



Status Update: Development Of New Hardness Conversion Tables For ASTM E140

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Project Overview

- The objective is to develop new hardness conversion tables for ASTM E140
 - Phase 1
 - PH nickel alloys (i.e., Alloys 718, 925, 935, 945, 625 Plus & 725)
 - Martensitic stainless steels (F6NM, CA6NM and 410)
 - Phase 2
 - Duplex stainless steel and super duplex stainless steel
- Scales: HRC, HR15N, HV, HBW, and LEEB
- Project proposed to the API CSOEM in January of 2014 in Dallas
- Project proposed to ASTM E28.06 in May 2014 in Toronto
- Round robin tests will be performed using a new test procedure approved by ASTM at the November 2015 meeting in Tampa
- Results of the round robin test programs will be published in an API Technical Report
- Data in the API TR will be used to ballot new ASTM E140 tables in ASTM E28.06 .



This is a joint API and ASTM initiative



TASK GROUP MEMBERS

1. Al Gavenas - EA Alloys
2. Brian Wilfahrt – ExxonMobil
3. Darrell Copsey - John Crane Co
4. Iain Macleod – Howco Metals
5. John Bringas – CASTI
6. Joshua Rooker - Bohler-Edelstahl
7. Karthik Krishnan - Halliburton
8. Kevin Johnson – Cameron
9. Marco Deuterio – SQA
10. Roy Wolters – Mokveld
11. Steven Shademan – BP
12. Stanley Gregory - Foroni
13. Steve Tassen – Special Metals
14. Tim Haeberle – GE
15. Tinsley S. Fehnel – Carpenter Tech

TASK GROUP MEMBERS

1. Andy Personett – Outokumpu
2. Annette O'Connell – Haynes Intl
3. Brett Puckett – Shell
4. Craig ? – AADFW
5. Cynthia Campbell – AK Steel
6. Dave O'Donnell – RathGibson
7. Florent Krajcarz - Aperam
8. Glenn Eavenson – EVRAZ North America
9. James Wei - Shell
10. John Bringas – CASTI
11. John Grubb – ATI Metals
12. Ken Jester – Tinius Olsen
13. Lee Garrett – Buehler
14. Marco Deuterio – SQA

15. Mark Antonik – Suntech Corp
16. Mike ? – Pacific Metallurgical
17. Mike Markley – Haynes Intl
18. Njall Stefansson – ATI Metals
19. Phillip M. Claditis – ATI Metals
20. Poweleit ? – SFSA
21. R. Faircloth - CMCMMI
22. Richard Schreiman – Elgiloy
23. Robert A. Ellis– David L. Ellis Co
24. Tim Haeberle - GE
25. Walter J. Moorhead – PES Testing
26. Yong Kim – Webco Industries Inc.

CONTRIBUTORS

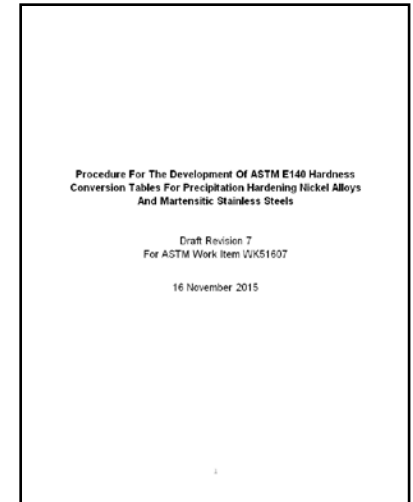
1. Samuel R. Low III – NIST
2. Ed Tobolski - Retired

Thank you to each of the individuals that have participated .



Status Update – PH Nickel Alloys & Martensitic Stainless Steels

- Round robin test procedure approved by ASTM E28.06
- Six companies volunteered to participate in test program
 1. Buehler plus Proceq for LEEB
 2. Exova
 3. David L. Ellis Co. Inc.
 4. PES Testing
 5. SUN-TEC
 6. Stress Engineering Services, Inc.
- Calibration blocks have been purchased for circulation with the test samples to each lab .



