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GIS 43-334

Welding of Corrosion Resistant Alloy, Internally Clad, and Mechanically Lined Pipelines

Group Instruction for Supply

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GIS 43-334. It is not based on any heritage documentation, but brings together the elements of good welding practice developed for carbon steel pipelines and the constraints required for the successful welding of corrosion resistant materials.

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Introduction

This GIS details BP's requirements for the arc welding and non destructive testing of corrosion resistant alloy (CRA) and internally clad (metallurgically bonded) or lined (mechanically bonded) pipelines and risers.

The technical integrity of all aspects of design, construction, and operation of pipelines is of the highest importance to BP and compliance with BP HSSE policy remains paramount. BP's philosophy regarding the construction of pipelines for the transmission and distribution of hydrocarbon or other hazardous/corrosive fluids is that such pipelines should be welded, whenever possible, by mechanised or automatic welding methods using welding procedures and materials that have been rigorously qualified by test to produce welds that are fully capable of meeting all aspects of the design premise of the pipeline.



1. Scope

This GIS is applicable to pipelines carrying hydrocarbons, or other hazardous/corrosive fluids. It is applicable to land based and subsea pipelines and may be applied to both onshore and offshore fabrication. It is applicable to the fabrication of static offshore risers and also includes the off-line fabrication of items such as welding pups to valve bodies or other fittings and the fabrication welding of branches. The following items are outside the scope of this GIS:

- a. Carbon steel pipelines.
- b. Welding of process piping in terminals, pump or compressor stations, or in refineries.
- c. Hyperbaric welding.
- d. Wet welding.
- e. Pin brazing, stud and thermite welding.
- f. Overlay welding.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this GIS. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this GIS are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

American Petroleum Institute (API)

API Spec Q1	Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry.
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American Society for Testing and Materials (ASTM)

ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
ASTM A380	Recommended Practice for Cleaning and De-scaling Stainless Steel Parts, Equipment and Systems.
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials.
ASTM E92	Standard Test Methods for Vickers Hardness of Metallic Materials.
ASTM E562	Practice for Determining Volume Fraction by Systematic Point Counting.
ASTM E1815	Standard Test Method for Classification of Film Systems for Industrial Radiography.

American National Standards Institute (ANSI)/American Welding Society (AWS)

ANSI/AWS A5.32	Specification for Welding Shielding Gases.
ANSI/AWS B5.16	Specification for the qualification of welding engineers.
ANSI/AWS C5.3	Recommended practice for air carbon arc gouging and cutting.

BP

GN 18-003	Deposition of CRA weld overlay in small diameter tubulars and other components.
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GIS 18-012	Storage and Control of Welding Consumables.
GIS 43-311	Manufacture of Longitudinal or Helical Seam Welded Linepipe in Grades up to X80.
GIS 43-313	Manufacture of Seamless Linepipe in Grades up to X80.
GIS 43-314	Manufacture of 13%Cr Seamless Line Pipe.
GIS 43-315	Manufacture of 22%Cr and 25%Cr Duplex Stainless Steel Seamless Line Pipe.
GIS 43-316	Manufacture of CRA Clad or Lined Steel Pipe.
GIS 43-339	Automatic Ultrasonic Testing of Pipeline Girth Welds.

British Standards Institution (BSI)

BS 7448	Fracture mechanics toughness tests Parts 1 & 2. Method for the determination of K_{Ic} , critical CTOD and critical J values of metallic materials.
BS 7910	Guide on methods for assessing the acceptability of flaws in metallic structures.

European Standard (EN)

EN 439	Welding consumables – Shielding gases for arc welding and cutting.
EN 473	Non destructive testing – Qualification and certification of NDT personnel – General principles.
EN 875	Destructive tests on welds in metallic materials - Impact tests - Test specimen location, notch orientation and examination.
EN 10045-1	Charpy impact test on metallic materials Part 1: Test method (V- and U-notches).

International Organisation for Standardisation (ISO)

ISO 148	Steel - Charpy impact test (V-notch).
ISO 2504	Radiography of welds and viewing conditions for films - Utilization of recommended patterns of Image Quality Indicators (I.Q.I.).
ISO 3834-1	Quality requirements for the fusion welding of metallic materials – Part 1: Criteria for the selection of the appropriate level of quality requirements.
ISO 3834-2	Quality requirements for the fusion welding of metallic materials – Part 2: Comprehensive quality requirements.
ISO 4136	Destructive tests on welds in metallic materials - Transverse tensile tests.
ISO 5173	Destructive tests on welds in metallic materials – Bend tests.
ISO 5580	Non-destructive testing - Industrial radiographic illuminators - Minimum requirements.
ISO 6507-1	Metallic materials – Vickers hardness test – Part 1: Test method.
ISO 9001	Quality management systems – Requirements.
ISO 10005	Quality management – Guidelines for quality plans.
ISO 11699-1	Non-destructive testing - Industrial radiographic films – Part 1: Classification of film systems for industrial radiography.
ISO 17636	Non-destructive testing of welds – Radiographic testing of fusion-welded joints.
ISO 17638	Non-destructive testing of welds – Magnetic particle testing.

