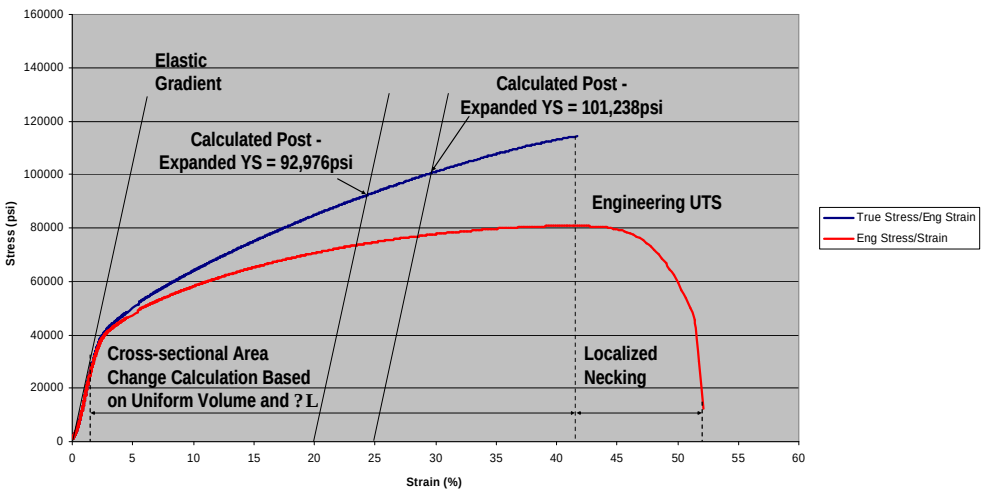
Isotropic Hardening (Tensile Y.S = Compressive Y.S)



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Physical Properties

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Post-Expanded Property Determinations

Currently:

- Preliminary Kinematic Hardening Data Available
- Still Utilizing API 5C3 Calculations which now take into Account Initial Kinematic Hardening Data

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Physical Properties

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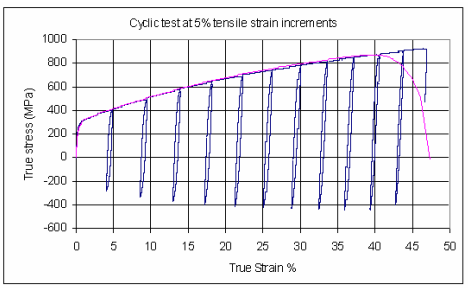
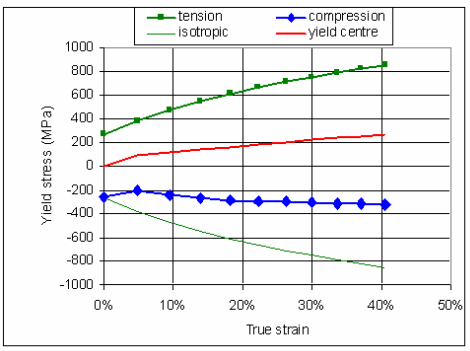
Kinematic Hardening Cyclic Loading Technique



Kinematic Hardening Results



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Physical Properties

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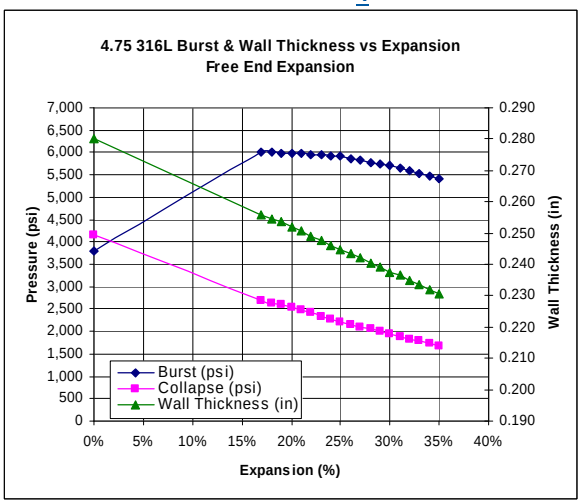
Kinematic Hardening Affects on Unconfined, Free End Burst & Collapse Values for 4 3/4" 316L Expanded Pipe



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Corrosion & Environmental Limits

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Phase 1 - EXPress Metallurgy Environmental Testing

- Test Environments for 316L SS Post Expanded EXPress Screen

	Case 1	Case 2
Temperature °F (°C)	266 (130)	200 (93)
Chlorides (ppm)	36,000	36,000
Bicarbonates (ppm)	664	100
Organic Acids (ppm)	1,472	0
H_2S (ppm)	500 Partial Pressure H2S = 4.005psia	0 Partial Pressure H2S = 0psia
CO_2	0.13 mol% Partial Pressure CO2 = 8psia Actual CO2 = 10.5psia (temp.effects)	100 mol% Partial Pressure CO2 = 125psia
pH	4.9	4.6
Bubble Point (psi)	8010	125
Gas Mix Used	27% H_2S / CO_2 Balance	100% CO_2