PRECIPITATION HARDENED NICKEL ALLOY RESULTS

NOTE: The test locations for this subtable on the test samples are the "X" locations

TEST SAMPLE - UNS M01921				
LOCATION	HTC	HTEN	HTHS	HTHW
A1				
A2				
A3				
A4				
A5				
NAME OF TEST LAB/TECHNICIAN				

TEST SAMPLE - UNS M01714-01P				
LOCATION	HTC	HTEN	HTHS	HTHW
A1				
A2				
A3				
A4				
A5				
NAME OF TEST LAB/TECHNICIAN				

TEST SAMPLE - UNS M01714-02				
LOCATION	HTC	HTEN	HTHS	HTHW
A1				
A2				
A3				
A4				
A5				
NAME OF TEST LAB/TECHNICIAN				

TEST SAMPLE - UNS M01714				
LOCATION	HTC	HTEN	HTHS	HTHW
A1				
A2				
A3				
A4				
A5				
NAME OF TEST LAB/TECHNICIAN				

Comments on any issues during hardness measurements on nickel alloy steel test specimens

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Thank you to each of the companies that have volunteered .

Status Update – PH Nickel Alloys & Martensitic Stainless Steels

- continued -

- Companies volunteered and supplied PH nickel alloy bars for testing
 - UNS N09925 Special Quality Alloys
 - UNS N07718–OP Special Quality Alloys
 - UNS N07716 HOWCO Metals
 - UNS N07718–AS Special Metals

- Companies volunteered and supplied martensitic stainless steel for testing
 - UNS S41000 Special Quality Alloys & Halliburton – received
 - UNS J91540 Mokveld Valves
 - UNS S42400 Mokveld Valves

- All samples have been received at GE in Houston

- All samples have been boxed and shipped to David L. Ellis Co. Inc. for machining, grinding, lapping, marking of the test pattern, and the start of the testing .

Thank you to each of the companies that have volunteered .



