



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 231

**Induction bends for pipelines
(Intermediate and Severe Sour Service)**

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1. Scope

This specification defines the COMPANY's general requirements for the manufacture and inspection of butt welding bends that are shop fabricated by induction bending or induction forging for use in "Intermediate Sour Service" or "Severe Sour Service" (i.e. corresponding respectively to areas 2 and 3 in design specification **GS COR 170**), using seamless pipes or longitudinally submerged arc welded pipes.

It applies to bends in Grade B and Grade X42 up to Grade X65 of **API Spec 5L** for use in onshore or underwater pipelines.

This specification shall be used in conjunction with a so-called Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions of the pipeline Project (see § 3.2 in this specification).

Requirements are also specifically stated in this specification for bends where the properties of base material and weld (if any) are to be ascertained after a Post Weld Heat Treatment is made.

The present specification shall also apply to mother pipes whatever they are free issued by the COMPANY to the SUPPLIER, or they are directly procured by the SUPPLIER.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

The order of precedence of the applicable documents shall be:

- The PO/Requisition
- The Project Particular Specification (PPS)
- The present General Specification
- The Codes and Standards in reference.

Applicable Codes and Standards, which are to be used in conjunction with this specification, are stated in tables hereafter.

Unless otherwise specifically indicated in writing by the COMPANY, the SUPPLIER shall work in accordance with the requirements specified herein and the applicable requirements of the latest editions at time of Contract award of the referenced Codes and Standards, whenever requested in the present specification.

Where this specification states no overriding requirements, the referenced Codes and Standards shall apply in full.

Standards equivalent to those referred to herein shall not be substituted without written Approval from the COMPANY.

The SUPPLIER shall equip himself with copies of all the reference specifications referred to in this specification and shall make them readily available to all fabrication, testing and inspection personnel involved on the work.

Note: The specification **GS COR 170** is mentioned herein only as a background to the definition of the types of sour services (i.e. Intermediate Sour Service or Severe Sour Service) and corresponding "areas" on graph of the said specification (i.e. area 2 or 3).

Standards

Reference	Title
ANSI B 16.9	Factory-Made Wrought Steel Butt welding Fittings
ASTM A 370	Mechanical Testing of Steel Products
ASTM A 578	Straight-beam ultrasonic examination of plain and clad steel plates of special application
ASTM E 23	Notched Bar Impact Testing of Metallic Materials
ASTM E 384	Test Method for Micro hardness of Materials
ISO 148	Charpy impact test (V-notch)
ISO 1027	Radiographic Image Quality Indicators for non-destructive testing. Principles and identification
ISO 6507	Hardness test - Vickers test - Part 1: HV5 to HV10
ISO 9002	Quality systems: Model for quality assurance in production, installation and servicing
ISO 12096	Radiographic testing of longitudinal and spiral welds for the detection of imperfections
EN 10204	Types of inspection documents
EN 473	Qualification and certification of non-destructive testing personnel

Professional Documents

Reference	Title
API Spec 5L	Specification for Line pipe
API RP 5L1	Railroad Transportation of Line pipe
API RP 5LW	Transportation of Line pipe on Barges and Marine Vessels
MSS SP 75	Specification for high test wrought butt welding fittings
NACE MR 01-75	Sulfide Stress Cracking Resistant Metallic Materials for oil field Equipment

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
ASME, Section V	Boiler and Pressure Vessel Code. Non-destructive Examination
ASME Section VIII, Division 1	Boiler and Pressure Vessel Code

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS COR 170	Materials for sour service. Specification for design
GS PLR 211	Fabrication of seamless pipes for pipelines (Intermediate and Severe Sour Service)
GS PLR 212	Fabrication of longitudinally submerged arc welded pipes for pipelines (Intermediate and Severe Sour Service)
GS PLR 421	Site welding of carbon steel pipelines to API 1104 (Intermediate and Severe Sour Service)

3. General

3.1 Definitions

- Inspector**

The COMPANY's inspector(s) or the inspector(s) from an independent Inspection Agency duly appointed by the COMPANY to act on its behalf for the purpose of the Contract shall be referred to herein as the "Inspector".
- Mill**

The plants, Mills, workshops, laboratories or other locations where the fabrication, inspection and testing of materials and products are to be performed complete or in part, shall be referred to herein as the "Mill".
- Contract Documents**

The material requisitions, material specifications, etc. issued by the COMPANY and attached to the Contract or the Purchase Order shall be referred to herein as the "Contract Documents".
- Approval**

Authorisation in writing given by the COMPANY to the SUPPLIER on a procedure or to proceed with the performance of a specific part of the work without releasing in any way the SUPPLIER from any of his obligations or liabilities under the Contract or at law. The words Approve, Approved and Approval shall be construed accordingly.

