



SPECIFICATION FOR PIPEWORK WELDING, INSPECTION, SUPPORTING AND TESTING

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SECTION 1: SPECIFICATION FOR PIPEWORK WELDING INSPECTION AND TESTING



GENERAL

This specification for pipework welding complies with American and European pipework design codes.

All pipework will be welded according to its design code and City University London Specification.

All pipework systems will be classified to define weld inspection procedures.



CLASSIFICATION OF PIPEWORK SYSTEMS AND INSPECTION PROCEDURES

Classification I piping is defined as piping where the process fluid in combination with operating temperatures, pressures and such other conditions which in the judgments of City University London make weld failure especially hazardous (hazards shall include flammability, toxicity, explosion etc).

Classification II piping is defined as follows:

- a) Where piping is intended for service at temperatures above 1876oC or pressures above 150 psig (10.3 barg)
- b) Where piping is intended for pressure temperature rating of Class 300 and 600
- c) Any piping which is not classified as Classification I or Classification III.

Classification III piping is defined as follows:

- a) Where the design temperature is in the range –29oC to 186oC and
- b) Where the design pressure does not exceed 150 psig (10.3 barg) and
- c) Where the process conditions of the fluid are considered safe (i.e. nonflammable, non-toxic, and not damaging to human tissue). Examination of welds will comply with Table 1 requirements listed in the following specifications.



CHEMICAL PIPEWORK SYSTEMS AND SPECIFICATIONS

Chemical Piping Systems

Design Code ASME B31-3

City University Specification PE47

Specification for Fabrication Testing and Inspection of Stainless Steel Pipework - F552 B/6064

Specification for Fabrication Testing and Inspection of Carbon Steel Pipework - F554 B/6064

Specification for Fabrication Testing and Inspection of Hastelloy Pipework - F558 B/6064

Specification for Welding Pipe and Fittings - F559 B/6064

Pressure Test Specification - F555B B/6064

Erection of Pipework Specification - F557 B/6064

Welding Qualifications

All above specifications for welding require welders to be qualified in accordance with ASME Section IX of the ASME Boiler and Pressure Vessel Code.

Approval Test of Welders for fusion welding of pipework all welders shall comply with BSEN 287

Approved Welding Procedures shall comply with BSEN 288

Site Utilities Pipework Systems

Design Code ASME B31-1 or BS EN13480-1

City University Specification PE47

City University Specification for Pipework Welding Sub Sections PE11 PE11

Specification for the Welding of Pipe and Fittings F559 B/6064



Welders Qualifications

All above specifications require welders to be qualified in accordance with ASME Sections IX of the ASME Boiler and Pressure Vessel Code.

Approval Testing of Welders shall comply with BSEN 287

Approval Welding Procedures shall comply with BSEN 288



BUILDING SERVICES PIPING SYSTEMS

Building Services Piping Systems

Design Codes Materials Steels BSEN 13480-1

Materials Copper and copper alloys BS 1306-1975

City University London Specifications

All pipework welding shall comply with the following specifications:

Brazing – British Standard BS 1723 – 1986

Bronze Welding – British Standard BS 1724 – 1990

Class 1 Oxyacetylene Welding of Ferritic Steel Pipework BS 1821 – 1982

Class 2 Oxyacetylene Welding of Carbon Steel Pipework BS 2640 – 1982

Class 1 Arc Welding of Ferritic Steel Pipework BS 2633 – 1987

Class 2 Welding of Carbon Steel Pipework BS 2971 – 1991

Austenitic Stainless Steel Pipework BS 4677 – 1984

Approval of testing of welders for fusion welding of all comply with BS EN 287.

Approval of welding procedures shall comply with Appendix A BS 2633 1987, see Table 10 of the appendix.

Examination of welds.

Examination of welds will be in accordance with BSEN 13480-5. 2002.



CERTIFICATION

The pipework contractor must certify that all pipework welding is in accordance with the appropriate design code.

On completion of pipework fabrication the following weld listing documentation must be offered in duplicate to City University London as follows:

- a) Isometric drawings of the pipework systems showing location of all welds with each weld having a unique number.
- b) Weld history log shall be supplied listing all welds denoting type of weld and which welder performed the weld.
- c) Welding Procedure Approval Test Certificate as BSEN 288.
- d) Material certification for pipework and fittings.
- e) Pressure Test Certification.
- f) NDT of Radiography reports where required.
- g) Validation documentation where required which may entail boroscope readings for internal surfaces of welds.
- h) Flanges in PTFE lined piping systems using star washers: TRED 000-006-008- 000-00107
- i) Proposed static linkage of flanges in S and CS piping systems using start washers: TRED 000-006-008-000-00108
- j) Proposed static linkage for loose flanges in PTFE piping systems: TRED 000- 006-008-000-00109



SECTION 2: SPECIFICATION FOR FABRICATION, TESTING AND INSPECTION OF CARBON STEEL PIPEWORK



GENERAL

Purpose

The purpose of this specification is to define an acceptable standard for the fabrication, testing and inspection of carbon steel pipework.

Related Documents

This specification, together with the Contract Conditions of Order, Requisition Sheets, Data Sheets and Drawings, covers the requirements for the fabrication, testing and inspection of carbon steel pipework.

Application of Standards

The fabrication, testing and inspection of pipework shall be in accordance with ASME code for pressure piping, B31.3 1993 Edition plus Addenda B31.3a 1993, the requirements of this specification any applicable governmental rules or regulations.

Where differences exist between the Codes and City University requirements, the latter shall govern. Where governmental rules apply, City University shall be informed in writing at the earliest possible time.

Definitions

The term 'City University' shall be deemed to mean City University London or those acting on behalf of City University London.

The term 'Fabricator' shall be deemed to mean the Contractor, Sub-Contractor or Site Fabricator who undertakes the fabrication of pipework.

The term 'Code' as used in this document, shall be deemed to mean the American National Standard Code for Pressure Piping – Chemical Plant and Petroleum Refinery Piping, ASME B31.3.



Drawings

Where possible City University will furnish piping detail drawing or orthographic or isometric type. Other drawings or standards showing typical details will also be included where applicable. General arrangement drawings will show the routing of lines, controlling dimensions, component parts and attachments for fabrication and erection. The dimensions shown on the isometric or details drawings will be true, with no allowance for weld gaps.

Generally, gaskets 1/16 in (1.5mm) or less in thickness are ignored in dimensional computations while gaskets or greater thickness will be included.

Materials

This specification covers the fabrication of carbon steel pipe designated 'P-1' in appendix C of the Code. For mixed metals fabrication, refer to the respective standards.

City University will furnish piping and valve specifications defining material requirements and method of fabrication for the specific service and pressure classes.

It will be the Fabricator's responsibility to correctly interpret the detail drawings and specifications.

Unless contract instructions dictate otherwise, all materials will be supplied by the Fabricator. The material shall conform to the requirements of the piping specification and shall be supplied with the relevant certification as specified in Section 9 of this standard. Any substitution of materials by the Fabricator must be approved by City University in writing before commencement of fabrication.

It is the Fabricator's responsibility to produce and maintain correct records of materials used. The Fabricator shall also be responsible for any loss or damage to materials supplied.

Colour coding shall be in accordance with contract instructions, if required.

Special piping items not included in the piping specification but requiring fabrication or installation will be listed and separately specified.



FABRICATION

General

Cuttings should be accurate, smooth and true to template. Slag and cutting dross shall be removed before fitting or welding.

Longitudinal weld seams in adjoining lengths shall be 180° apart where possible, but minimum distance between seams of 6 in. (150mm) measured around the pipe, is acceptable. Longitudinal seams in seam welded pipe shall be located so as to clear openings and external attachments. The Fabricator shall not make longitudinal joints without prior approval of City University.

Installation and protection of proprietary items shall be in accordance with the manufacturer's installation instructions and good engineering practice.

Flanges, when indicated on the drawings as 'supplied loose' for site welding, shall be lightly tack welded to the pipe by the Fabricator. Unless specified as a "site fitted weld", the corresponding pipe end shall be prepared for welding to the flange. For "site fitted welds" (unprepared pipe end), the flanges shall be securely wired on.

Unless otherwise stated on the drawings, all flange bolt holes shall straddle the vertical centerline of the pipe where the flange is installed vertically, and the northsouth center lines where the flange is installed horizontally.

Where City University drawings indicate a site-fitted weld in the pipe assembly, the Fabricator shall supply relevant pipe 6 in. (150mm) longer than indicated by the drawing, with the unconnected end left unprepared.

Branch connections shall be in accordance with the piping and valve specifications or as detailed on fabrication drawings.

Materials which have been damaged or found to have defects shall not be used in Classification I fabrication. For classification II and III fabrication, minor surface marks may be cleaned providing that the minimum wall thickness is maintained after considering manufacturing tolerances defined in the appropriate material specifications.

Sections of pipe shall not be welded together to form a random length shorter than 10 ft. (3000mm).

Bending of fabricated pipework after welding is not permitted without the approval of City University. If bends are necessary and agreed to meet the dimensional requirements, the bending shall be carried out with the work piece in cold condition.

Tolerances

In addition to tolerances contained within the specified codes or standards, the following shall also apply:-



- i. All linear dimensions involved in the relative position of branches, bosses, flanged ends and changes in direction, each to each other, shall be maintained with $\pm 1/8$ in. (± 3 mm). (See Figure 2 for details).
- ii. All angular dimensions of bends and branches shall be maintained within $1/4$ degree. (See Figure 2 for details).
- iii. Misalignment of flanges from the indicated position, marked 'A' in Figure 1, shall not exceed $1/16$ in (1.5mm).
- iv. Alignment of flanges and branch welding ends, measured as dimensions 'B' in Figure 1 (across any diameter), shall not deviate from the indicated position more than $1/32$ in/ft (2.5mm/m) of diameter.
- v. Flange faces shall not be concave. Convexity of flange contact faces shall not exceed 0.015 in/in (1.6mm/100mm) width of the flange face. On flanges with smooth finish or grooved for RTJ, the convexity shall not exceed 0.015 in (0.4mm) across the entire width of the raised face.
- vi. In general, tolerances for fabricated pipework shall not exceed those shown in Figure 2.
- vii. Lines should not deviate by more than 1 mm per meter to a maximum of 10mm from its specified plane.

Preparation

The ends of pipe shall preferably be shaped by machine but other methods may be employed providing a smooth and true surface is obtained free from tears, slag or scale and suitable for welding. Flame cut material (the cut end) shall be ground back a minimum of 3 mm before preparation for welding.

Unless specified otherwise, fabricated branch intersections shall be of the "set-on" type with the branch pipe prepared to suit a full penetration weld of quality equal to the girth welds. Preparation and cutting shall be in accordance with the Code.

Where reinforced pads are fitted, either for branches or structural attachments, they shall be accurately shaped so that no gap larger than $1/16$ in (1.5 mm), measured before welding, shall exist between the periphery of the pad and the pipe.

For pressure reinforcement, each segment of each reinforcement pad shall be provided with a hole drilled and tapped $1/4$ in. (6 mm) BS21 (taper) for testing and venting.

Forged branch attachments shall be of the type specified on City University drawings and fitted accurately to the contours of the run pipe.