Status Update - Test Specimen Visual Representation

- continued -

PH Nickel Alloys



UNS N09925
Aim 31 – 33 HRC



UNS N07718 OP
Aim 38 - 40



UNS N07716
Aim 40 – 43 HRC



UNS N07718 AS
Aim 41 – 44 HRC

Martensitic SS



UNS S41000-C1
Aim 20 – 22 HRC



UNS S41000-C2
Aim 22 – 25 HRC



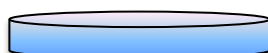
UNS S41000-C3
Aim 26 – 34 HRC



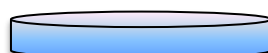
UNS S41000-C4
Aim 38 – 44 HRC



UNS J91540-C1
Aim 240 HBW



UNS J91540-C2
Aim 260 HBW



UNS J91540-C3
Aim 280 HBW



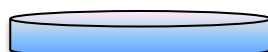
UNS J91540-C4
Aim 300 HBW



UNS J91540-C5
Aim 320 HBW



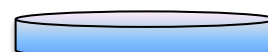
UNS S42400-C1
Aim 240 HBW



UNS S42400-C2
Aim 260 HBW



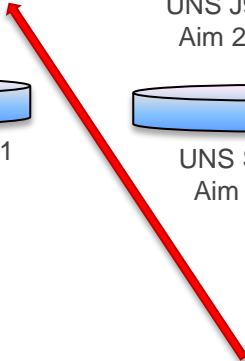
UNS S42400-C3
Aim 280 HBW



UNS S42400-C4
Aim 300 HBW



UNS J91540-C5
Aim 320 HBW



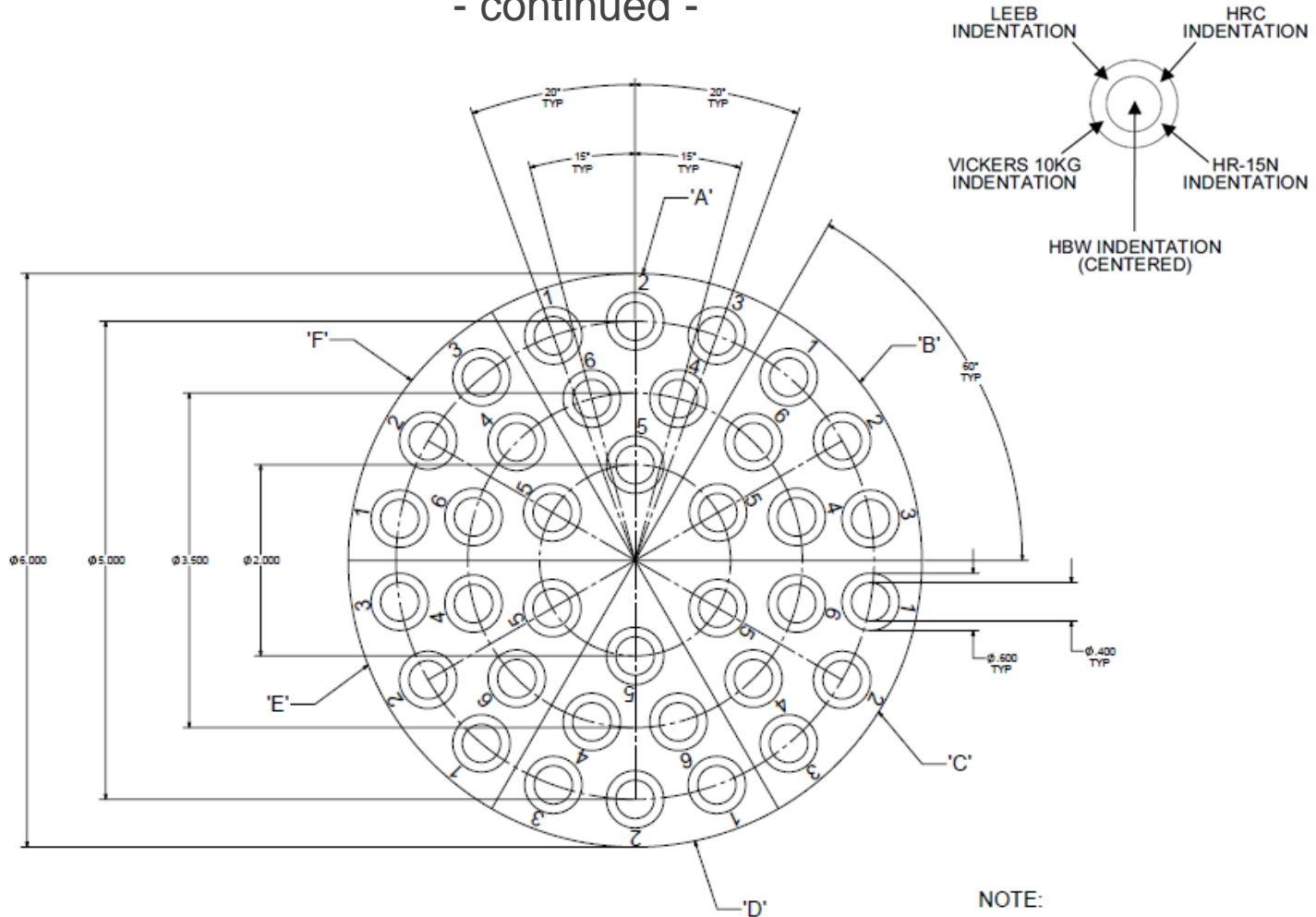
Please note that two rectangular blocks were supplied instead of a disk.

The circular test grid will need to be split between the two blocks.



Status Update - Test Specimen Visual Representation for PH Nickel Alloy & Martensitic Stainless Steels

- continued -



TITLE:

ASTM E140 HARDNESS CONVERSION TEST BLOCK

REVISION: NC

NOTE:

1. ALL DIMENSIONS ARE IN INCHES
2. SCALE IS 1:1

The two rectangular samples will each have a semi-circle of hardness test locations



Status Update – PH Nickel Alloys & Martensitic Stainless Steels

- continued -

- Work required to machine, grind, lap, and mark the test pattern is more than expected
- David L. Ellis Co. Inc. requested \$9,700 for this work in September of 2016
- The project is under the original API project budget, but API exceeded it's overall 2016 research budget
- API staff agreed to provide funding for this expense at the API CSOEM in Austin, TX in January 2017
- Hopefully, this project can move forward to completion.