- **Mother Pipe** The original pipe or base pipe used for fabricating the bend or any portion of it shall be referred to herein as the "mother pipe".
- **PPS** Used to designate the Project Particular Specification.

3.2 Project Particular Specification (PPS)

The following information will be supplied in the Project Particular Specification (PPS):

- a) Steel Grade
- b) Specified minimum wall thickness
- c) Nominal Inside Diameter and minimum bore (or gauge) of pipeline and bend
- d) Radius of curvature and angle of bends
- e) Minimum length of tangential ends or welded pup pieces. Minimum length to be not less than 1,000 mm (refer to § 6.1.7)
- f) The sour service severity and type of pipeline effluent to clarify the H₂S test conditions and hardness requirements in weld (if any) (refer to § 6.4.9 and 8.5.1)
- g) Profile and dimensions of bevelled ends (refer to § 7.8)
- h) Post Weld Heat Treatment (if any) before supplementary testing (at least for WT above 25.4 mm) (refer to § 6.4.6).
- i) Routine test temperature for impact tests (refer to § 8.4 and section 11)
- j) If it is confirmed that there are no HIC and SSC tests in production tests (refer to § 8.1)
- k) The party (i.e. COMPANY or SUPPLIER) in charge for supplying the mother pipes (refer to section 4).
- l) Number of originals and copies of Mill certificates and final production report (refer to § 16.2).

The PPS shall include the bend Data Sheet, if it is not included elsewhere in any other PPS.

3.3 Approval of SUPPLIER's Procedures

The SUPPLIER shall submit the following documentation for review and Approval by the COMPANY one month, at least, before production commences:

- a) A detailed Manufacturing Procedure Specification, describing all proposed fabrication and inspection operations in their correct sequence, together with their parameters of execution. The bend manufacturing procedure shall include the methods of controlling and recording the bending heat input and/or temperature and shall state if the induction heating cycle applies also to tangent lengths, if any. This document will also mention the characteristics of equipment used to carry out above-mentioned operations
- b) Nominal initial outside or inside (where applicable) diameter and wall thickness of mother pipes
- c) Detailed heat treatment procedures
- d) Non-destructive testing procedures (including inspection procedures to be used on bend body, weld seam and bend ends)



- e) Proposals for mechanical testing, namely on trial bends and/or on production bends
- f) Dimensional procedures.

Once approved these procedures shall not be altered without the written Approval of the COMPANY.

The SUPPLIER shall submit, at the bid stage, to COMPANY's prior Approval any deviations to requirements specified in applicable technical specifications.

3.4 Quality Assurance/Quality Control

- a) The SUPPLIER shall operate a Quality Assurance system in accordance with ISO 9002, or equivalent, approved by a COMPANY recognised authority. The Quality Assurance Manual shall be submitted to COMPANY before production commences and made available to the Inspector at all times.
- b) Four weeks prior to commencement of the pipe manufacture, the SUPPLIER shall prepare and submit to the COMPANY a written Quality Control Plan which describes the inspections to be performed during the fabrication of bends. The Quality Control Plan shall set forth "witness", "hold", "review", and "monitor" points.
- c) At bending mills: offices, workshops, laboratory, storage yards etc..., information on paper and / or in computers (procedures, working instructions, data, records, tracking system etc...) concerning the order manufacturing and inspection, shall be made fully available and comprehensible to Inspector reading. Where the mill country language is not English, all these information shall be written in double language, i.e. mill country language and English language.
- d) Just before production starting, mill QA Representative accompanied by Inspector shall check at every production and inspection station, that the relevant working instructions and procedures are available, complete, conform to the procedures agreed by COMPANY or to COMPANY specification requirements. A report shall be issued by supplier, signed by Inspector and enclosed with the final dossier.

4. Materials

Pipeline bends shall be manufactured from mother pipes of same source and same manufacturing procedure (where applicable) as the line pipes, with appropriate WT : refer to COMPANY General Specifications [GS PLR 211](#) and [GS PLR 212](#) (where applicable) and related Project Particular Specifications (PPS). Any deviations to line pipe specifications shall be submitted to COMPANY.