Couplings and half couplings shall be accurately shaped and 'set-on' to suit the contour of the run pipe.

Reinforcement pads for structural attachments shall be provided with an untapped hole of $1/4$ in (6 mm) diameter.



Fit-Up

Pipes shall be properly supported and aligned by jigs or clamps as required in order to preclude extraneous loads and minimise strains during tacking.

Small tack welds, i.e. between $\frac{1}{2}$ in (12.5 mm) and $\frac{3}{4}$ in (18mm) in length, penetrating to the bottom of the groove may be used in fitting up (see Clause Welding).

Weld “bridge pieces” may be used only with prior approval of City University.

Alignment of Bores

Pipes with wall thickness $\frac{1}{4}$ in. (6 mm) and greater shall not have internal misalignment of pipe wall exceeding $\frac{1}{16}$ in (1.5mm).

Pipes with wall thickness less than $\frac{1}{4}$ in (6mm) shall not have internal misalignment of pipe wall exceeding 25 percent of the pipe wall thickness.

When misalignment is greater than the above, the components shall be aligned by drifting, rolling or machining in accordance with the Code, ensuring that the minimum wall thickness is maintained after considering the manufacturing tolerances defined in the appropriate material specifications.

Threading

Threads shall be to BS 21 (taper), or ANSI B1.20.1 NPT (taper) where required to match connections on equipment etc. All threading shall be carried out after bending, forging or heat treatment, but where possible, suitable thread protection must be provided.

When threaded flanges are specified, the pipe shall terminate $\frac{1}{16}$ in (1.5 mm) short of the face of the flange.

Threaded joints which are to ‘seal welded’ shall be made up dry (without thread compound or tape).



Bends

Changes of direction shall be made in accordance with drawings and specifications.

Pulled bends, when specified, shall be fabricated in accordance with the relevant piping specification using formers or shoes which fit the desired contour of the pipe.

Tolerances on diameter and thickness after bending shall not exceed those defined in the Code.

Unless stated otherwise on City University drawings, pulled bends shall be made in accordance with the piping specifications.

For hot bending or forming, the temperature ranges and heat treatment requirements specified in Code ASTM A234 shall be adhered to.

WELDING

No welding processes or procedures which have not been approved in writing by City University will be used in welding pipework or attachments to pipework. Fabrication shall not commence until City University has approved the weld procedural tests.

Unless otherwise noted on City University drawings, welding shall be in accordance with the Code.

The use of backing rings is not permitted.

Small tack welds used for 'fit-up', if free from breaks, may be included in the first pass provided they are crack-free and have been made up by a qualified welder to the same procedures as that required for the first pass. Larger or defective tack welds shall be chipped out before laying the first pass.

During welding, section of pipe shall be adequately supported so that joints are relieved of unnecessary strain.

Welders shall be properly qualified in accordance with the requirements of Section IX of ASME Boiler and Pressure Vessel Code.

Competency test certificates shall be current and shall be approved by City University before welding is commenced.

All welding shall be supervised and records maintained to ensure that each weld can be subsequently identified with the individual welder concerned, the weld procedure, and electrodes used.

The Fabricator shall provide all electrodes, filler wires and gases. Electrodes shall be kept clean and dry and stored in a heated place in accordance with the maker's instructions. The issue of electrodes shall be supervised to ensure the use of correct electrodes and the rotational consumption of stocks. Electrodes shall be dried according the manufacturer's recommendations.



For all fabrication, the complete circumference of the first five butt welds of each welder, shall be radiographed. The radiographs shall be retained for examination and approval by the City University responsible person.

Minor defects in welds may be repaired provided complete records are kept and passed to the City University responsible person when he inspects the finished work. Major defects which might indicate incorrect choice of materials or unsuitable welding procedures shall be reported to City University in writing for a decision regarding acceptance. Defects in welds requiring repair shall be removed by flame or arc gouging followed by grinding and dressing. As an alternative, grinding, chipping or machining may be used.

After welding, all flange faces shall be cleaned of weld spatter, arc strike or any other defects or damage.



HEAT TREATMENT

Preheating

Where preheat treatment is required prior to welding, it shall be in accordance with the Code and the approved Weld Procedure.

In ambient conditions where metal temperatures are below 0°C, the work piece shall be preheated in accordance with the Code, and the approved Weld Procedure.

Post Heat Treatment

Where post heat treatment is required, it shall be in accordance with the Code, and the approved Weld Procedure and shall precede any non-destructive testing.



TREATMENT AFTER FABRICATION

Surface Treatment

The requirements for surface preparation for painting shall be in accordance with the City University Painting Specification.

Internal Cleaning

No special cleaning of pipe is required, however, the Fabricator shall ensure that bores of pipes are kept clean at all times, free from rust, swarf, sand, scale and other matter.



INSPECTION

General

City University's representative shall have the right to inspect any aspect of the work at the Fabricator's works at any reasonable time during fabrication, testing or on completion. Pipework received from the Fabricator which does not conform to the requirements of this standard may be returned to the Fabricator for repair. Alternatively, after prior agreement, City University may perform repairs as required and bill the charges to the Fabricator.

Where necessary, the preventative of proprietary equipment manufacturers shall, by arrangement, be afforded similar facilities to inspect incorporation of their equipment into the pipework.

Pipework shall be checked against drawings and other related documents to verify that it is fabricated in compliance with requirements.

Fabrications shall have dimensions falling within the tolerances defined in this standard.

Non-Destructive Testing

The extent of radiographic or other non-destructive examination shall be in accordance with the classifications given on the drawings and as defined in Table 1.

The standard acceptance for non-destructive tests shall be as specified in the Code.

Where pressure testing is to be carried out, it will be in accordance with City University Standard and as specified in Section Pressure Testing.

Classification of Piping

Classification I piping is defined as piping where the process fluid, in combination with operating temperatures, pressures and such other conditions, which in the judgment of City University, make weld failure especially hazardous. (Hazards shall include flammability, toxicity, explosion, etc).

Classification II piping is defined as follows:

- i. Where piping is intended for service at temperatures above 186°C or pressures above 150 psig (10.3 barg); or
- ii. Where piping is intended for pressure temperature rating of Class 300 and 600; or
- iii. Any piping which is not classified as Classification I or Classification III.

Classification III piping is defined as follows:-



- i. Where the design temperature is in the range -29°C to 186°C ; and
- ii. Where the design pressure does not exceed 150 psig (10.3 barg); and
- iii. Where the process conditions of the fluid are considered safe. (i.e. nonflammable, non-toxic and not damaging to human tissue).

Examination of Welds

Examination of all welds shall be applied in accordance with Table 1 on completed work only.

Radiography shall be applied in accordance with Table 1 on completed work only.

The accepted standard for welds shall be that specified in the Code except that complete penetration is essential, with no notches or undercutting permitted.

The standard acceptance for non-destructive tests shall be as specified in the Code.

Where a random examination is called for any welds are rejected, further welds shall be examined until the specified proportion of welds is found to be acceptable. All this work shall be carried out at the Fabricator's expense.

Visual examination of all welds shall be external and internal to detect defects, e.g. incomplete penetration, lack of fusion, misalignment, undercut and concave reinforcement on butt welds.

Pressure Testing

See Section 6. Pressure testing shall be carried out following the guidelines as presented in the HSE Guidance Note GS4



PAINTING AND PROTECTION DURING TRANSIT

The external surfaces of all fabricated pipework shall be painted with a rust preventative or base primer to provide a protective coating against rust during transit and storage. The rust preventative applied should be of a type which can easily be removed at site by some means other than blast cleaning.

Paints selected shall be in accordance with those listed in the Painting Specification.

Protection for flanges, pipe ends and other components against mechanical damage or ingress of dirt shall be provided by the Fabricator.



MARKING

Fabricated parts requiring trial shop assembly shall be match marked with white paint to facilitate erection.

Each fabricated item shall after the application of primer, be plainly marked in white paint with the piece number and an arrow indicating the direction of flow.

Permanent marking of pipework by stamping is not permitted. Should permanent markings be required, they shall be etched with an 'electric pencil'.

Each crate, box, bag etc., shall be marked to show their contents.



REPORTS AND RECORDS

One date stamped copy of each of the following certificates and reports shall be supplied where applicable:-

- i. Mill Certificates covering all materials furnished by the Fabricator.
- ii. Welding procedure specifications and qualification results.
- iii. Operators' welding qualification test results.
- iv. Pyrometer charts or records of heat treatment.
- v. Pressure test certificates.
- vi. Non-destructive test certificates.
- vii. Impact test certificates, where applicable.



REFERENCES

This standard refers to the following documents:-

i. American Society of Mechanical Engineers (ASME) Standard B31.3, Chemical Plant and Petroleum Refinery Piping.

ii. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code:

Section I Power Boilers

Section IX Welding and Brazing qualifications

The application edition dates of ASTM, ASME, and ANSI specifications shall be as per Appendix E of ASME B31.3



Table 1 – Extent of Weld Inspection by Class

Class	Diameter	Method	Girth Weld	Branch Welds**
Classification I	All	Visual	100%	100%
		Radiographic* Magnetic Particle	100%	-100%
Classification II	150 NPS	Visual	100%	100%
	and over	Radiographic* Magnetic Particle	***Random 10% -	Random 20% of joints
	100NPS	Visual	100%	100%
	and under	Radiographic* Magnetic Particle	***Random 10% -	-Random 20% of joints
Classification III	All	Visual	100%	100%

*** Ultrasonic inspection service may be used at the option of City University in lieu of radiographic inspection.

* Includes half coupling and welds between reinforcing pads and pipe walls where used. The complete circumference or 10% of welds of any size, by each welder shall be examined.

** Random selection, each welder at Inspector's discretion. Normally 10% i.e. one exposure of one weld in each ten welds of the same size by each welder.

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SECTION 3: SPECIFICATION FOR FABRICATION, TESTING AND INSPECTION OF HASTELLOY STEEL PIPEWORK



GENERAL

Purpose

The purpose of this specification is to define an acceptable standard for the fabrication, testing and inspection of Hastelloy pipework.

Related Documents

This specification, together with the contract conditions of order, requisition sheets, data sheets and drawings, covers the requirements for the fabrication, testing and inspection of Hastelloy pipework.

This specification must be read in conjunction with the "Specification for the Erection of Pipework".

Application Standards

The fabrication, testing and inspection of pipework shall be in accordance with AMSE code for pressure piping, B31.3, 1993 edition plus Addenda B31.3a 1993, the requirements of this specification and any applicable governmental rules or regulations. Where differences exist between the codes and City University's requirements, the latter shall govern. Where governmental rules apply, City University should be informed in writing at the earliest possible time.

Definitions

The term 'City University' shall be deemed to mean City University London or those acting on behalf of City University London.

The term 'Fabricator' shall be deemed to mean the Contractor, Sub-Contractor or Site Fabricator who undertakes the fabrication of Pipework.

The term 'Code' used in this document shall be deemed to mean the American National Standard Institute Code for Pressure Piping – Chemical Plant and Petroleum Refinery Piping, ASME B31.3.