After a 6 month delay, the project should get moving again

Status Update – Duplex Stainless Steels

- John Bringas (CASTI) is coordinating along with A01 and E28 staff
- Companies have volunteered to provide the raw material
- A company has volunteered to prepare the test specimens
- Six companies have volunteered to perform the hardness testing
- Working to define the requirements for the test matrix
 - Alloys to be tested - product forms – finished conditions - heat treat conditions
 - Test sample configuration – based on product forms (i.e. bar versus tubing)
- A round robin test procedure based on the procedure for PH nickel alloys and martensitic stainless steels will be created and submitted to ASTM E28.06 for approval
- Calibration blocks need to be purchased for circulation with the test samples .



Thank you.



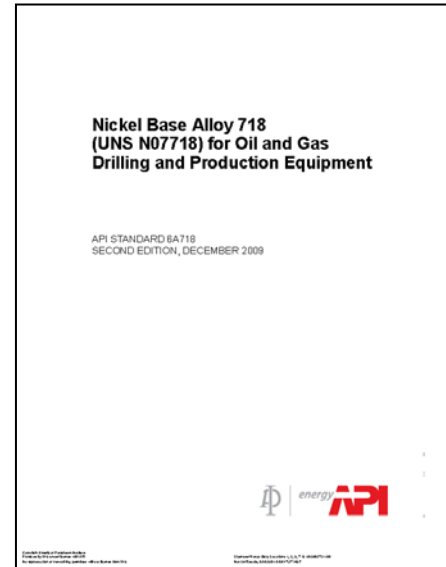


BACKUP SLIDES



Background: NACE / ISO plus API

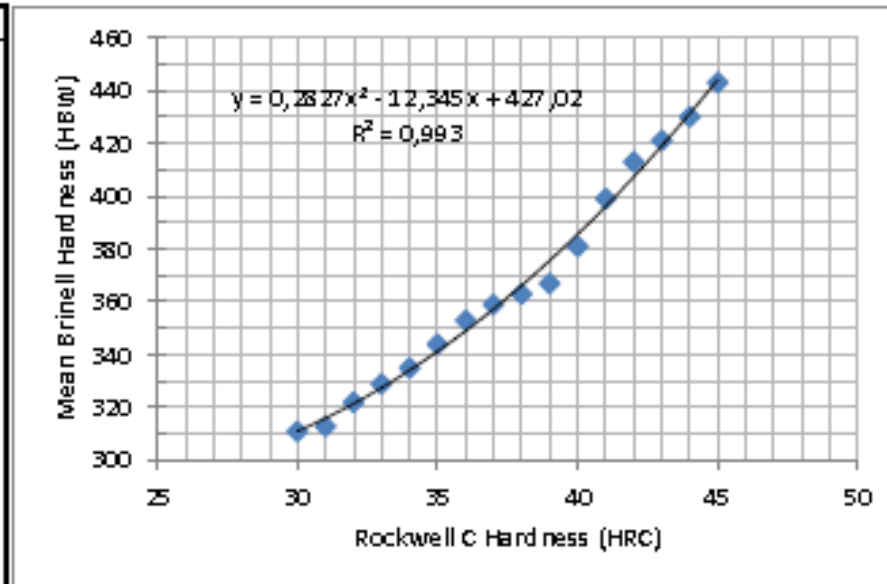
- NACE MR0175 / ISO 15156 and numerous API specs require hardness testing of finished components as a quality control check
- The HRC limits in NACE MR0175 must be converted to HBW values for quality control hardness measurements on larger components
- The HRC values must be converted to HR15N, HV5, & HV10 values for weld procedure qualification testing
- Problems with the use of two of the ASTM E140 hardness conversion tables have been raised in two separate API committees
- In the API SC6 TG for API Standard 6A718, alloy manufacturers have identified ASTM E140 Table 3 as not being valid for precipitation hardening nickel–chromium–molybdenum–iron alloys
- In the API SC6 Task Group for revision of API Spec 6A, members have identified ASTM E140 Table 1 as not being valid for 3 martensitic stainless steels & also for both duplex and super duplex stainless steels .