When sourcing of mother pipes is different, a full definition of those pipes (chemical composition, as-delivery condition, I.D., WT, etc.) shall be given by the SUPPLIER for prior approval of the COMPANY when the bids are submitted. Chemical composition of weld seam of welded bends shall also be known. The chemical analysis of weld deposit shall not include more than 1.0% Nickel and 0.5% Molybdenum.

HIC tests and SSC tests are not required on mother pipes. However, those tests are required on finished bends (refer to § 6.4.9).

In all cases, the SUPPLIER shall submit the material Mill test certificates of mother pipes for review and Approval by the COMPANY prior to commencing bend manufacture.

Wall thickness of mother pipes shall be selected so that to compensate for the thinning produced by the bending operation and also to avoid any internal misalignment in excess of 4 mm (unless otherwise specified) between bend and pipeline in connection.

No girth weld shall be present in mother pipes.

For welded pup pieces (if any), refer to § 6.1.7 of this specification.

5. Checking of mother pipes prior to bending

5.1 Dimensional check

1. The requirements of paragraph 2 to 3 below apply only where the material procured is of the same nominal thickness as that of the line pipes, or up to plus 15% of this nominal thickness.
2. On receipt of the mother pipes the SUPPLIER shall survey the mother pipe thickness as specified below. Should the pipes not meet the nominal wall thickness at all points, the mother pipe shall be rejected.
3. Wall thickness measurements shall be taken using a suitably approved ultrasonic procedure (minimum accuracy: ± 0.1 mm) at four equally spaced points around the circumference of pipe, repeated at intervals equal to two pipe diameters, including the start, middle and stop area of the subsequent bending operation.

5.2 Ultrasonic check

The following applies to COMPANY free issued mother pipes and to any mother pipes not coming from the lines pipes ordered as per the Project specifications. It may not apply, with COMPANY prior approval, when it is so agreed between mother pipe Manufacturer and bend SUPPLIER, under full responsibility of bend SUPPLIER.

1. On receipt of mother pipes, the SUPPLIER shall carry out a confirmation lamination check to an approved ultrasonic procedure. The check shall be carried out along grid spaced at 100 mm centres. Any indication of laminations shall be checked for their dimensions.

Acceptance criteria of lamellar imperfections shall be those stated in § 9.2.3 of this specification.

2. All longitudinal welded seams (if any) shall also be checked by ultrasonics using angle probes as per § 9.2.5 of this specification.

6. Bend manufacture

6.1 General

1. Bends shall be manufactured in accordance with [MSS SP 75](#), unless otherwise stated in the present PPS.
2. Bends shall be produced by induction heating and either forming over a solid internal mandrel (Induction Forging) or forming in a bending machine (Induction Bending). The forming procedure shall include the continuous monitoring and recording of heating temperature or heat input (refer also to § 6.2 hereafter).
3. Longitudinally welded pipe shall be oriented so that the weld seam is as close as possible to the neutral axis of the bend.

4. During bending, seamless pipe shall be oriented so that the maximum thinning occurs on the thickest wall.
5. No girth weld shall be present in the mother pipe to be bent.
6. Bend shall not include any stop and re-start of heating cycle. In case of interruption of heating cycle during bending process, the bend shall be rejected.
7. Bends shall be fabricated in one piece including tangent lengths.

However, with prior approval of the COMPANY, bends may be fitted with welded pup pieces as tangent lengths provided that the following is met:

- Pup pieces are selected in the line pipes ordered for the Project as per the Project specifications.
 - The circular welds are double sided and weld reinforcements (at inside and outside) are ground flush with base material. When impracticable (e.g. small diameter), single sided welds may be acceptable provided that the root run is carried out with GTAW process, the outside weld reinforcement still being ground flush.
8. External and internal reinforcements of longitudinal welds shall be ground flush for a distance of 100 mm from the ends of the bend.
 9. Bend manufacturing procedures shall be qualified according to provisions of § 6.4 of this specification.

6.2 Bending heat input and cooling conditions

Induction bending shall be carried out within the temperature range 800°C to 1150°C. Temperature control shall be carried out with appropriate device (optical pyrometer and/or emission thermometer) to the satisfaction of the COMPANY. Heating temperature on the outer and inner radius shall be continuously measured and recorded.