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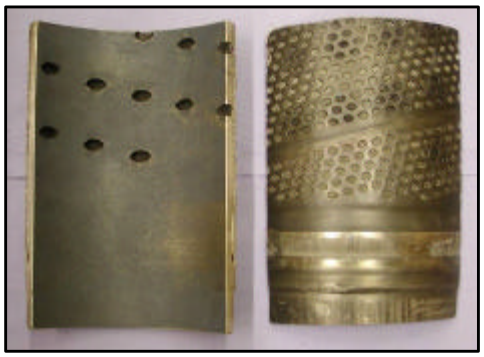
EXPress Environmental Limitations

Operator Test – Case 1 Results

- Visual examination - Good
- Micro-examination - No EC, or pitting
- SEM of the wire mesh showed no signs of cracking or surface pitting



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Corrosion & Environmental Limits

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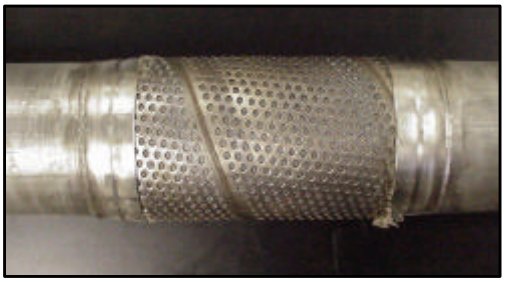
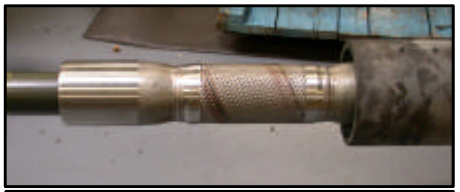
EXPress Environmental Limitations

Specialized Test Fixture:
Case 2 Results

- No evidence of corrosion





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Corrosion & Environmental Limits

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Phase 2 – Solid Post-Expanded Tubular Prepared for Corrosion & Environmental Limits Investigation

Alloy	Proposed Percentage Expansion			
	18%	22%	27%	35%
AISI 316L UNS S31603		✓	✓	✓
22%Cr UNS S31803	✓	✓	✓	
904L UNS N08904		✓	✓	✓
Nickel 825 UNS N08825	✓	✓	✓	✓

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Corrosion & Environmental Limits

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Corrosion & Environmental Test Matrix

Test Variables	Expanded CRA Trial Alloy																							
Alloy	22%Cr																							
% Expansion Ratio (ID)	18						22						27											
Type of Test	4PBT			C-Ring			4PBT			C-Ring			4PBT			C-Ring							
% Applied Stress	60	75	90	60	75	90	60	75	90	60	75	90	60	75	90	60	75	90						
Test Environment																								
Alloy	Nickel 825																							
% Expansion Ratio (ID)	18						22						27						35					
Type of Test	4PBT			C-Ring			4PBT			C-Ring			4PBT			C-Ring			4PBT			C-Ring	
% Applied Stress	60	75	90	60	75	90	60	75	90	60	75	90	60	75	90	60	75	90	60	75	90	60	75	90
Test Environment																								

Slightly Corrosive → → Highly Corrosive

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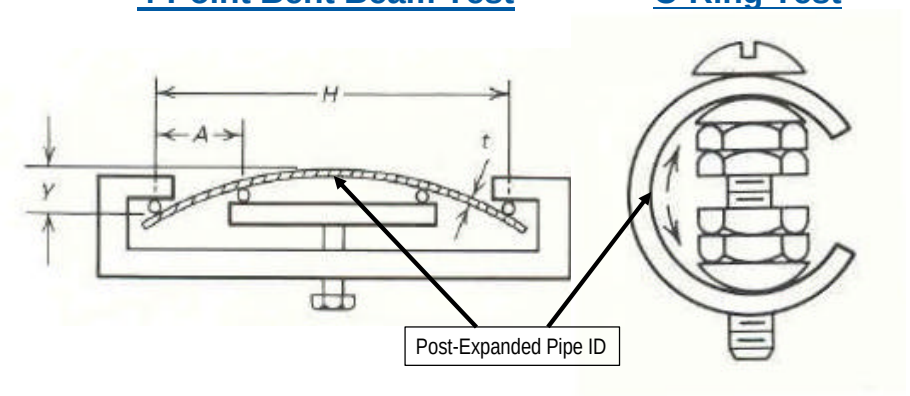
Corrosion & Environmental Test Specimens

4-Point Bent Beam Test

C-Ring Test



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Conclusions

- Theoretical & Practical Operational Limitations available for many Commercially available Post-Expanded CRA Tubular Grades
- Definitive Limitations Placed on Post-Expanded CRA Operating Environments
- Goal: Complete Range of Post-Expanded CRA Metallurgies Suitable for all Prospective Well Environments

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