ISO TS 29001 Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems requirements for product and service supply organizations.

UK regulations

[SI 1999 No. 3232 Ionising Radiation Regulations 1999 Statutory Instrument 1999 No. 3232](#)
[Work with ionising radiation - Ionising Radiations Regulations 1999](#)
[Approved code of practice and guidance \(UK HSE\)](#)

3. Definitions of terms

For the purposes of this GIS, the following terms and definitions apply:

Arc Energy

The unfactored energy input calculated from the current, voltage and travel speed of the arc welding process.

BP

BP p.l.c. and their associates.

Clad

Refers to a metallurgically bonded CRA layer produced by roll bonding, explosive cladding or weld deposited overlay on a carbon or C/Mn steel.

Contractor

A contractor responsible to BP for construction (including welding) of the pipeline.

Lined

Refers to a mechanically bonded CRA layer.

Quality Plan

Document specifying which procedures and associated resources shall be applied by whom and when to a specific project, product, process or contract.

Note: Guidance for the production of Quality Plans is given in ISO 10005.

4. Abbreviations and acronyms

For the purpose of this GIS, the following symbols and abbreviations apply:

ACCP	ASNT Central Certification Program
ASNT	American Society for Non Destructive Testing
AUT	Automatic Ultrasonic Testing
BAM	Federal Institute for Materials Research and Testing (Germany)
BGAS-CSWIP	British Gas Approval Scheme – Certification Scheme for Welding and Inspection Personnel
BINDT	British Institute of Non Destructive Testing



C Eng	Chartered Engineer (U.K.)
CRA	Corrosion resistant alloy
CTOD	Crack tip opening displacement
CSWIP	Certification Scheme for Welding and Inspection Personnel
Dipl Ing	Diploma Ingenieur (Europe)
ECA	Engineering Critical Assessment
FCAW	Flux-cored arc welding
GMAW	Gas-metal arc welding
HAZ	Heat affected zone
HV	Vickers Hardness
ID	Internal diameter
IQI	Image Quality Indicator
IWE	International welding engineer
MDT	Minimum design temperature
MT	Magnetic testing
MUT	Manual ultrasonic testing
NDT	Non-destructive testing
NIST	National Institute of Standards and Technology (U.S.A.)
OD	Outside diameter
PCN	Personnel Certification in Non-Destructive Testing
PE	Professional Engineer (U.S.A.)
PQR	Procedure Qualification Record
PT	Penetrant Testing
pWPS	Preliminary Welding Procedure Specification
QMS	Quality Management System
RT	Radiographic testing
SAW	Submerged arc welding
SMAW	Shielded metal arc welding
SMYS	Specified minimum yield strength



SWV	Single wall viewing
SWE	Single wall examination
TWI	The Welding Institute (U.K.)
UT	Ultrasonic Testing
VT	Visual testing
WPS	Welding procedure specification
WPQT	Welding procedure qualification test

5. HSE for pipeline welding operations

- a. Welding, cutting, NDT, and associated operations shall be undertaken in a safe manner and with due regard to individual health and safety, and the minimisation of environmental impact consistent with BP requirements. Welding, cutting, NDT activities, and associated operations shall feature in Contractors' operational safety planning and in the safety audit schedule.

Detail of good practice related to safety during welding, cutting, and associated operations can be found in ANSI Z49.1. Reference should also be made to API RP 2009.

EN 14717 provides guidance on environmental considerations when undertaking welding and its associated processes.

- b. Measures shall be taken to ensure adequate ventilation and control the quality of breathing air during welding operations.

Further information may be provided by government bodies such as the Occupational Safety and Health Administration (OSHA) in the USA and the Health and Safety Executive (HSE) in the UK.

- c. As a minimum, radiography operations shall conform to local regulations, e.g. in the UK radiography should be undertaken in accordance with the [Ionising Radiation Regulations 1999 \(SI 1999 No. 3232\)](#) and the Approved Code of Practice and Guidance – Working with Ionising Radiation: Ionising Regulations 1999.

6. Duties of the contractor

6.1. General

- a. Construction, welding and pipe-lay shall be carried out by a well trained and qualified workforce employing reliable, modern, and well maintained equipment and shall also be fully compliant with safe and environmentally sound working practices at all times.
- b. Unless advised otherwise by BP welding and associated equipment including, but not limited to: heating equipment, fluxes, gases, filler metals, welding units, mechanical handling, testing equipment, and NDT equipment shall be supplied.
- c. Supplied equipment shall be appropriately calibrated.
- d. Sub-contractors shall also comply with this GIS

6.2. Quality management system

- a. The QMS shall comply with either ISO/TS 29001 (API Spec Q1) or ISO 9001.