Drawings

City University will furnish piping detail drawings of the orthographic or isometric type. Other drawings or standards showing typical details will also be included where applicable. General arrangement drawings will show the routing of lines, controlling dimensions, component parts and attachments for fabrication and erection. The dimensions shown on the isometric or detail drawing will be true, with no allowance for weld gaps. Generally, gaskets 1/16 in (1.5 mm) or less in thickness are ignored in dimensional computations while gaskets of greater thickness will be included.

Materials

This specification covers the fabrication of Hastelloy pipe designated 'P-44' in Appendix A of the Code.

City University will furnish piping and valve specifications defining material requirements and method of fabrication for the specification service and pressure classes.

It will be the Fabricator's responsibility to correctly interpret the details drawings and specifications.

Unless contract instructions dictate otherwise, all materials will be supplied by the Fabricator. The material shall conform to the requirements of the piping specification and shall be supplied with the relevant certification as specified. Any substitution of materials by the Fabricator must be approved by City University in writing before commencement of fabrication.

It is the Fabricator's responsibility to produce and maintain correct records of materials used. The Fabricator shall also be responsible for any loss or damage to materials supplied.

Colour coding shall be in accordance with contract instructions, if required.

Special piping items not included in the piping specification but requiring fabrication or installation will be listed and separately specified.



FABRICATION

General

Cuttings should be accurate, smooth and true to template. Slag and cutting dross shall be removed before fitting or welding. Cutting methods which involve heating, e.g., arc, or plasma jet cutting, must be approved by City University.

Longitudinal weld seams in adjoining lengths shall be 180o apart where possible, but a minimum between seams of 8 in (200 mm), measured around the pipe, is acceptable. Longitudinal seams in seam welded pipe shall be located so as to clear opening and external attachments. The Fabricator shall not make longitudinal joints without prior approval of City University.

Installation and protection of proprietary items shall be in accordance with the manufacturer's installation instructions and good engineering practice. They must not under any circumstances be contaminated with grinding dust or subjected to weld spatter. Surfaces must be properly cleaned prior to re-assembly.

Unless stated otherwise on the drawings, all flange bolt holes shall be off-centre. Branch connections shall be in accordance with the piping material specification or as detailed on fabrication drawings.

Materials have been damaged or found to have defects shall not be used in the fabrication. Minor surface marks may be cleaned providing the minimum wall thickness is maintained after considering manufacturing tolerances defined in the appropriate material specification. Equipment and cleaning methods, as well as the acceptance of such materials, must be approved by City University.

Sections of pipe shall not be welded together to form a random length shorter than 10 ft (3000 mm).

Bending of fabricated pipework after welding is not permitted without approval of City University.

Tolerances

In addition to tolerances contained within the specified codes or standards, the following shall also apply:-

- i. All linear dimensions involved in the relative position of branches, bosses, flanged ends and changes in direction each to each other shall be maintained within +/- 0.125 in (+/- 3 mm). (See figure 2 for details).
- ii. All angular dimensions of bends and branches shall be maintained within ¼ degree. (See Figure 2 for details).
- iii. Misalignment of flanges from the indicated position, marked 'A' in Figure 1, shall not exceed 1/16 in. (1.5 mm).



- iv. Alignment of flanges and branch welding ends measured as dimensions 'B' in Figure 1 (across any diameter) shall not deviate from the indicated position more than 1/32 in/ft (2.5 mm/m) of the diameter.
- v. Flange faces shall not concave. Convexity of flange contact faces shall not exceed 0.015 in/in (1.6 mm/100 mm) width of the flange face. On flanges with smooth finish or grooved for RTJ, the convexity shall not exceed 0.015 in (0.4 mm) across the entire width of the raised face.
- vi. In general, tolerances for fabricated pipework shall not exceed those shown in Figure 2.
- vii. Lines should not deviate by more than 1 mm per meter to a maximum of 10 mm from its specified plane.

Preparation

Where reinforced pads are fitted, either for branches or structural attachments, they shall be accurately shaped so that no gap larger than 1/16 in (1.5 mm), measured before welding, shall exist between the periphery of the pad and the pipe.

For pressure reinforcement, each segment of each reinforcement pad shall be provided with a hole drilled and tapped ¼ in (6 mm) BS 21 (taper) for testing and venting.

Forged branch attachments shall be of the type specified on City University's drawings and fitted accurately to the contours of the run pipe.

Couplings and half couplings shall be accurately shaped and 'set-on' to suit the contour of the run pipe.

Reinforcement pads for structural attachments shall be provided with an untapped hole of ¼ in (6 mm) diameter.

Fit-Up

Pipes shall be properly supported and aligned by jigs or clamps as required in order to preclude extraneous loads and minimise stresses during tracking.

Small tack welds, i.e. between ½ in (12.5 mm) and ¾ in (18 mm) in length, penetrating to the bottom of the groove may be used in fitting up.

Welded 'bridge pieces' may be used only with the prior approval of City University.

Alignment of Bores

Pipes with a thickness of ¼ in (6 mm) and greater shall not have internal misalignment of pipe wall exceeding 1/16 in (1.5 mm).



Pipes with a thickness less than $\frac{1}{4}$ in (6 mm) shall not have internal misalignment of pipe wall exceeding 25 percent of the pipe wall thickness.

When misalignment is greater than the above, the components shall be aligned by drifting, rolling or machining in accordance with the Code, ensuring that the minimum wall thickness is maintained after considering the manufacturing tolerance defined in the appropriate material specifications.

Threading

Threads shall be to BS21 (taper), or ANSI B1.20.1 NPT (taper) where required to match connections on equipment etc. All threading shall be carried out after bending, forging or heat treatment, but where this is not possible, suitable thread protection must be provided.

When threaded flanges are specified, the pipe shall terminate $\frac{1}{16}$ in (1.5 mm) short of the face of the flange.

Threaded joints which are to be 'seal-welded' shall be made up dry (without thread compound or tape).

Bends

Changes of direction shall be made in accordance with the drawings and specifications.

Cold formed bends are preferred and they shall be heat treated after bending in accordance with ASME B31.3.

The use of an induction bending process is acceptable providing the procedure is approved by City University.

Where pulled bends are specified they will be supplied to site preformed. The Fabricator shall not undertake any pulling of pipe to form bends.



WELDING

No welding processes, or procedures which have not been approved in writing by City University will be used in welding pipework or attachments to pipework. Fabrication shall not commence until City University has approved the weld procedural tests.

Unless otherwise noted on City University drawings, welding shall be in accordance with the Code.

The use of backing rings is not permitted.

Small tack welds used for 'fit-up', if free from cracks, may be included in the first pass provided that they have been made up by a qualified welder and to the same procedure as that required for the first pass. Large or defective tack welds shall be chipped out before laying the first pass.

During welding, sections of pipe shall be adequately supported so that joints are relieved of unnecessary stresses.

Welders shall be properly qualified in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code. Competency test certificates must be current and shall be approved by City University before welding is commenced.

All welding shall be supervised and records maintained to ensure that each weld can be subsequently identified with the individual welder concerned, the weld procedure used, and electrodes used.

The Fabricator shall provide all electrodes, filler wires and gases. The issue of electrodes shall be supervised to ensure the use of correct electrodes and the rotational consumption of stocks.

For all fabrication, the complete circumference of the first five butt welds, of each welder, shall be radiographed. The radiographs shall be retained for examination and approval by City University's Inspector.

No repair shall be done without the approval of City University's Inspector. The extent of repair and the procedure shall be agreed before the work is started. Defects in welds requiring repair shall be removed by flame or arc gouging following by grinding and dressing. As an alternative, grinding, chipping or machining may be used.

After welding, all flange faces shall be cleaned of weld spatter, arc strike or any other defects or damage.

Where fillet welds other than those covered by ASME B31.1 are used and no weld preparation is called for, the minimum length of the weld leg shall be equal to 1.4 times the thickness of the thinner component.

All pipe butt welds shall be a smooth bore profile with no root over-penetration. A procedure shall be agreed which will ensure no root over-penetration.



HEAT TREATMENT

Preheating

No welding or tack welding shall be carried out when the temperature of the parent metal within 75 mm of the joint is less than 5°C.



TREATMENT AFTER FABRICATION

Internal Cleaning

No special cleaning of pipe is required, however, the Fabricator shall ensure that bores of pipes are kept clean at all times, free from rust, swarf, sand, grease, oil, scale and other matter.



INSPECTION

General

The Fabricator is responsible for Quality Control, however City University's representative shall have the right to inspect any aspect of the work at any reasonable time during fabrication, testing or on completion. Pipework which does not conform to the requirements to this standard will be returned to the Fabricator for repair.

Where necessary, City University will require representatives of proprietary equipment manufacturers to be afforded similar facilities to inspect incorporation of their equipment into the pipework.

Pipework shall be checked against the drawings and other related documents to verify that it is fabricated in compliance with the requirements.

Fabrications shall have dimensions falling within the tolerances defined in this standard.

No piping spools are to be dispatched from the fabrication shop to site without prior approval of City University.

Non-Destructive Testing

The extent of radiographic or other non-destructive examination shall be in accordance with the classifications given on the drawings and as defined in the following table.

The standard acceptance for non-destructive tests shall be as specified in the Code.

Where pressure testing is to be carried out, it will be in accordance with City University's Standard and as specified.

Classification of Piping

Classification I Piping is defined as piping used where the process fluid, in combination with operating temperatures, pressures and such other conditions, which in the judgment of City University, make weld failure especially hazardous (hazards shall include flammability, toxicity, explosion, etc.), or unacceptable for process reasons.

All Hastelloy pipework systems are Classification I.

Examination of Welds

Examination of all welds shall be applied in accordance with the following table on completed work only.



Limitations on imperfections for welds shall be that specified in the Code except that complete penetration is essential, with no notches or undercutting permitted.

Where a random examination is called for and any welds are rejected, further welds shall be examined until the specified proportion of welds is found to be acceptable.

All this work shall be carried out at the Fabricator's expense.

Visual examination of all welds shall be external and internal, where possible, to detect defects including incomplete penetration, lack of fusion, misalignment, undercut and concave reinforcement of butt welds.

Pressure Testing

See Section 6.

All pressure testing shall be carried out following the guidelines preseted in HSE Guidance Note GS4.

When shop testing is specified, the Fabricator shall provide all the necessary materials for closing open ends of piping under test.

Extent of Weld Inspection

The extent of weld inspection is as follows:-

Class	Diameter	Method	Girth Welds	Branch and Fillet Welds **
Classification I	All	Visual	100%	100%
		Radiographic*	100%	100% ***
		Dye Penetrant	-	100%
* Ultrasonic inspection service may be used at the option of City University in lieu of radiographic inspection				
** Includes half coupling, outlets and welds between reinforcing pads and pipe walls				
*** Where the nominal size of the branch is 2/3 or more of the nominal size of the main pipe, the flanks of the welds shall be radiographed				



PROTECTION DURING TRANSIT

Protection for flanges, pipe ends and other components against mechanical damage or ingress of dirt shall be provided by the Fabricator, these shall be either plastic end caps or plugs, or hardboard or wooded discs covered with a heavy duty plastic sheeting secured with steel banks.



MARKING

Fabricated parts requiring trial shop assembly shall be match marked with white paint to facilitate erection.

Each fabricated item shall be plainly marked or tagged by the Fabricator with the piece number and an arrow indicating the direction of flow. The piece number consists of the line number plus a sequential number.

Permanent marking of pipework by stamping is not permitted. Should permanent markings be required, they shall be etched with an 'electric pencil'.

Hastelloy shall not be marked with crayons or paints containing sulphur, zinc, lead or aluminium or compounds of these substances.

Each crate, box, bag, etc. shall be marked to show their contents.



REPORTS AND RECORDS

Where applicable one date-stamped copy of the following certificates and reports shall be supplied:-

- i. Mill Certificates covering all materials furnished by the Fabricator.
- ii. Welding procedure specifications and qualification results.
- iii. Operators' welding qualification test results.
- iv. Pyrometer charts or records of heat treatment.
- v. Pressure test certificates.
- vi. Non-destructive testing certificates.
- vii. Impact test certificates, where applicable.



REFERENCES

This standard refers to the following documents:

- i. City University's standards:-
 - Specification for the Welding of Pipes and Fittings
 - Specification for the Erection of Pipework
 - Specification for Pressure Testing of Pipework
- ii. American Society of Mechanical Engineers (AMSE) Standard B31.3 Chemical Plant and Petroleum Refinery Piping.
- iii. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code:
 - Section I Power Boilers
 - Section IX Welding and Brazing Qualifications

The application edition dates of ASTM, ASME and ANSI specifications shall be as per Appendix E of ASME B31.3.



SECTION 4: SPECIFICATION FOR THE WELDING OF PIPE AND FITTINGS



SCOPE

This specification applies to the welding of all butt, fillet and branch welds for pipe, fittings and valves.

The welding shall be in accordance with the Code and the requirements of this specification.



DEFINITIONS

'Owner' means City University London.

'Engineer' means City University London or those acting on behalf of City University London.

'Contractor' means the Supplier, Sub-Contractor, Vendor of welded equipment, or Piping Fabricator responsible for welding of pipes and fittings.

'Code' means American National Standard Institute Code for Precision Piping – Chemical Plant and Petroleum Refinery Piping ASTM B31.3 1990 Edition plus Addenda B31.3 1990 and B31.3b 1991.



MATERIAL SPECIFICATIONS

The materials to be used are specified in the Engineer's Piping Specification and are summarised as follows:-

Carbon Steel

(Piping Specification codes CS1A, CS1B, CS1C, CS1D, CS1E, CS1F, CS1G, CS3A, CS3B, CS3C, CS6A, CS6B, CS7A)

Pipe API 5K Grade B, ASTM A106 Gr. B, BS 1387.

Fittings ASTM A234 Grade WPB, ASTM A105, BS 1965 Ptl Size Range: 15 mm NPS to 60 mm NPS

Stainless Steel

(Piping Specification Codes SS1A, SS1B, SS1C, SS1D, SS1F, SS1G, SS1T, SS1U, SS3A, SS3B, SS3C, SS6C, SS3T, SS9T, SS25T).

Pipe ASTM A312 TP 316L, ASTM A312 TP 304L

Fittings ASTM A403 Grade WP 316L, ASTM A182 Grade WP3 16L. ASTM A403 Grade WP 304L, ASTM A182 Grade WP304L.

Size Range 15 mm NPS to 600 mm NPS

Hastelloy

(Piping Specification Codes HS1A, HS1T, HS3A, HS6A)

Pipe ASTM B619 N06022 – Hastelloy C22.

Fittings ASTM B366 N06022, ASTM B574 N06022.

Size Range 15 mm NPS to 150 mm NPS.



WELDING PROCESSES

The welds referred to herein shall be by:-

- i. The shielded metal-arc welding (SMAW) process.
- ii. The gas tungsten-arc welding (GTAW) process.

Or by such combinations of these processes as may be defined in this specification.

Shielded Metal-Arc Welding (SMAW) Process

Unless otherwise stated, the shielded Metal-Arc Welding Process shall be used for the following:-

- i. Butt and fillet welding of all carbon steel piping 50 mm NPS and above.
- ii. Fillet welding of all stainless steel and Hastelloy piping 50 mm NPS and above.
- iii. Filling and capping runs on butt welds for all stainless steel piping 50 mm NPS and above.
- iv. Structural steel fittings such as lugs, brackets, pipe supports, etc., for all carbon and stainless steel and Hastelloy piping.
- v. Butt and fillet welding of carbon steel valves 50 mm NPS above.

The current for Shielded Metal-Arc Process welding shall be AC or DC for carbon steel and DC electrode positive for stainless steel and Hastelloy. For all cases the current shall be in accordance with the electrode Manufacturer's recommendations.

Gas Tungsten-Arc Welding (GTAW) Process

Unless stated otherwise, the Gas Tungsten-Arc Welding Process with either manually or mechanically fed filler wire shall be used for the following:-

- i. Butt and fillet welding of all carbon steel, stainless steel and Hastelloy piping below 50 mm NPS.
- ii. Butt welding of all stainless steel and Hastelloy piping 50 mm NPS and above, first run only. Second and subsequent runs shall be carried out as SMAW.
- iii. Butt and fillet welding of carbon steel valves below 50 mm NPS.

For stainless steel and Hastelloy butt welds, an internal purge of argon or nitrogen, i.e. 'backing gas' shall be fed into the pipe during root fusion technique using suitable blanking devices to reduce argon or nitrogen consumption for a minimum of two runs. The backing gas is not required



for the remaining filling runs nor for stainless or Hastelloy fillet welds. DC equipment using negative electrodes shall be used. The equipment shall include a high frequency unit of the spark gap type to assist in starting and stabilising the arc. Tungsten electrodes of the thoriated type shall be used. The welding torch shall be of the air cooled type.

For butt welding only, the root run may be made by the Autogenous gas tungsten-arc method (without the addition of filler metal). The weld faces must be close-buttet. Where site conditions result in poor fit up or poor edge preparation, a filler wire shall be used.

WELDING ELECTRODES AND FILLER METALS

Materials

Electrodes and filler rods for the welding of the various base metals are specified in Table 1.

Table 1 – Welding process for different materials

BASE METAL		WELDING PROCESS	
		SMAW ELECTRODES	GTAW FILLER RODS
Carbon Steel		Root Pass	AWS A5.18
		AWS A5.E6010	ER70-S2 or ER70-S6
		2.5 mm and 3.2 mm	1.6 mm and 2.4 mm
		Filler and Cap AWS A5.1 E6013	
		3.2 mm and 4.0 mm	
Stainless Steel	316L	AWS A5.4E316L-16	AWS A5.9 ER316L
		2.5 mm and 3.2 mm	1.6 mm and 2.4 mm
	304L	AWS A5.4E304L-16	AWS A5.9 ER316L
		2.5 mm and 3.2 mm	1.6 mm and 2.4 mm
Hastelloy		AWS A5.11 E Ni Cr Mo –10	AWS A5.14 Er Ni Cr Mo – 10
		2.5 mm and 3.2 mm	1.6 mm and 2.4 mm

Storage Facilities

The Contractor shall provide adequate and suitable storage facilities on site for electrodes and filler rods. Electrode types shall be clearly identified and completely separated. Immediately prior to use, sufficient electrode packets shall be opened and placed in electrically heated, thermostatically controlled, storage cabinets which shall remain heated at all times at a temperature in accordance with the electrode Manufacturer's recommendations. (Damp electrodes shall not be used).



PREPARATION OF PARENT METAL

Edge Formation

The edges of carbon steel piping shall be prepared for welding by machining, machine flame cutting and grinding, grinding, filing or any combination of same. Flame cut edges shall be prior to welding.

The edges of austenitic chromium nickel steel piping shall be prepared for welding by mechanical means wherever possible. Sawing or filing may be employed, but it must be ascertained and confirmed by the Contractor, that any grinding wheel or file used for this purpose is free from any ferrous or copper deposit which could be detrimental to the quality of the weld. (Filler rods shall be degreased prior to use).

It is not permitted to use a flame cutting or gouging process or an arc gouging process for the preparation of edges on any stainless steel weld.

Cleaning

Immediately prior to welding, the fusion faces shall be thoroughly cleaned of scale, rust, grease, paint or other foreign matter which may affect the quality of the deposited metal. Particular care shall be taken to ensure cleanliness when preparing stainless steel for inert gas shielded arc welding.

The fusion faces and adjacent parent material shall be thoroughly degreased with acetone, propanol, or iso-propanol. Chlorinated solvents shall not be used. Weld preparation faces shall not be handled after degreasing.

Methanol or industrial methylated spirit must not be used under any circumstances.

Weld Preparation

Shall be the single vee unbacked butt on material wall thickness 5.22 mm inclusive as per figure 328.4.2a of the Code.

Thickness less than 5 mm need not be bevelled by may be cut square.

Fabrication of pipework shall comply with the Code.

Where branches are fabricated by welding, their joint design shall comply with the Code.

Branch Connections

Branch connections in piping shall be made in accordance with the Piping Specification. All such branch connections shall comply with the requirements for materials and their applications as given in the Piping Specification and this Welding Specification.





ASSEMBLY FOR WELDING

Alignment of Pipes, Branches, Flanges and Fittings

The alignment of pipes, branches, fittings and other similar details to be joined shall be aligned in accordance with the Code.

Butt welding joints in pipes or differing wall thicknesses shall conform to the Code.

Tack Welding

To maintain specified alignment and gap, where used during welding, the parts to be welded shall be securely held in position by mechanical means or by tack welding.

The specified dimensions of the root gap are the dimensions after tack welding.

The electrodes, where used for tack welding, shall be of the same type and class as, and of size not larger than, those to be used for completing the root penetration weld.

The minimum size and length of track welds shall not be less than four times the thickness of the material and shall be similar in area to the first run of welding to be applied. They shall be sound in strength, free from pin-holes and cracks and the slag shall be removed before the joint is welded. The extremities of the tack welds shall be dressed by grinding or chipping to facilitate proper fusion when they are incorporated in the root run.

Clamps for aligning shall not be removed until at least half the root run has been completed and its uniformly distributed around the circumference of the joint. A partially filled joint must NOT be subjected to any undue stress.

Tacking shall be done by qualified welders only.



WORKMANSHIP

Striking the Arc

Accidental contact of the electrode or of non-insulated part of the electrode holder with the pipe or assemblies shall be avoided.

Slag Removal and Inter Run Inspection

Each layer of weld metal shall be thoroughly cleaned and visually examined. All slag shall be removed from each run of weld metal before a further run is superimposed, particular care being paid to the junctions between weld metal and fusion faces. Each run of weld metal shall be free from visible defects such as cracks, blow-holes, cavities or other deposition faults.

All such defects shall be removed by chipping, grinding, or filling before a deposition of a subsequent run. Flame gouging of defects in welds is NOT permissible. Stainless steel wire brushes must be used for the cleaning of all stainless steel and Hastelloy deposition welds. Peening of weld runs is not permitted.

Continuity

Welding shall not be interrupted when a groove is only partially filled unless the thickness of the weld metal; deposited is more than half of the thickness of the joint. No partially filled joint shall be subjected to undue stresses.

Current Control

Welding current shall be regularly checked by the supervisors or inspectors using a suitable current-measuring device.

Earthing

Current return cables from the work to the welding machines shall be clamped firmly to the ends of the pipe assemblies. The earth return shall not pass through any machinery. When welding to assembled valves, care should be taken to ensure that return cables are attached to the end to be welded.



WEATHER

Climatic Conditions

Welding shall not be made when weather conditions are likely to impair the quality of the weld metal or joint. In particular, welds shall not be made on surfaces which are wet due to rain or condensation, etc. Wind shields and shelter shall be used wherever necessary.

Temperature

When the general atmospheric temperature is 0°C or less, the weld metal or joint must be gradually heated until the pipework temperature is at approximately 10°C.



WELDING PROCEDURES, WELDERS AND WELDING QUALIFICATIONS

Welding procedure specifications, procedure qualifications and records and welder qualifications shall be in accordance with the Code which refers to ASME Boiler and Pressure Vessel Code Section IX (1992).

Procedures, stating clearly where they apply, shall be approved by the Engineer before welding commences.



INSPECTION AND TESTS OF WELDED JOINTS

The extent of weld inspection shall be by Class of Pipe as specified in Table of the Engineers Fabrication of Pipework Specifications. See also Piping Specification Summary Sheets.

The welds of pipework fabricated by fusion welding shall be subject to inspection by both visual and by non-destructive means by the Engineer in accordance with the requirements of this specification. The Contractor shall provide and maintain facilities for such inspection both in his fabrication shop and on the site.

External Inspection

All welds shall be visually examined externally for faults and irregularities. Butt weld reinforcement shall be uniform and shall merge smoothly into the pipe surface without undercut. Fillet welds shall be regular in form and with undercut not exceeding that stated in ASME B31.3.

Internal Inspection

The backs (i.e. bore sides) of all joints which are accessible shall be inspected throughout their circumference; full use shall be made of suitable optical instruments for quality acceptance in accordance with the following requirements:-

- i. In general the maximum limits of positive root penetrations shall not exceed 1.5 mm in pipe up to and including 50 mm NPS and 3 mm in pipes greater than 50 mm NPS.
- ii. Initial (root) runs in carbon steel pipe joints shall not show lack of root penetration, or evidence of non-fusion.

Radiographic Examination Welds

To comply with this specification the quality of butt joints shall be assessed by radiographic examination.

Radiography shall be in accordance with the Code using fine grain film and gamma techniques. The quality of radiograph shall also conform to the Code.

In the case of the single image technique the pentameter shall be placed between the film and the pipe surface. For the double image technique the pentameter shall be placed on the surface of the pipe nearest the source of radiation.

Each section of the weld shall be marked so that the radiographs can easily be correlated to the particular part of the joint represented.

Welds shall be accepted or rejected in accordance with the requirements of the Code and paragraph Internal Inspection.



Rectification of Faulty Welds

Where welds fail to comply with the requirements of this specification wholly, or in part, all unacceptable defects shall be removed.

Localised defects shall be removed by chipping, grinding, filing, flame cutting or flame gouging and grinding. Flame cutting or gouging is not permitted for stainless steel or Hastelloy.

All repair welds shall be made by the same or other similarly qualified welder, using the same complete procedure as was employed in making the original welds, including pre-heating and stress relieving, where these were originally required.

All repair welds shall meet the requirements of this specification and shall be subject to radiographic examination which shall be carried out before stress relieving if this is required by the Code.



SUPERVISION

The Contractor shall provide competent welding supervision during all welding.



POST WELD HEAT TREATMENT

The heat treatment process shall be carried out in accordance with the requirements of the Code.
(Table 331.3.1).



FINAL RECORDS DOSSIERS

Throughout the construction/fabrication of the pipework NDT results shall be monitored, date stamped and kept up to date and the final bound dossiers shall include the following items and shall be compiled by the Contractor:-

- Approved Welding Procedure Specification (WPS)
- Approved Welding Procedure Qualification Records (PQR)
- Material Test Certificates and Letter of Conformity for all materials supplied by the Contractor
- List of welders names and identification numbers that are used on marked up isometrics, fabrication sketches and gas.
- Complete set of Radiograph Reports.
- All drawings marked up with welder identification numbers and weld numbers on each weld in conjunction with a weld schedule for each drawing to enable to weld reports and radiographs to be easily identified.
- Pressure Test Certificates.

Upon completion, the Contractor shall retain one copy of the dossier, for their own records and hand over two dossiers to the Engineer, who will review, accept and retain one copy of his own records.

Storage of Documentation and Radiographs

Great care must be taken of original documents and radiographs, until they are officially handed over to the Engineer or Owner. In particular, radiographs shall be stored in a fireproof container.



SECTION 5: SPECIFICATION FOR PRESSURE TESTING OF PIPELINES



PURPOSE

The purpose of this specification is to define the procedure to be adopted for the pressure testing of carbon steel and stainless steel piping after erection.

Testing is required to meet two objectives:-

- i. Pressure testing in accordance with this specification to ensure that the pipework has adequate strength for the design conditions, and;
- ii. Leak testing, to ensure leak tightness during operation.



PROVISION OF TEST EQUIPMENT

The Contractor shall be responsible for providing all equipment, i.e. pumps, gauges, blanks, etc., necessary to carry out the testing of the pipework system. Equipment shall be suitable for the range of required test pressures.

The Contractor shall demonstrate to City University that all the necessary items are available at the site in advance of commencing testing to ensure the testing programme is not delayed in any way.

The test gauge shall comply with the requirements of BS 1780 – Bourdon Tube Pressure and Vacuum Gauges.

The scale range of the test gauge used shall be suitable for the test pressure.

Test gauges shall be checked against a standard gauge or dead-weight tester before use or whenever there is reason to believe a true reading is not being obtained. Such tests shall be witnessed by City University's responsible person.



PREPARATION AND PROCEDURE

The piping shall as far as practically be tested as complete systems including equipment, providing the line test pressure does not exceed the equipment test pressure, and not as individual lines. The number of untested joints shall be kept to an absolute minimum. The extent of pipes and/or systems to be tested shall be agreed with City University.

Following erection, the inside of all pipes, valves, fittings and other associated equipment shall be cleaned and all loose mill scale and foreign matter removed, as follows:-

- i. All piping systems and equipment shall be flushed out with water (or blown out with air where water is not the test medium) prior to test. Precautions shall be taken to ensure that debris is not flushed into vessels, equipment or 'dead ends'. All flushing, shall be carried out to the satisfaction of City University.
- ii. Control valves shall, where possible, be removed until the initial flushing of the system has been completed.
- iii. Where flushing occurs through a control valve and when no by-pass or inline strainer is fitted, the cover shall be removed and the seat cleaned under supervision of City University. The inline strainer may be either of the permanent or temporary type.
- iv. Flushing shall not be carried out through any control valve or other type of valve fitted with a Teflon, silver, titanium or soft seat, or through any other piece of equipment (such as rotameters) which might be damaged in the flushing operation. Such equipment shall be either removed from the system or suitably isolated.
- v. The general precautions outlined in the Section on Pneumatic Testing shall be observed when blowing out with air. Air pressure in the system shall be not greater than 1 barg or the air test pressure, whichever is less.
- vi. The handles of all temporary strainers shall be painted bright yellow to make them readily identifiable for removal prior to start-up operations. A list of all temporary strainers shall be kept by the Contractor.

All welded and mechanical joints shall remain uninsulated and free from paint until pressure testing has been completed.

Wherever possible, underground lines shall be tested before back-filling. Where it is essential to back-fill any section of a line before testing it is recommended that such section should be subjected to the test pressure for period of at least two hours and checked for pressure drop.

Testing of lines supported by springs shall be carried out with the locking pins installed in the springs. The locking pins shall then be removed prior to commissioning. Springs are individually identified on the pipe support schedule. Thus giving a readily accessible schedule of locking pins. Supports of pipelines will generally be designed taking into account hydrostatic test loadings.



Sensitive in-line items and pressure relieving devices shall be blanked off or removed from the line during pressure testing. Control valves and all other valves should be set in the open position for the duration of the test.

Open ends of piping systems where equipment has been removed or disconnected shall be blinded using standard flanges or temporary spools shall be installed.

Where a system is to be isolated between a pair of companion flanges properly and test spades are to be used. The test spades used shall as far as practical be of the minimum thickness consistent with the piping design in order to prevent excessive stress or movement of pipework and equipment during installation.

Spades shall not be used where this could cause misalignment or damage to equipment such as pumps and compressors which have been aligned, clocked and checked.

Test blank handles shall be painted a bright red to make them readily identifiable for removal prior to start-up operations.

All restrictions, such as flow nozzles and orifice plates, which interface with filling, draining or venting, shall be removed from the piping.

Lines containing check valves shall have the source of test pressure located on the upstream side of the valve.

Unless otherwise specified on the line schedule, lines open to atmosphere or drain shall not be tested. Such lines shall be examined to determine that all joints are properly made.

Any equipment, or in-line items for which the maximum permissible cold test pressure is lower than the test pressure applied to the system, shall be removed or blanked off from the line before testing.

Where expansion bellows are subject to test pressures the bellows shall be fitted with constraints. A record of any such constraints shall be kept and a check made for commissioning to ensure that they have been removed.

Connections for which spiral-wound gaskets are specified, and which are to be dismantled after testing (e.g. temporary spools) shall be fitted with compressed nonasbestos fibre gaskets during testing, except where specified below is applicable. Non-asbestos gaskets for testing shall be supplied by the Contractor. The spiralwound gaskets shall be fitted on final assembly.



The use of non-asbestos gaskets for testing shall be limited as follows:-

Gasket Size	Maximum Test Pressure
½" – 250 mm NPS	250 bar g
12" – 600 mm NPS	200 bar g
Above 600 mm NPS	100 bar g

Where the test pressure exceeds these limitations, spiral wound gaskets shall be used for the test.

Before applying pressure, the lines or systems shall be inspected for tightness and to verify that all parts that are not to be included in the test are isolated.



TEST PRESSURES AND MEDIA

Hydrostatic testing is the preferred method of testing. Any testing other than hydrostatic testing shall be subject to the approval of City University.

All test pressures and media shall be stipulated in the Line Schedule and unless dictated otherwise by the requirements of the contract, will be calculated in accordance with the following rules extracted from ASME B31.3.

Piping systems tested hydrostatically shall be tested to a pressure of not less than 1.5 times the design pressure adjusted to 50°C, but in no case less than 7 barg. To determine the test pressure the following formula shall be used:-

$$P_t = \frac{1.5 P S_t}{S}$$

Where

P_t = minimum hydrostatic gauge pressure Pa (psig)

P = internal design gauge pressure Pa (psig)

S_t = allowable stress at test temperature Pa (psi)

S = allowable stress at design temperature Pa (psi)

Pneumatic test pressure shall be 110% of the design pressure, unless otherwise specified. The minimum pneumatic test pressure shall be 1.0 bar g.



HYDROSTATIC TESTING

With austenitic stainless steel pipe, to avoid the possibility of subsequent failure due to stress corrosion, cracking or pitting, potable water having a chloride content of less than 30 ppm shall be used. Water having a chloride content above 100 ppm shall not be used in any circumstances, and where it is necessary to use water within a range of 30 to 100 ppm lines shall be flushed with a water containing less than 30 ppm chlorides.

Care shall be taken that stainless steel items used in lines of carbon steel or other materials are flushed away when checking lines for the above requirement.

Piping and equipment tested with water containing chlorides will contain chloride residues after drying out. Austenitic stainless steel surfaces operating at temperatures of 70oC or above shall be additionally flushed using chloride-free water (1 ppm maximum) to remove chloride residues.

If there is a possibility of damage due to freezing, or if the operating fluid would be adversely affected by water, e.g. instrument air, then oil-free air may be used; approval shall be obtained from City University before testing.

All vents and other connections which may serve as vents, shall be open during filling in order to release all air before applying pressure.

The pressure reading shall be taken at the lowest point in a system (the static head shall be taken into consideration).

Pressure shall be applied by means of a suitable test pumps which shall not be connected to the system until ready for test. A test gauge shall be provided at the pump discharge to determine the test pressure of the system and to avoid overpressurising. The pump shall be attended constantly during pressurising by an authorised operator and effectively isolated from the system during the test and whenever left unattended.

In order to prevent pressures in excess of the test pressure, power operated test pumps shall be equipped with a relief valve with a set pressure slightly above the test pressure.

Leaking valve glands shall only be tightened sufficiently to prevent leakage; control valve glands shall only be tightened under supervision of City University, and the valve shall be actuated after test.

Where there may be residual moisture in the valve packing after hydrostatic testing, consideration shall be given to repacking the valves used in low temperature and corrosive chemical duties.

After the system has been filled, the test pressure should be raised in two stages, over a period of approximately 1 hour.

The test pressure should be held without loss, for 1 hour but slight variation in pressure (5%) may be experienced if there have been significant changes in climatic conditions during the filling and testing period.

Where leaks are found during test, the lined shall be repaired and retested.



All lines and equipment shall be completely drained after the hydrostatic test of a system has been completed. Vents shall be opened first to prevent excessive vacuum and permit complete draining.



PNEUMATIC TESTING

Because of the danger resulting from failure of any part of a system under test due to the stored energy in a compressed gas, pneumatic testing shall be conducted after normal working hours with a minimum number of personnel in attendance. At least one technical representative from the Contractor shall be present during the test.

Air shall be admitted to the system through a single air hose not exceeding 20 mm diameter. A safety valve set at not greater than 10% above the test pressure and of adequate capacity shall be installed in the system close to where air is admitted to the system.

The air hose shall be disconnected whenever the system is left unattended or when a test is in progress.

A test gauge shall be located in the system close to the air supply point and all pressure gauges in the system with scale ranges above that of the test pressure shall be connected in.

The system to be tested shall be brought slowly up to a maximum pressure of 1.0 barg and a check made to locate any leaks. When any leaks have been rectified, the pressure shall be gradually increased to the full test pressure, with no personnel in the vicinity of the system. (The test shall be maintained for a minimum of four hours). When the system integrity has been certified, the pressure shall be reduced to the maximum operating pressure and the lined checked for leaks with a soapy water solution, and all leaks and defects marked. In this condition the restriction on personnel in the vicinity is ended.

Before any remedial work is undertaken on weld defects, leaking flanges, etc., the system shall be depressurized and valves opened to prevent any accidental pressurizing. No work shall be attempted on a pressurized system.

After the system defects have been rectified, the system shall be re-tested at the original test pressure.

Systems subject to pneumatic testing may have a permissible maximum pressure loss in four hours, after allowing for air and ambient temperature changes as follows:

- i. 10% for large capacity system comprising vessels and piping.
- ii. 15% for low capacity systems, such as the instrument air piping, providing that it is established that the loss is attributable to slightly passing valves or the like.



INSTRUMENT PIPING

Instrument piping shall normally be tested with the piping system, up to the first block valve leading to the instruments only. The union or flange downstream of the block valve shall be broken during the test to prevent foreign matter entering the instrument or instrument lines.

All other instrument piping shall be tested independently, except in specially defined circumstances, when the instrument leads shall not be connected until blowing of the piping system is complete.

Operational pressure gauges may be connected to the system during pneumatic test, provided that the test pressure does not exceed the scale range.



SERVICE TESTING

Certain pipelines will be identified for service test only.

At the Owner's option, service testing is allowed for utility piping systems designed for 10.5 barg at 186°C or less providing a safe procedure for doing this has been defined. Therefore, all lines which fall into this category with the exception of low pressure steam in pipelines 10" NPS and above, can be service tested as a minimum requirement. Service testing shall be carried out in accordance with procedures which shall include provision for examination of pipelines at intervals of pressure, i.e. 15% of the service pressure or 1.7 barg whichever is the lower. The test shall be preceded by a 100% visual inspection of the system being tested for fabrication and erection completeness.

During or prior to initial operation, the pressure shall be gradually increased in steps until the operating pressure is reached, holding the pressure at each step long enough to equalize piping strains.



RECORDS

The records of each test shall be made, and kept for future reference.

These records must show, as a minimum, the following details:-

i Date of Test

ii Line Number

iii Test Medium

iv Test Pressure

v Pressurisation Time

vi Observations, including leakages, etc.

vii Remedial Action

viii Details of Re-Testing

ix Name and signature of the Contractor's personnel responsible for test, and name and signature of City University's representative witnessing test.



SECTION 6: SPECIFICATION FOR THE ERECTION OF PIPEWORK



OBJECTIVE

The objective of this specification is to define the acceptable standards for the erection of pipework, and to illustrate the relevant technical documents forming the contract.



DEFINITIONS

“Owner” means City University London.

“Engineer” means City University London or those acting on behalf of City University London.

“Contractor” means the Supplier, Sub-Contractor, Vendor of welded equipment, or Piping Fabricator responsible for welding of pipes and fittings.

“Code” means American National Standard Institute Code for Precision Piping – Chemical Plant and Petroleum Refinery Piping ASTM B31.3a Edition plus Addenda B31.3a 1993.



SCOPE

The Contractor shall be responsible for the erection of all carbon steel, stainless steel and lined pipe systems including pipe supports, in accordance with the documents and special requirements listed herein.



APPLICATION OF STANDARDS

The erection of pipework shall be in accordance with this and the other specifications listed herein and with the requirements of the ASME code for pressure piping B31.3. Where differences exist between any of these codes and specifications the more stringent requirements shall govern.



PIPING MATERIALS

The pipe (carbon and stainless) in random lengths, fittings, valves and special items will be supplied by the Contractor, at or before the time required to comply with the construction programme.

Lined pipe for on-site erection will be supplied by the Contractor in fabricated flanged spool pieces.

GRP, plastic and glass pipe may be supplied and installed by a nominated supplier.



GENERAL

The contractor shall not take any decision that could jeopardize the plants design integrity.

To ensure no error occurs in the selection of materials for fabrication and erection, it is the Contractor's responsibility to identify and segregate all materials. The Contractor shall establish an efficient material control procedure and demonstrate the same to the satisfaction of City University. He shall also be responsible for any loss or damage to any material supplied.

No piping spools shall be dispatched from an off-site fabrication shop to site without prior agreement of City University.

The Contractor shall be responsible in all cases for ensuring the accurate fabrication and erection of all sizes of pipework. Positions of field welds(in all planes) including those at loose flanges shall be decided by the Contractor. Allowance shall be made in the fabrication to account for fabrication and construction tolerances of the overall project. The Contractor shall demonstrate to City University at any time that he has made these allowances. It is the Contractor's responsibility to establish the number of configurations and length of individual spools to make up the isometrics.

Where isometrics are provided for small bore piping (40 mm NPS and smaller) the Contractor shall be responsible for verifying the route, configuration and dimensions of small bore pipes before erection proceeds.

Except where cold springing is specified on the piping drawings, all piping shall be installed in place without springing or forcing, and the Contractor must be able to demonstrate this to City University by breaking joints.

Slopes on piping shall be as indicated on the piping drawings.

The Contractor shall ensure that all City University's and Vendor's equipments of the specific installation instruction for valves, flexible bellows units and other specialist in-line items are met.

In particular, valves subjected to heat during installation shall have internal parts removed prior to welding which could be damaged by heat.

The sequence, programme and methods of pressure testing shall be submitted by the Contractor at an early stage of erection for the approval of City University. The installation of test blinds at equipment shall be accomplished during pipe erection in accordance with hydrostatic test plans.

Hoses shall be installed prior to pressure testing.

Temporary suction strainers shall be installed as indicated on the piping isometrics at all pumps and compressors during the piping erection.

Completed spool assemblies from an off-site fabrication shop, which have been inspected and accepted shall be forwarded to the site lay-down area. The organization of this lay-down area shall be agreed with City University.



After fabrication and erection, compressor lube oil and seal oil systems require special cleaning. The inside of the piping, except stainless steel, shall then be chemically cleaned. After washing thoroughly, the inside of the pipe shall be lightly oiled and sealed until installation.

If the Contractor intends to use spool drawings these shall be produced from City University's Isometric or Piping General Arrangements Drawings.



ASSEMBLY OF PIPEWORK

Flange Joints

The Contractor shall be responsible for the proper assembly of flanged joints, and shall pay due attention to the following paragraphs:

- The flange faces shall be cleaned free of all dirt, corrosion, grease and protective coatings, and shall be inspected for defects such as scratches or dents prior to installation.
- The flanges shall be properly aligned prior to the insertion of gaskets and bolts to avoid undue stresses or uneven gasket loads.
- Flange machine bolts and studbolts shall extend fully through their nuts, studbolts shall have equal lengths showing on each side. The lengths of bolts are in accordance with the Code or Pipe Manufacturer's Standards and allow for maximum tolerances of flange, gasket and equipment. In some cases this results in quite a long stud protrusion. Proprietary thread lubricants should be evenly applied to all bolts.
- The use of washers or spacers to take up excess bolt length is not permitted. Plain washers are not to be used, except with the express permission of City University.

Particular attention should be paid to glass-lined vessel nozzles. No strain or jacking shall be applied to the mating pipework flanges.

Flange protection shall be kept on all flanged connections to pumps, compressors and similar equipment, until ready to connect the piping.

The bolt tightening operation shall be carried out in a diametrical sequence in a minimum of three stages with a tightening sequence at the final torque loading.

Grease or gasket compound shall not be used on gasket or flange faces. Spiral wound gaskets shall never be re-used. Pipe manufacturer's recommendations shall be adhered to.

Star washers shall only be used on flanged joints within hazardous and process areas. Star washers shall be manufactured from stainless steel and shall be of the externally serrated type.

Where applicable at least two bolts on each flanged joint shall be fitted with star washers between the nut/machine bolt head and the flange. This shall ensure electrical continuity across the flanges.

Studbolts may be substituted for machine bolts only where the use of machine bolts is found to be impractical i.e. where a bolt has to screw into a threaded blind hole, as may be found on some valve flanges and lined pipe fittings.



Screwed Pipework

Pipe ends shall be cut square, threaded and reamed, all cuttings both internal and external shall be cleaned from the surfaces.

Threads shall be concentric with the outside of the pipe and shall be stated on the pipe and valve specification.