Background – PH Nickel Alloy Problems

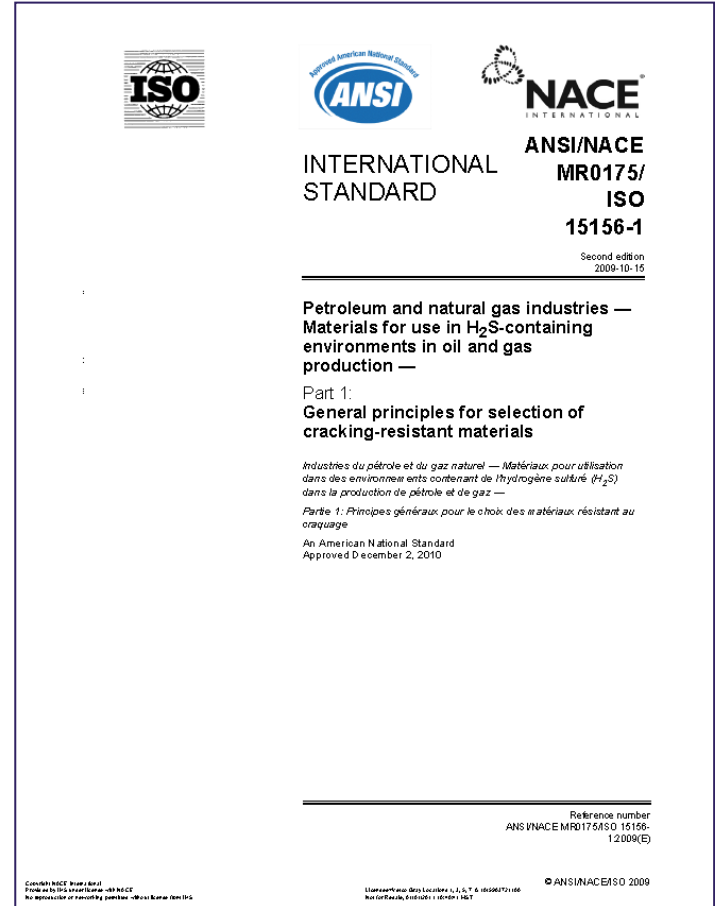
- ASTM E140 Table 3 provides the conversions for “nickel and high-nickel alloys (nickel content over 50 %)”
- ASTM E140 states that, “These hardness conversion relationships are intended to apply particularly to the following: **nickel-aluminum-silicon** specimens finished to commercial mill standards for hardness testing, covering the entire range of these alloys from their annealed to their heavily cold-worked or age-hardened conditions, including their intermediate conditions”
- ASTM E140 Table 3 provides a conversion of **40 HRC = 363 HBS**
- Data developed primarily by Foroni Metals with some data from Carpenter Technology results in a conversion of **40 HRC = 386 HBW** .

HRC	Calculated HBW
30	311
31	316
32	321
33	327
34	334
35	341
36	349
37	357
38	366
39	376
40	386
41	396
42	407
43	419
44	431
45	444

