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Guidance on Industry Standard for Hardness Testing, Post Weld Heat Treatment, Stress Relief, and Pickling for Pressure Vessels, Piping, and Other Components

GIS 36-102

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This revision of Engineering Technical Practice (ETP) BP GIS 36-102 consists of implementing hardness data forms (DS 36-102) and increasing the PWHT temperature of carbon steel for caustic applications. This Guidance on Industry Standard (GIS) is based on parts of heritage documents from the merged BP companies as follows:

Amoco

A MM-GEN-00-G	Metallic Materials—General—Guide.
A MM-GEN-00-E	Metallic Materials—General—Selection Specification.
PTA FE-VE-TI-P	Fabricated Equipment—Pressure Vessels—Ti Clad—Procurement Specification.
PTA FE-VE-LINE-P	Fabricated Equipment—Pressure Vessels—Corrosion Resistant Liners—Procurement Specification.

BP OUS

RP 13-4-1	Material Hardness Requirements.
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1. Scope

This GIS covers material hardness, heat treating, and pickling guidelines when required by a GP, GIS, applicable Code, or purchase order for all components and equipment, including but not limited to pressure vessels, tankage, piping components, furnace tubes, pressure containing machinery components, valves, shafts, etc.

Where applicable, welding procedures for all equipment shall be developed such that the hardness requirements of this GIS will be satisfied.

Deviations from this GIS require approval of the BP materials specialist.

2. Normative references

American Society of Mechanical Engineers (ASME)

ASME BPVC	Boiler and Pressure Vessel Code
Section VIII	Rules for Construction of Pressure Vessels, Divisions 1 and 2.

American Society for Testing and Materials (ASTM)

ASTM A494	Standard Specification for Castings, Nickel and Nickel Alloy.
ASTM A380	Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.

NACE International (NACE)

NACE MR0175	Petroleum, Petrochemical and Natural Gas Industries – Materials for Use in H ₂ S-containing Environments in Oil and Gas Production (ISO 15156).
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3. Symbols and abbreviations

BM	base metal
HAZ	heat affected zone
HB	Hardness Brinell
HV	Vickers hardness number
PWHT	post weld heat treatment
SCC	stress corrosion cracking
SR	stress relief
WM	weld metal
WPQ	weld procedure qualification

4. General considerations for hardness requirements and testing

The hardness test procedures, the extent of component testing, and the hardness acceptance limits shall conform to the following:



4.1. Hardness limits

- a. Maximum hardness limits for materials and environments are provide in Table 1
- b. If the hardness limits specified in this GIS are lower than those specified in ISO 15156/NACE MR0175, the limits in this GIS shall be used.

4.2. Weld procedure qualification hardness testing

Hardness testing of the WPQ test coupon shall be performed when identified in Table 1.

The WPQ hardness tests are the most appropriate method to confirm hardness control to prevent potential performance problems in subsequent services. However, production hardness tests are performed to spot check that high hardness is not present.

- a. Hardness testing shall be performed on WPQ for the actual heat of material used in the fabrication. If multiple heats of steel will be used by a given fabricator, a single test will be acceptable if it is performed on the heat of steel having the highest carbon equivalent (CE) as follows:

$$CE = \%C + \%Mn/6 + (\%Cr + \%Mo + \%V)/5 + \% (Ni + Cu)/15$$

- b. Subject to BP approval, the hardness test may be performed on the WPQ for a different test plate material, if the other material is the same ASTM specification, has a specified tensile strength within 34 MPa (5 ksi) of the steel in the fabrication, and has a CE value no less than the highest value of the plates to be used in fabrication.
- c. Hardness tests shall be performed with either Vickers or Knoop micro hardness testers.
 - 1. At least 3 scans (traverses) shall be performed, incorporating BM, HAZ, and WM regions.
 - 2. For butt welds, at least one of these scans shall be near the surface where the last weld passes were completed.
 - 3. Both the original Vickers or Knoop values and a conversion to HB shall be reported.

One scan is required near the surface of the last passes to minimize a temper bead effect. Hardness test reporting forms provided in Annex A may be used for reporting results to BP. Alternative forms approved by BP may also be acceptable.

4.3. Production and field hardness testing requirements

The extent of production and field hardness testing shall be per Table 2.

- a. All tests should be conducted after any final bending, straightening, or heat treatment operations.
- b. If assessable, hardness tests shall be conducted on metal surface that will be in contact with the process environment as well as the opposite surface.
- c. For repairs, if access to the repaired surface is not possible, hardness testing may be waived by BP.
- d. Production and field hardness tests shall be made on clean metal surfaces that have been hand file or sanded with a course grit paper or wheel. A minimum of 0,75 mm (0,03 in) shall be removed from the surface. Care should be taken to avoid excessive heating. A grinder may be used if approved by BP.
- e. The production and field hardness tests shall be done using a portable Brinell hardness tester provided:

