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Guidance on Industry Standard for BS 4515-1 Pipeline Welding

GIS 43-333

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This is the first issue of Engineering Technical Practice (ETP) GIS 43-333. This Guidance on Practice (GP) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

GS 118-9	Welding of Transmission Pipelines (Supplementary to API 1104).
GS 118-10	Welding of Transmission Pipelines (Supplementary to BS 4515).

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A PN-OFS-WLD-C	Piping-Offshore-Welding Pipelines-Construction.
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Introduction

- a. Guidance for Pipeline Welding is based on BS 4515-1.
- b. Guidance statements of this GIS are modifications to BS 4515-1, Specification for welding of steel pipelines on land and offshore - Part 1: Carbon and carbon manganese steel pipelines, Second Edition, November 2004.
- c. Modifications to BS 4515 are identified as Add, Modify to Read, or Delete.
- d. Paragraph numbers in this specification correspond to BS 4515-1.
- e. Paragraphs of BS 4515-1 that are not revised remain applicable.
- f. If any statement is contradictory to BS 4515-1, the requirements of this GIS shall take precedence.
- g. 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 shall remain paramount.

The normative text of BS 4515-1 and this GIS is primarily applicable to the main line, double joint and tie-in welding operations for the construction of C-Mn steel and low alloy steel pipelines.

This GIS has been written primarily for pipelines up to X80 grade. However, it also allows for construction of pipelines in higher strength steels up to Grade X120 (which are not yet included in the base BS 4515-1 standard and for which some parameters such as mechanical properties and defect acceptance criteria will need to be specified individually).



1. Scope

Modify First Paragraph to Read

The requirements of this GIS are applicable for carbon and alloy steels of specified minimum yield strength not exceeding 827 MPa (equivalent to X120 grade).

Add

The scope 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:

- Corrosion resistant alloy (CRA) clad linepipe
- Solid CRA linepipe
- The welding of process piping in terminals, pump or compressor stations, or in refineries
- Wet welding
- Overlay welding
- Hyperbaric welding
- Steel catenary risers

Additional requirements for high strain pipelines are given in Annex H.

Add

1.1. HSE for pipeline welding operations

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. Welding, cutting, NDT activities, and associated operations shall feature in operational safety planning and in the safety audit schedule.

During welding operations, adequate ventilation shall be provided and the quality of breathing air shall be controlled.

Further information may be provided by government bodies such as the Health and Safety Executive (HSE) in the UK and the Occupational Safety and the Health Administration (OSHA) in the USA. Detail of good practice related to safety during welding, cutting, and associated operations can be found in AWS Z49.1 [4].

Radiography operations shall conform to local regulations regarding the dangers of ionizing radiation, 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.

Environmental guidance shall be taken from EN 14717 when undertaking welding and its associated processes.

1.2. Pre-production consultation

Pre-production meetings shall be held with BP and any third-party inspection personnel in order to ensure that all parties fully understand the specified requirements. These meetings shall be held before welding procedure qualification testing and before commencement of fabrication.

The BP Welding Engineer shall, as a minimum, be consulted at the following stages:

- a. During bid evaluation to review the basic welding and NDT methods proposed and to advise on acceptability



- b. Before weld procedure qualification for approval of the proposed welding procedures
- c. Before production welding for final WPS approval

1.3. General duties of contractor

Be responsible for quality management.

Be responsible for the compliance of sub-contractors with this GIS.

Unless advised otherwise by BP, supply necessary welding and associated equipment including, but not limited to: heating equipment, fluxes, gases, filler metals, mechanical handling, inspection, and testing equipment.

If NDT is conducted by the contractor, appropriate NDT equipment including consumables and handling equipment shall be provided.

If NDT services and equipment are provided by sub-contractors, ensure that the equipment provided is suitable, well maintained, and, if necessary, is calibrated.

1.4. Quality management

The quality management system shall comply with either ISO TS 29001 (API Q1) or ISO 9001.

A Quality Plan for the systematic control of construction, inspection, and testing shall be prepared and implemented. The Quality Plan shall define inspections and tests, the sequence in which they are to be performed during fabrication, and the level of involvement for the contractor's quality control/inspection personnel, third-party inspection personnel, and BP.

The Quality Plan shall be submitted to BP and approval shall be obtained before commencement of fabrication.

1.5. Records

A log identifying, by number, each pipe or fitting and identifying the weld numbers joining them to other items, shall be compiled. 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, radiographs, and test documents.

Documentation shall be collated, indexed, stored safely, and presented to BP.

1.6. Contractor's personnel

1.6.1. Welding engineer

A competent and suitably qualified Welding Engineer shall be employed. The Welding Engineer shall be responsible for the technical aspects of welding operations including the following:

- a. Selection of welding processes, equipment, and consumables
- b. Preparation and qualification of welding procedures
- c. Qualification of welders
- d. Providing technical oversight of the production welding
- e. Liaison with BP and the NDT sub-contractors

The minimum experience and qualification level for the Welding Engineer should be:

- 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. The requirements of 5.2.2, EN 719 should be met as demonstrated by the European Welding Engineer (EWE) or International Welding Engineer (IWE) qualification. Professional Membership of The Welding Institute (UK) is



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desirable and a minimum of 5 years relevant experience in the pipeline welding or fabrication industry is required.

- In USA: Professional Engineer (PE) holding as a minimum a degree in engineering, metallurgy or materials science and having specialised training in welding technology. Membership of American Welding Society (AWS) is desirable and a minimum of 5 years relevant experience in the pipeline welding or fabrication industry is required.

1.6.2. Welding inspectors

Competent and certificated welding inspection personnel shall be employed in sufficient numbers to ensure that all welding related activities are adequately inspected.

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:

- Conduct of routine inspections and checks on site and at suppliers in a systematic manner
- Production of accurate records and reports

Welding Inspectors shall hold current certification to any of the following standards as a minimum:

- CSWIP (TWI, UK) – Welding Inspector
- BGAS-CSWIP (TWI, UK) – Welding Inspector
- PCN (BINDT, UK) – Weld Inspection Level 2
- AWS QC1 (1996 or later edition) – Certified Welding Inspector (CWI)

Alternative Welding Inspector certification is unacceptable unless approved by BP.

A Senior Welding Inspector shall be employed to coordinate and supervise the work of the welding inspectors. The role of Senior Welding Inspector requires at least 10 years relevant experience and sound knowledge of welding processes and their application. Formal engineering training through apprenticeship and technical college education are required.

Senior Welding Inspectors shall hold current certification to any of the following standards as a minimum:

- CSWIP (TWI, UK) – Senior Welding Inspector
- BGAS-CSWIP (TWI, UK) – Senior Welding Inspector (SWI) or Senior Pipeline Inspector (SPI)
- PCN (BINDT, UK) – Weld Inspection Level 3
- AWS QC1 (1996 or later edition) – Senior Certified Welding Inspector (SCWI)

1.7. Abbreviations and acronyms

The following abbreviations and acronyms are used in this GIS:

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 (UK)
CRA	Corrosion resistant alloy
CSWIP	Certification Scheme for Welding and Inspection Personnel
CTOD	Crack tip opening displacement
Dipl Ing	Diploma Ingenieur (Europe)
DWE	Double wall exposure
DWV	Double wall viewing
ECA	Engineering Critical Assessment
FBW	Flash butt welding
FCAW	Flux-cored arc welding
HAZ	Heat affected zone
ID	Internal diameter
IIW	International Institute of Welding
IQI	Image quality indicator
LPT	Liquid penetrant testing
MAG	Metal active gas welding
MDT	Minimum design temperature
MIG	Metal inert gas welding
MPT	Magnetic particle testing
MUT	Manual ultrasonic testing
NIST	National Institute of Standards and Technology (USA)
OD	Outside diameter
PCN	Personnel Certification in Non-Destructive Testing
PE	Professional Engineer (USA)
PQR	Procedure qualification record
PWHT	Post weld heat treatment
RMS	Root mean squared
RT	Radiographic testing



SAW	Submerged arc welding
SMAW	Shielded metal arc welding
SWE	Single wall exposure
SWV	Single wall viewing
TIG	Tungsten inert gas
TWI	The Welding Institute (UK)
UT	Ultrasonic testing
VE	Visual examination
WPQT	Welding procedure qualification test
WPS	Welding procedure specification

2. Normative references

Add

American Petroleum Institute (API)

API Spec 5L	Specification for Linepipe
API Spec Q1	Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry

American Society for Testing and Materials (ASTM)

ASTM E1815	Standard Test Method for Clarification of Film Systems for Industrial Radiography
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American Welding Society (AWS)

AWS A4.3	Determination of Hydrogen Content Produced by Arc Welding
AWS C5.3	Recommended Practices for Air Carbon Arc Gouging and Cutting
AWS A5.32	Specification for Welding Shielding Gases
AWS QC1	Standard for AWS Certification of Welding Inspectors

British Standards Institute (BSI)

BS 7448 Part 1	Fracture Mechanics Toughness Tests Part 1: Method for determination of K _{Ic} , critical CTOD and critical J values of metallic materials
BS 7448 Part 2	Fracture Mechanics Toughness Tests Part 2. Method for determination of K _{Ic} , critical CTOD and critical J values of welds in metallic materials

BP

GIS 43-311	Guidance on Industry Standard for Manufacture of Longitudinal or Helical Seam Submerged Arc Welded Linepipe in Grades up to X80
GIS 43-312	Guidance on Industry Standard for Manufacture of High Frequency Induction (HFI) or Electric Resistance Welded (ERW) Linepipe in Grades up to X70



GIS 43-313	Guidance on Industry Standard for Manufacture of Seamless Linepipe in Grades up to X80
GIS 43-334	Guidance on Industry Standard for Welding of CRA, Internally Clad or Mechanically Lined Pipelines
GP 18-02	Guidance on Practice for Storage and Control of Welding Consumables
GP 43-34	Guidance on Practice for Automatic Ultrasonic Testing of Pipeline Girth Welds

European Standards (EN)

EN 10204	Metallic Products - Types of Inspection Documents
EN 10208-1	Steel Pipes for Pipelines for Combustible Fluids. Technical delivery Conditions. Pipes of Requirement Class A
EN 10208-2	Steel pipes for Pipelines for Combustible Fluids. Technical Delivery Conditions. Pipes of Requirement Class B
EN 14717	Welding and Allied Processes – Environmental Check List

International Organisation for Standardisation (ISO)

ISO 2504	Radiography of Welds and Viewing Conditions for Films - Utilization of Recommended Patterns of Image Quality Indicators (I.Q.I.)
ISO 3183	Petroleum and Natural Gas Industries - Steel Pipe for Pipeline Transportation Systems
ISO 3690	Welding and Allied Processes - Determination of Hydrogen Content in Ferritic Steel Arc Weld Metal
ISO 5580	Non-Destructive Testing - Industrial Radiographic Illuminators - Minimum Requirements
ISO 9001	Quality Management Systems Requirements
ISO 11699-1	Non-destructive testing - Industrial Radiographic Films. Part 1: Classification of Film Systems for Industrial Radiography
ISO 15609	Specification and Qualification of Welding Procedures for Metallic Materials – Welding Procedure Specification – Pt 1 Arc Welding
ISO 17636	Non-Destructive Testing of Welds – Radiographic Testing of Fusion Welded Joints
ISO 17638	Non-Destructive Testing of Welds – Magnetic Particle Testing
ISO 17640	Non Destructive Testing of Welds – Ultrasonic Testing of Welded Joints
ISO TS 29001	Petroleum, Petrochemical and Natural Gas Industries Sector Specific Quality Management Systems Requirements for Product and Service Supply Organisations

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. Terms and definitions

3.5. Contractor

Modify to Read

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



3.6. EmployerModify to Read

BP plc or its authorised representative

3.22. ServiceModify to Read

To be defined by BP as either sour or non-sour.

Add**3.26. Batch (lot)**

A single heat of filler wire, a single blend of flux, or for covered electrodes or cored wire, the combination of a single heat of cored wire with a single dry blend of flux cover or core

3.27. BP

BP plc, an associate or subsidiary of BP, or other organisation as defined in the Conditions of Contract on a project

3.28. 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 [6].

4. Information and requirements to be approved and documented**4.1. Information to be supplied by the employer**Add

- ah) Whether pre-qualification trials of welding processes are required (6).
- ai) Whether additional hardness surveys on macro-sections are required (8.3.4).
- aj) Whether additional Charpy test locations are required (8.3.5).

4.2. Items subject to approval by the employerAdd

- ap. Use of automatic and semi-automatic welding systems (6).
- aq. Approval of welding consumable handling and storage procedure (7.2).
- ar. The mixing of Ar/CO₂ shielding gas at site (7.2).
- as. The type of weld monitoring equipment for use during WPQ testing (8.1.4).
- at. The forms used for recording for WPQ information (8.1.6).
- au. The re-use of existing WPSs (8.1.7).
- av. Alternative etchants to Nital (8.3.3).
- aw. Acceptance of existing welder qualifications (10.1).
- ax. Method of removing end coatings (11.2).
- ay. The solvent for grease removal (11.3).
- az. Use of internal tapering (11.4).



- ba. Method of PWHT (11.10.3).
- bb. Re-start of welding following suspension due to cracking (13.2.1).
- bc. Full scale bend procedure (H.3.1).

Add

4.3. Requirements to be agreed

In addition to the items identified by BS 4515-1, the following shall be subject to specific agreement with BP:

- a. Repetition of the operational demonstration for automatic and mechanised welding (6.2).
- b. The format for electronic copies of the WPSs and PQR packages (8.1.2).
- c. The method of measuring welding procedure parameters and the records to be kept (8.1.5).
- d. The location around the weld circumference for extracting CTOD and all weld tensile test specimens (8.3).
- e. The sensitivity required for pipe thicknesses greater than 40 mm (Table G).
- f. The number of cycles for full scale bend simulation (H.3.1).
- g. Misalignments greater than 1.5 mm for high strain installation (H.4).

5. Equipment

Add

Independent calibrated instrumentation shall be provided to measure all relevant parameters during production.

The use of permanent or consumable backing rings is not permitted. An exception is the outer pipe welds in a pipe-in-pipe system. Non-consumable temporary backing as an integral permanent feature on an internal clamp is permitted subject to satisfactory demonstration of the process.

SMAW electrode holders shall be fully insulated.

Welding return cables connections shall be of sufficient cross-sectional area to prevent concentration of current and shall be securely attached to prevent arc burns.

6. Welding processes

Add

6.1. General

Mechanised and automatic welding processes are preferred and should be used whenever possible for pipeline girth welding. Main line welding should be by mechanised or automatic gas metal arc welding (MAG) which may include single, multi-torch, or tandem-arc variants of the process and the use of cored wires. If the use of mechanised or automated MAG processes is impracticable, alternative processes may be used. In such instances, welding may be performed by shielded metal arc welding (SMAW), manual or automated gas tungsten arc welding (TIG), semi-automatic MAG processes using solid or cored wires, or a combination of these processes.

Limitations on the use of cellulosic SMAW electrodes are specified in Section 7.1.1.



For double or multiple jointing, girth welds should be made using submerged arc welding (SAW) whenever possible. If SAW cannot be used, the alternative mainline processes listed above may be utilised either alone or in combination with SAW.

The welding of pipelines by the oxy-acetylene process or by the flash-butt welding process (FBW) or by any other process not defined above is not permitted.

The welding process or combination of processes proposed for the pipelay welding operation shall be specified in the bid. Manual processes, semi-automatic or automatic welding systems may be offered. If a process or system is proposed of which BP has no previous experience, BP will specify welding and NDT trials which shall be undertaken and completed successfully before the proposed technique can be approved for qualification testing. Separate qualification of a SMAW procedure may also be required, for possible use in the event of failure of semi-automatic or automatic equipment in production welding.

6.2. Automatic (mechanised) welding

If mechanised or automatic processes are proposed for main line welding, tie-in welding, or multiple jointing of pipeline sub-assemblies, the bid shall include full details of the processes to be used, the associated welding equipment, and the proposed area of application.

For mainline welding applications, the proposal shall list the number of welding stations (root pass to final capping pass) on a spread by spread basis and detail the equipment and number of welders and other personnel required to operate each station. Full details of the welding shelters shall also be provided.

A similar level of detail shall be provided for tie in welding and multiple jointing.

Mechanised PC (2G) or PG/PF (5G) welding equipment should be operated in conjunction with data logging facilities capable of recording the essential variables associated with the arc, including wire feed speeds and travel speeds. The equipment shall record all parameters for each pass of every weld at a minimum rate of once per 10 degrees of angular rotation and shall indicate the angular position of each measurement. This data shall be readily retrievable for monitoring purposes and shall form part of the pipeline construction data package. Data logging is mandatory if welding with either multi torch or multi wire systems and for girth welds made in $\geq$ X80 grade linepipe.

Each mechanised (automatic) welding station shall be demonstrated to be fully operational before it is employed to weld any joints that will be incorporated into the pipeline. For example, for a spread of welding stations this demonstration may consist of two full girth welds made consecutively, each weld being required to meet the production acceptance criteria without the need for any repair. NDT shall utilise the agreed pipeline NDT techniques and equipment. Internal welding equipment shall also require operational demonstration. Each of these pre-construction welds shall be uniquely identified and reserved for possible mechanical evaluation by BP.

This operational demonstration shall be repeated as agreed with BP but should, as a minimum, be repeated after interruptions $\geq$ 7 days in pipeline welding and when a welding spread is disassembled and transferred from one section of the line to another.

The proposal shall also detail the intended level of technician support for equipment maintenance and list the principal spares that will be available in order to maintain equipment serviceability for the duration of the pipelay.

The proposal shall also advise if a manual welding procedure is to be qualified for production or repair welding.