Where temperature and service fluids permit, joints shall be assembled using PTFE tape which shall only be applied to the male thread.

Where seal welds are specified no PTFE tape or thread compounds shall be used and all cutting fluids shall be removed prior to the joint being made. Seal welds shall cover all exposed threads.

Where threaded couplings or nipples are welded onto pipe spools, the thread must be checked for fit and roundness after welding, using a thread gauge. If the thread is found to be unacceptable it shall be chased with a tap or die.



PIPE SUPPORTS

General

The Contractor shall supply, fabricate and erect all pipe supports required in the plant in accordance with the standards and drawings specified herein. All materials used for pipe supports, will be supplied by the Contractor.

Pipe supports shall be prefabricated, cut to suit and erected in advance of the piping being installed. It is emphasized that pipework must be erected on permanent supports.

Pipe supports types will be indicated on the Piping Arrangement drawing. The position of supports will not be dimensioned, locations shall be determined by visual and scaling means.

Variations to City University's Standards and Specification may be allowed provided the Contractor is able to demonstrate economical and functional advantages.

Pipes shall not be supported from other pipes without the prior agreement of City University.

Welding of clamps, lugs, or other erection aids to any alloy, stainless steel or lined pipe shall not be permitted.

Pipe spools shall be permanently attached, (i.e. bolted or welded) to mechanical equipment only after the equipment has been grouted and permanent pipe hangers and supports have been installed to accept the entire pipe load.

There are many pipe support manufacturers available and most provide suitable types of supports that are adequate for the chemical industry. However, to provide a standard support that will present conformity across the City University site it is recommended that the design and types provided be Carpenter and Paterson be used.

Types of Support

The type of support to be used for each application should be assessed by the piping designer and approved by the Engineer.

The material should be generally be hot dipped galvanised carbon steel with bright zinc plated fixings.

For some specific process cases galvanised pipe supports may be replaced by 304L stainless steel supports and fixings.

No painted carbon steel pipe supports or fixings should be used on external piping systems as they deteriorate rapidly and cause unsightly staining and corrosion of primary support structures.

For standard design types of pipe support City University Specification CU2, Pipe Support Specification.



The type, size and location of each support should be assessed by the piping designer with regard to the loading, thermal movement and direction of expansion and contraction.



SPECIFICATION FOR NEW STEELWORK PIPE TRACKS

The City University steelwork pipe track is to be constructed to the following British Standards and Codes of Practice at their current revision status.

BS 5950 Structural use of steelwork in buildings.

BS 648 Schedule of weights of building materials.

BS 6399 Part 1 Code of Practice for Dead and imposed Loads.

BS 6399 Part 2 Code of Practice for Wind Loads

BS 6399 Part 3 Code of Practice for imposed Roof Loads

City University Site Image Standard

The pipe tracks should be designed from rectangular rolled steel hollow sections (RHS) for the primary pylon supports, lattice beam structures of RHS for the bottom and top chords and welded vertical struts, bracing may be steel angle sections(RSA).

Horizontal stringers between the chord members of bridge sections should be steel channel sections bolted to welded cleats on the bridge chords.

Additional permanent steelwork to existing bridge structures should be attached by bolting to new welded-on fishplates on the main sections of the existing bridgework's.

All bridge structures should maintain the MOT vehicle height clearance for roads i.e. 6.0m and have future load capacity of 50% design load (min 10 kN/m) and minor offload service bridges 4 kN/m.

Steelwork fish plates and cap plates to be 8mm minimum thick steel and be welded to the main steelwork by 6 mm fillet welds min. Boltings to be BZP min 16 mm dia.

All steelwork and attachments to be hot dipped galvanised and etched and painted by two pack epoxy paint of Goosewing Grey colour (Crown).

Welded plates and repairs to existing steelwork to have a primer coat of: Epigrip C400 zinc phosphate primer, light grey to 200 microns DFT.



Finish Coat:

Two pack epoxy gloss paint of Goosewing Grey colour (Crown to 75 microns min).

Civil foundations should include allowance for wind exposure on the bridge structure.

All site works require work permit issue and ground works supported by electrical ground scans.



STANDARD CODE OF PRACTICE

Support Location Adjustment

When Fabricating and Erecting Pipe Supports the Contractor shall make allowance for site variations by:-

- i Shimming up
- ii Cutting the support to suit and welding

Spring Supports Units

Spring supports, and fixing nuts and bolts for spring supports etc, shall be supplied by the Contractor.

The Spring Units shall be adjusted upon completion of spring unit installation, pipe pressure and leak testing and if required insulation installation. Correct adjustment is obtained when the "Cold Pre-setting Pins" or plates (there are usually two pins which are painted red) may easily be removed. Adjustment is achieved by turning the rod turn-buckle on the hanger type units and the hexagon nuts on pedestal type units. Correct adjustment will facilitate pin removal.

"Cold Pre-setting Pins" shall be removed from all spring units before plant start-up. Pins shall be greased and wired to the unit for future use.

In the event that piping requires to be dismantled the pins shall be inserted to lock unit prior to the commencement of work.

NB: Close attention shall be paid to the spring Manufacturers installation instruction leaflets prior to work commencement.

Temporary Supports

The Contractor shall be responsible for the design and reaction of any temporary pipe supports for all sizes of pipework to ensure that damage by distortion is avoided.



TEMPORARY SPOOLS

The Contractor shall supply a sufficient number of temporary spool pieces in place of flexible bellows units and similar equipment to enable pipework completion and prevent mechanical damage. These spool pieces should be manufactured to the following tolerances.

Linear tolerances = $\pm 1.5\text{mm}$

Flange alignment/orientation = shall not exceed 1.5mm

Flange alignment/squareness = shall not exceed 0.75 mm across diameter.

The Contractor shall demonstrate by unbolting flanges that bellows units are correctly aligned.

Pipe supports shall be positioned such that the lined pipe does not sag at flange joints.

Generally, all supports shall be of the clamp type. Additional support shall be provided where there are changes in direction of the piping and in areas of high load concentration such as clusters of valves or fittings.

Welded attachments that are specified by City University shall be fixed prior to lining.

The Contractor is responsible for determining the correct torque value for bolts on flanged joints.

Non-Conductive Fluids

Anti-static gaskets will be used every 2 m when the pipe is used to convey nonconductive fluids.



DOCUMENTATION

Fabrication and erection of pipework shall be in accordance with the documents listed in the attached Schedule of Drawings. The Contractor's attention is drawn to the following:

Piping General Arrangement Drawings

When computerized piping general arrangement and section drawings are provided, these will show sufficient pipe routing dimensions for erection purposes only.

Manual piping arrangement drawings will show sufficient dimensions for producing isometrics of large bore lines (≥ 50 mm NPS) and for erection purposes.

Major pipe track routings are fully dimensioned on the Piping Arrangement drawings.

Isometric Drawings

When computerized isometric drawings are provided they will be for both large and small bore piping (excluding instrument piping and protective heating system piping).

When Manual Isometrics are provided they will generally be for large bore lines (≥ 50 mm NPS) and lined carbon steel lines. However, when a model is provided, Isometrics will be provided for all lines (other than Tracks etc).

Major track piping is not detailed on isometric drawings.

Piping Model

A Piping model will not normally be supplied unless specifically required by the Contract.

Protective Heating System Drawing

Isometric drawings will have a note to indicate protective heating requirements and tracing limits shown.

All detailed routing of protective heating systems shall be the Contractor's responsibility.

Piping Material Specifications and Materials

Piping and valve specifications defining materials of construction, pressure ratings for specific services are provided.



Piping material summaries are provided for piping materials excluding pipe supports which is the Contractor's responsibility to quantify and supply.

Special Piping Item (SPP's) not included in the standard piping and valve specification are listed in the Design Item List and cross-referenced in the SPP index.

Identification and Selection of Pipe Supports

All pipe supports, guides and anchors are indicated on the piping general arrangement drawings.

Special Pipe Supports, i.e. those supports outside the scope of the standard range of supports are detailed where necessary and located on the piping general arrangement drawing.

Documentation Discussions

The Contractor's Senior Site Supervisor together with City University shall attend City University's design office for a review and discussion of the design concepts and documentation before Fabrication and Erection begins.

Schedule of Documents

- i. This specification
- ii. Specification for Fabrication, Testing and Inspection of Carbon Steel Pipework.
- iii. Specification for Fabrication, Testing and Inspection of Stainless Steel Pipework.
- iv. Specification for Fabrication, Testing and Inspection of Hastelloy Pipework.
- v. Specification for Pressure Testing of Pipelines.
- vi. Specification for the Welding of Pipes and Fittings.
- vii. Pipe and Valve Specification.
- viii. Pipe Support Standards.
- ix. Special Pipe Support Drawings.
- x. Line Schedule
- xi. DI/SSP Index
- xii. SSP Specification
- xiii. Schedule of Piping Drawings



xiv. Schedule of Engineering Line Diagrams

xv. Schedule of Utility Line Diagrams

xvi. Schedule of Trace Heating Drawings

xvii. Schedule of Fire Protection Drawings

xviii. No Schedule is provided of isometric drawings, as each isometric is identified by the number of the line it represents with a suffix /2, /3, etc., if there is more than one isometric for a line.

xix. Materials Quantities data.



SPECIFICATION FOR STAINLESS STEEL TUBE ORBITAL WELDING

Scope

This specification covers the gas tungsten arc welding of austenitic stainless steel pipe using open head automatic orbital tube wire feed welding machines (and manual TIG equipment by exception).

General Requirements

All welds shall be made using an open head wire feed automatic programmable orbital Pipe Welding equipment.

At the beginning of each shift and whenever the machine is restarted, one sample weld shall be made for each automatic welding machine, head combination, materials and tube size, prior to its use on the job. The samples shall be visually examined. These welds shall be included on the daily sample log. The samples shall be identified by marker-pen and shall be referenced in the log.

All weld samples shall be as deposited, without being chemically or mechanically cleaned in any way after welding. Evidence of minor oxidization does not indicate an unacceptable weld.

Welding Procedures and Qualifications

All manual welders and automatic welding operators shall have recent work experience on pipe and have qualified to ASME EN287/288, Section IX for GTAW manual and/or automatic welding, as applicable to the joints they are to weld.

Written qualifications of all welders shall be available on site.

The Sub-Contractors Welding Supervisor will be experienced in programming, calibration and trouble-shooting of automatic orbital welding machines.

Weld Joint Preparation and Fit-Up

Prior to welding, the tubing and fittings shall be completely clean for at least 40mm on each side of the weld zone. When used tubing or fittings are being welded, cleaning shall extend to 75mm on each side of the weld zone. This cleaning shall be accomplished first by using an approved solvent, then by wiping with a clean lintfree cloth.

Prior to welding, a check shall be made for alignment and excessive gap and that the electrode is centred over the butt joint.



Tacking

The use of manual GTAW (TIG) welding of tack welds is permitted, however, no full butt welds are allowed with this method without the prior written approval of the project supervisor.

Manual welding shall be accomplished in such a manner as to not cause any deleterious effects on the completed weld or interior surface of the tubing or fitting. Tacks shall be as light as possible to reduce excessive heat. Tacks shall not penetrate to the inner surface and the same back-up purge/shield gas as the production weld shall be applied when welding manually.