- b. Compliance with ISO 3834-1 and ISO 3834-2 shall be demonstrated.
- c. A Quality Plan for the systematic control of construction, inspection, and testing shall be prepared and implemented.
- d. The Quality Plan shall define inspections and tests and the sequence in which they are to be performed during fabrication together with the level of involvement for quality control/inspection personnel, third-party inspection personnel, and BP.
- e. The Quality Plan shall be submitted to BP and approval shall be obtained (including approval of any revisions) before commencement of fabrication.

6.3. Records

- a. Documents required by this GIS shall be gathered, collated, indexed, stored, and finally presented to BP for secure long term storage.
- b. A log identifying, by number, each pipe or fitting and identifying the weld numbers joining them to other items shall be compiled.
- c. Each circumferential weld (whether a field joint or shop-made weld) shall be allocated a unique number, which shall be used for reference to the weld in reports and test documents.
- d. The documentation shall be available in an agreed, good quality, electronic format.

7. Contractor's personnel

7.1. General

Personnel associated with welding including engineers, welders, welding operators, welding inspectors and non-destructive testing technicians shall be properly trained and qualified to recognised industry standards by examination and/or by individual test.

7.2. Welding engineer

- a. A competent and suitably qualified Welding Engineer shall be employed.
- b. The Welding Engineer shall be responsible for the technical aspects of welding operations including, but not necessarily limited to, the following:
 - 1. Selection of welding equipment and consumables.
 - 2. Preparation and qualification of welding procedures.
 - 3. Qualification of welders.
 - 4. Providing technical oversight of fabrication techniques and production welding.
 - 5. Liaison with BP and the NDT sub-contractors.
- c. The minimum experience and qualification level for the Welding Engineer should be:
 - 1. In USA: PE Welding Engineering or Metallurgy with specialised training in welding technology. Alternatively, American Welding Society Certified Welding Engineer (CWE) in compliance with AWS B5.16 or the International Institute of Welding (IIW) International Welding Engineer (IWE) diploma. Membership of American Welding Society (AWS) is desirable and a minimum of 5 years relevant experience in the pipeline welding or fabrication industry is considered to be essential.
 - 2. In Europe/Rest of the World: Chartered Engineer (C Eng/Dipl Ing) holding as a minimum a degree in engineering, metallurgy or materials science and having specialised training in welding technology qualifying for the International Institute of Welding (IIW) International Welding Engineer (IWE) diploma. Professional



Membership of The Welding Institute (UK) is desirable and a minimum of 5 years relevant experience in the pipeline welding or fabrication industry is considered to be essential.

7.3. Welding inspectors

- a. Competent and certificated welding inspection personnel shall be employed in sufficient numbers to ensure that welding related activities are adequately inspected in accordance with the approved Quality Plan.
- b. Welding Inspectors shall have a sound knowledge of welding processes and their application to pipeline welding and possess the knowledge and skills to carry out the tasks given in the approved Quality Plan, including those necessary for the following:
 1. Conduct of routine inspections and checks on site or at suppliers in a systematic manner.
 2. Production of accurate records and reports.
- c. Welding Inspectors shall hold current certification to, as a minimum, any of the following standards:
 1. CSWIP (TWI, UK) – Welding Inspector.
 2. BGAS-CSWIP (TWI, UK) – Welding Inspector.
 3. PCN (BINDT, UK) – Weld Inspection Level 2.
 4. AWS QC1 (1996 or later edition) – Certified Welding Inspector (CWS).
- d. Alternative Welding Inspector certification is unacceptable unless approved in writing by BP.
- e. A Senior Welding Inspector shall be employed to coordinate and supervise the work of the Welding Inspectors.
- f. The Senior Welding Inspector shall have at least 10 years relevant experience and sound knowledge of welding processes and their application. The Senior Welding Inspector should also have formal engineering training through apprenticeship and technical college education.
- g. Senior Welding Inspectors shall, as a minimum, hold current certification to any of the following standards:
 1. CSWIP (TWI, UK) – Senior Welding Inspector.
 2. BGAS-CSWIP (TWI, UK) – Senior Welding Inspector (SWI) or Senior Pipeline Inspector (SPI).
 3. PCN (BINDT, UK) – Weld Inspection Level 3.
 4. AWS QC1 (1996 or later edition) – Senior Certified Welding Inspector (SCWI).