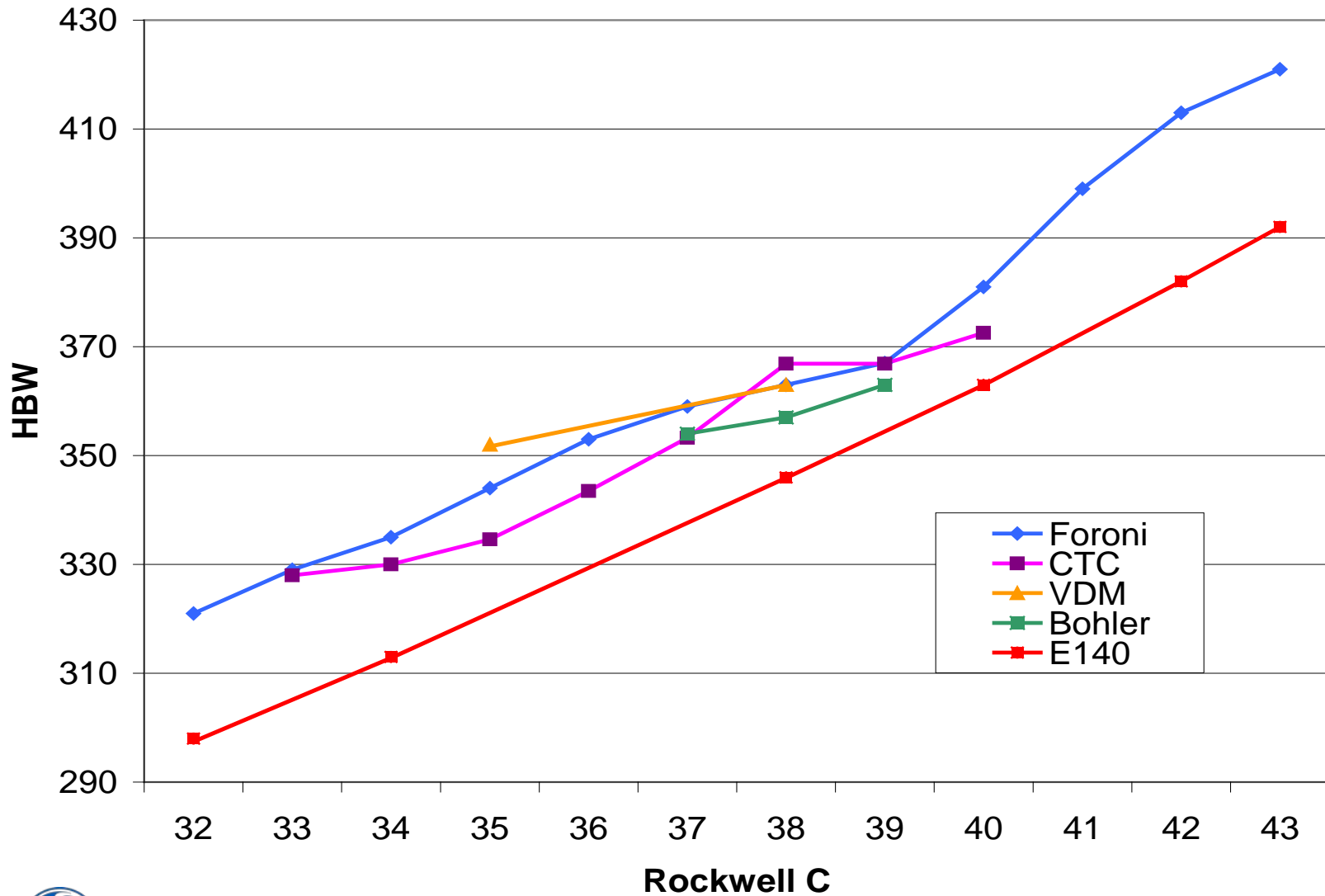


Background – NACE MR0175 / ISO 15156

- For sour oil & gas drilling & production wells where H₂S is present, equipment must be manufactured in strict compliance with NACE Standard MR0175 / ISO 15156
- NACE Standard MR0175 / ISO 15156 lists acceptable alloys and manufacturing practices, and also specifies maximum HRC hardness values for many alloys
- These hardness values represent the threshold required to prevent sulfide stress cracking (SSC) or hydrogen embrittlement (HE) in environments containing H₂S .



Background – PH Nickel Alloy Problems



Background – Martensitic And Duplex Stainless Steels

- ASTM E140 Table 1 provides the conversions for "non-austenitic steels".
- ASTM E140 states, "non-austenitic steels including carbon, alloy, and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions provided that they are homogeneous".
- ASTM E140 Table 1 provides a conversion of **23 HRC = 243 HBW**
- 23 HRC is the NACE MR0175 / ISO 15156 specified maximum hardness for F6NM & CA6NM
- Data developed by Gray Tool Company and utilized in the NACE / ISO document for many years resulted in a conversion for these alloys of **23 HRC = 255 HBW**
- NACE / ISO have removed any hardness conversions from the document, so we are now stuck with an inaccurate conversion in ASTM E140 for martensitic stainless steels
- Conversion of hardness values for duplex stainless steels and super duplex stainless steels is also an issue, with no table being provided in ASTM E140 for these alloys families .