After a tack weld has been completed, the fit-up shall be checked for poor alignment or excessive gap.

All tack welds shall be performed by the same qualified welders and meet the same requirements as the production weld.

Welding Equipment

Open head wire feed automatic orbital tube as tungsten arc welding machines shall be used.

Shielding gas shall be High Purity Filtered Argon preferably from cryogenic source.

External purge gas to the head can be from cylinders.

Filler Metal to be in accordance with the weld procedure.

Tungsten electrodes shall be 2% ceriated.

Electric current shall be continuous or pulsed DC electrode negative, base material positive.

Welding control programmer shall be lockable and shall provide a printout of conditions used for each weld. And all machines shall have calibration records.

Shielding

The High Purity Argon for arc shielding and back purging shall be used at a controlled rate via use of flowmeters. Gas lenses shall be used in manual torches. Pressure regulators shall be of high quality and shall have metallic diaphragms. Purge hoses/tubes shall be clean and manufacturers from PFA.

Internal gas purge shall be applied for a minimum time until the oxygen level as indicated by a hand held "Oxytech" oxygen meter indicates an oxygen level of less than 0.01% (minimum scale). Welding shall not be permitted until the Supervisor is satisfied that full blanketing is in place and oxidation of inside shall not occur. The length of purge time and flowrates for various tubing sizes shall be established during procedure qualification and adjusted prior to welding.



The work area shall be protected from draughts to ensure effectiveness of shielding.

An oxygen analyser shall be available periodically to check purge and shield gas at the flowmeter outlets prior to a new batch of gas being used. Acceptance criteria shall be less than 1 ppm oxygen content.

Oxygen meters to have current Calibration Certificates.

Inspection

General acceptance standard for welds shall meet requirements of EN 287/288 (latest Edition) Table 341.3.2A Acceptance Criteria for Welds.

Concave Root Surface (see fig. 341.3.2 of EN 287/288) shall be minimised to not more than 5% of tubing wall thickness.

All welds (100%) shall be visually examined per para 341.4.1 of EN 287/288.

Visual acceptance criteria shall be as per para MJ-6 of EN 287/2889.

Tube Sections Verification

The following points to be checked:-

Tube ends are machined in accordance with the weld procedure i.e. V or J prep., and any possible contamination from the cut-off removed.

Burrs removed from machined ends.

No tool has been contaminated by contact with carbon steel.

Cleaning Verification

The following points to be checked:-

No visible foreign material is at the weld ends of the components. This includes lint from cleaning cloths.

Tungsten electrode is clean and uncontaminated.



Joint Fit-Up

The following points to be checked:-

The gap between ends of welding components shall be in accordance with the weld procedure.

The internal surface of the joint is smooth with the two components in perfect alignment.

The tungsten electrode is centred on the joint.

Weld Machine Settings

The following points to be checked:-

Parameters are set in accordance with appropriate welding procedure.

Verify that the Supervisor has checked machine settings.

Full Penetration

The weld bead shall be even in width over the full periphery of the welded joint. The edges of the butt joint shall not be visible adjacent to the weld bead and there shall be no other crevices or holes visible.

Proper Back-Up Gas Purging

Zero discolouration shall be the target level of colouration in the heat affected zone region. Light straw is acceptable, blue is unacceptable.

Proper Back-Up Gas Pressure

A concave surface at the weld joint indicating excessive back-up gas pressure is not permitted.



Weld Defects

The following defects are examples for which re-welding may be attempted.

Incomplete penetration: one time only

Lack of fusion

Excessive penetration: 0.4mm max. allowable.

Internal Silica Slag – None allowed.

The following defects shall be rejected and cut out:-

Lack of fusion after re-flow

Cracks: none allowed

Undercut: none allowed

Crater crack: none allowed

Burn through: none allowed

Porosity: none allowed

Oxidation: none allowed

Misalignment (high point only): Maximum allowable is 0.25mm.

Arc strikes as determined in EN 287/288.

OD convexity as determined in EN287/288.

OD concavity as determined in EN 287/288.

ID concavity as determined in EN 287/288

ID convexity as determined in EN 287/288

Weld Repairs

Repairs to welds shall not be permitted without the prior permission of UKGT Welding Inspector.

A weld repair is permitted when, through examination, it is determined that an unacceptable defect exists and that the defect is correctable.

The tube ends shall be re-prepared in the proper manner and a new weld performed that will be subject to all standards tests.



Tube sections from rejected welds may be re-used after the heat affected zone is cut off. The heat affected zone shall be considered to extend to the limit of the discolouration adjacent to the weld.



SPECIFICATION FOR STAINLESS STEEL PIPE ORBITAL WELDING

Scope

This specification covers the gas tungsten arc welding of austenitic stainless steel tubing using enclosed head automatic orbital tube welding machines (and manual TIG equipment by exception). Under certain circumstances this specification may be applied to welding of nominal bore pipe but in most instances the specification "For welding of stainless steel Pipe pipework and fittings" should be applied.

General Requirements

All welds shall be made using an enclosed head automatic programmable orbital Tube and Pipe Welding equipment.

At the beginning of each shift and whenever the machine is restarted, one sample weld shall be made for each automatic welding machine, head combination, materials and tube size, prior to its use on the job. The samples shall be visually examined. These welds shall be included on the daily sample log. The samples shall be identified by marker-pen and shall be referenced in the log.

All weld samples shall be as deposited, without being chemically or mechanically cleaned in any way after welding. Evidence of minor oxidization does not indicate an unacceptable weld.

Welding Procedures and Qualifications

All manual welders and automatic welding operators shall have recent work experience on tubing/pipe and have qualified to ASME EN 287/288, Section IX for GTAW manual and/or automatic welding, as applicable to the joints they are to weld. Written qualifications of all welders shall be available on site.

The Sub-Contractors Welding Supervisor will be experienced in programming, calibration and trouble-shooting of automatic orbital welding machines.

Weld Joint Preparation and Fit-Up

Prior to welding, the tubing and fittings shall be completely clean for at least 40mm on each side of the weld zone. When used tubing or fittings are being welded, cleaning shall extend to 75mm on each side of the weld zone. This cleaning shall be accomplished first by using an approved solvent, then by wiping with a clean lintfree cloth.

Prior to welding, a check shall be made for alignment and excessive gap and that the electrode is centred over the butt joint.



Tacking

The use of manual GTAW (TIG) welding of tack welds is permitted, however, no full butt welds are allowed with this method without the prior written approval of the project supervisor.

Manual welding shall be accomplished in such a manner as to not cause any deleterious effects on the completed weld or interior surface of the tubing or fitting.

Tacks shall be as light as possible to reduce excessive heat. Tacks shall not penetrate to the inner surface and the same back-up purge/shield gas as the production weld shall be applied when welding manually.

After a tack weld has been completed, the fit-up shall be checked for poor alignment or excessive gap.

All tack welds shall be performed by the same qualified welders and meet the same requirements as the production weld.

Welding Equipment

Enclosed head automatic orbital tube gas tungsten arc welding machines shall be used.

Shielding gas shall be High Purity Filtered Argon preferably from cryogenic source.

External purge gas to the head can be from cylinders.

No filler metal of any type shall be used.

Tungsten electrodes shall be 2% ceriated.

Electric current shall be continuous or pulsed DC electrode negative, base material positive.

Welding control programmer shall be lockable and shall provide a printout of conditions used for each weld. And all machines shall have calibration records.

Shielding

The High Purity Argon for arc shielding and back purging shall be used at a controlled rate via use of flow meters. Gas lenses shall be used in manual torches. Pressure regulators shall be of high quality and shall have metallic diaphragms. Purge hoses/tubes shall be clean and manufactured from PFA.

Internal gas purge shall be applied for a minimum time until the oxygen level as indicated by a hand held "Oxytech" oxygen meter indicates an oxygen level of less than 0.01% (minimum scale). Welding shall not be permitted until the Supervisor is satisfied that full blanketing is in place and oxidation of inside shall not occur. The length of purge time and flowrates for various tubing sizes shall be established during procedure qualification and adjusted prior to welding.



The work area shall be protected from draughts to ensure effectiveness of shielding.

An oxygen analyser shall be available periodically to check purge and shield gas at the flowmeter outlets prior to a new batch of gas being used. Acceptance criteria shall be less than 1ppm oxygen content.

Oxygen meters to have current Calibration Certificates.

Inspection

General acceptance standard for welds shall meet requirements of EN 287/288 (latest Edition) Table 341.3.2A Acceptance Criteria for Welds.

Concave Root Surface (see fig. 341.3.2 of EN 287/288) shall be minimised to not more than 5% of tubing wall thickness.

All welds (100%) shall be visually examined per para 341.4.1. of EN 287/288 Visual acceptance criteria shall be as per para MJ-6 of EN 287/2889.

Tube Sections Verification

The following points to be checked:

Tube ends are machined square and any possible contamination from the cut-off removed.

Burrs removed from machined ends.

No tool has been contaminated by contact with carbon steel.

Cleaning Verification

The following points to be checked:

No visible foreign material is at the weld ends of the components. This includes lint from cleaning cloths.

Tungsten electrode is clean and uncontaminated.

Joint Fit Up

The following points to be checked:

The gap between ends of welding components shall not exceed 0.25mm.



The internal surface of the joint is smooth with the two components in perfect alignment.

The tungsten electrode is centred on the joint.

Weld Machine Settings

The following points to be checked:

Parameters are set in accordance with appropriate welding procedure.

Verify that the Supervisor has checked machine settings.

Full Penetration

The weld bead shall be even in width over the full periphery of the welded joint. The edges of the butt joint shall not be visible adjacent to the weld bead and there shall be no other crevices or holes visible.

Proper Back-Up Gas Purging

Zero discolouration shall be the target level of colouration in the heat affected zone region. Light straw is acceptable, blue is unacceptable.

Proper Back-Up Gas Pressure

A concave surface at the weld joint indicating excessive back up gas pressure is not permitted.

Weld Defects

The following defects are examples for which re-welding may be attempted.

Incomplete penetration: one time only

Lack of Fusion

Excessive penetrations: 0.4mm max. allowable.

Internal Silica Slag – None allowed.

The following defects shall be rejected and cut out:-

Lack of fusion after re-flow

Cracks: none allowed



Undercut: none allowed

Crater crack: none allowed

Burn through: none allowed

Porosity: none allowed

Oxidation: none allowed

Misalignment (high point only): Maximum allowable is 0.25mm.

Arc strikes as determined in EN 287/288

OD convexity as determined in EN 287/288

OD concavity as determined in EN 287/288

ID concavity as determined in EN 287/288

ID convexity as determined in EN 287/288

Weld Repairs

Repairs to welds shall not be permitted without the prior permission of UKGT Welding Inspector.

A weld repair is permitted when, through examination, it is determined that an unacceptable defect exists and that the defect is correctable.

The tube ends shall be re-prepared in the proper manner and a new weld performed that will be subject to all standard tests.

Tube sections from rejected welds may be re-used after the heat affected zone is cut off. The heat affected zone shall be considered to extend to the limit of the discolouration adjacent to the weld.



REVISION

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