7.4. NDT personnel

- a. NDT personnel shall hold current Level 2 certification (or equivalent) specific to weld testing for the appropriate NDT methods to, as a minimum, any of the following standards:
 1. CSWIP (TWI, UK).
 2. BGAS-CSWIP (TWI, UK).
 3. PCN (BINDT, UK).
 4. ACCP (ASNT).
 5. SNT-TC-1A (ASNT).



- b. NDT personnel certificated to the requirements of a written practice under the rules of SNT-TC-1A shall not be used, unless the written practice and the personnel certification has been reviewed and accepted by BP for the specific work.
- c. Personnel engaged in AUT shall be qualified in accordance with GIS 43-339.

8. Pre-production consultation

- a. Pre-production meetings shall be held with BP and any appropriate third-party inspection personnel in order to ensure that all parties fully understand the requirements.
- b. These meetings shall be held before welding procedure qualification testing and before commencement of fabrication.
- c. The BP Welding Engineer shall be consulted at the following stages:
 - 1. During bid evaluation to agree the basic welding and NDT methods proposed and to advise on acceptability.
 - 2. Before weld procedure qualification for approval of the proposed welding procedures (pWPS).
 - 3. Before production welding for approval of the final WPS.

9. Equipment

- a. Welding equipment shall be calibrated and maintained in a condition that ensures continuity of operation and the production of welded joints that consistently meet the quality requirements of this GIS.
- b. In the case of semi-automatic and mechanised /automatic welding, the welding unit, the welding power supplies, and the associated control software used for procedure qualification shall be of the same type/model/version as those used in production. The manufacturer's model and type of equipment and software shall be identified in the procedure qualification record.
- c. Independent calibrated instrumentation shall be provided to measure relevant parameters, such as current, voltage, welding speed, preheat, and inter-pass temperatures during production.
- d. Gauges for measuring the weld preparation, weld bead profile, and the profile of weld repair excavations shall also be provided.
- e. Equipment including hand tools shall be selected, stored, and operated in order to avoid contamination of CRA materials with carbon steel.
- f. Pipe handling equipment, pipe end preparation machines, rollers, and line up clamps shall not damage or contaminate the CRA materials.
- g. Low melting point metals or their alloys shall not come into contact with the CRA.
- h. Copper backing bars may be used for welding provided use is in accordance with clause 18.8.h.
- i. Copper contact tubes shall be visually checked after each weld pass to ensure that they are not being fused into the weld pool.



10. Materials

10.1. General

- a. This GIS applies to line pipe materials manufactured in accordance with API 5LC and API 5LD as supplemented by GIS 43-314, GIS 43-315 and GIS 43-316 respectively.
- b. This GIS also applies to line pipe materials manufactured in accordance with API 5L as supplemented by GIS 43-311 and GIS 43-313 and subsequently internally overlaid with CRA weld metal in accordance with [GN 18-003](#).
- c. It may be applied to CRA linepipe manufactured to other standards at the discretion of BP.
- d. Bends, fittings, and flanges shall be specified on a project-by-project basis.

Solid alloy pipe and internally clad pipe may be used to manufacture induction bends., However, carbon steel components manufactured in accordance with GIS 43-317, GIS 43-318, or GIS 43-319 and subsequently internally overlaid with CRA weld metal can represent the optimum manufacturing route for fittings.

- e. Weld metal buttering techniques shall not be used to incorporate bends, fittings, or flanges into the pipeline.

10.2. Storage

- a. Materials shall be securely stored above ground using non metallic dunnage.
- b. Solid CRA materials shall be stored under cover on a prepared surface to minimise external contamination.
- c. End caps shall remain in place until the materials are required for fabrication.
- d. If end caps are removed from the pipe during storage and internal surface contamination is suspected by BP, the Ferroxy test (ASTM A380, 7.3.4) shall be applied to each open end.
- e. If end caps are removed from fittings during storage, the entire internal surface shall be subject to the Ferroxy test.

11. Welding processes

- a. Mechanised and automatic gas shielded arc welding processes are preferred and should be used whenever possible for pipeline girth welding.
- b. Single torch, multi-torch, and tandem arc welding techniques may be employed.
- c. Semi-automatic gas shielded and manual arc welding techniques may be used in applications where mechanised or automatic gas shielded welding processes are inappropriate.
- d. The root and hot pass of pipeline girth welds shall be deposited by a gas shielded solid wire arc welding process.
- e. The root and hot pass of branches and fittings may be completed by solid wire gas shielded welding or SMAW.
- f. For double or multiple jointing, SAW may be used for the fill and cap passes.

The use of highly alloyed filler wires for SAW requires particular attention to ensure that the specified strength and toughness are consistently achieved. Weld quality may also be an issue with nickel alloy SAW welding consumables and it is strongly recommended that manufacturer's advice should be sought before selection/application.

- g. Self shielded cored wire welding techniques shall not be used.