The bending heat input, as a minimum, or the heating temperature shall be automatically recorded on a chart for each bend. Charts shall be made available to the Inspector.

The whole bent section shall be subject to the same induction heating cycle. The SUPPLIER shall state at the bid stage if tangent lengths will be (or not) subject to the same induction heating cycle as that of the bent section.

The bending parameters applied to the qualification bend are temperatures, bending speed, cooling speed (i.e. water flow rate, the water pressure, the surface water cooled (OD only or OD and ID), the distance of cooling coil to induction coil, shall be recorded and shall be the bending parameters to be applied to production bends.

It will be given reasonable tolerances to qualification bending parameters.

6.3 Post bending heat treatment

After induction heating and water cooling at the bending machine, the whole bend shall receive a furnace heat treatment (accuracy: $\pm 20^\circ\text{C}$ max) to achieve the mechanical properties required in this specification.

Heating cycle of heat treatment shall be continuously recorded on a printed chart by thermocouples attached to the material.

Details of this heat treatment, including location of thermocouples, shall be submitted to the COMPANY in the SUPPLIER's Manufacturing Procedure Specification (refer to § 3.3).

6.4 Qualification of bend manufacturing procedure

1. For each bend size, grade steel and pipe source, a trial bend of the tightest radius/max. wall thickness combination shall be dimensionally inspected and destructively tested to qualify the bend manufacturing procedure. Separate qualifications are required for bends fabricated from seamless pipes and bends fabricated from longitudinally seam welded pipes. Grouping of materials may be made but shall have prior agreement of the COMPANY before production commences. Procedures established on trial bends shall be fixed for the successive production bends.
2. Destructive tests shall be carried out in accordance with provisions of the present para. and of Section 8 of this specification. Trial bends shall be of sufficient size to accommodate the required test specimens as detailed herein. Test specimens shall be cut after the final heat treatment is carried out. Specimens shall be removed from the bent portion of the bend in accordance with Figure 1 for seamless bends and with Figure 2 for welded bends.
3. Destructive tests as above shall be repeated on tangent lengths when they have been heated, whatever the way, during the fabrication process. This can be, for example, the case when tangent lengths have been subject to:
 - The same induction heating cycle as that on the bent portion
 - A post-bending heat treatment
 - The two above heating cycles.
4. No destructive tests are required on tangent lengths when they have not been heated whatsoever and that mother pipes used have shown satisfactory mechanical test results against the requirements of the COMPANY line pipe specifications.
5. Dimensional inspection shall be carried out according to COMPANY approved procedures in accordance with the requirements of Section 7 of this specification.
6. Post Weld Heat Treatment tests: For bends with wall thickness in excess of 25.4 mm at bevelled ends, tensile tests and Charpy V-notch impact tests as per § 8.2 and 8.4 of this specification shall be repeated after a simulated Post Weld Heat Treatment (PWHT) is made.
All these tests are also acceptance tests and test results shall meet the requirements of this specification. PWHT soaking temperature shall be basically 600°C for one hour per 25 mm wall thickness. The PWHT procedure shall be agreed with the COMPANY.
7. The performance of trial bends for qualification purposes shall not supersede the requirements for production tests as required in Section 8 of this specification.
8. With prior agreement of the COMPANY, when bends do not include any tangent lengths, the trial bend may be omitted and replaced by tests made on an over length portion of the first bend produced.
9. HIC tests and SSC tests shall be carried out on test bends, in base material and weld, as per specification [GS PLR 211](#) or [GS PLR 212](#), where applicable, for each steel source, steel grade, bend size and minimum radius of curvature. Tests shall also apply to tangent lengths when any of the situations stated in § 6.4.3 is occurring. SSC tests shall be made at 80% actual yield strength of tested material. Test duration shall be 96 hours for HIC tests and 30 days for SSC tests. Acceptance criteria shall be as stated in the said specifications.

7. Dimensional inspection

Dimensional inspection, including thickness measurements, shall be made on each bend after final heat treatment and bevel preparation. A report shall be issued for each bend.

7.1 Wall thickness

Wall thickness measurements shall be taken using a suitably approved ultrasonic procedure (minimum accuracy: ± 0.1 mm) at four uniformly spaced points around the circumference (including intrados and extrados locations of bend) every $2 \times OD$ of the bend along the length of the bend, in all cases including the start, middle and stop of bent area, and also along the straight portions (tangent lengths).

The wall thickness shall not be less than the specified minimum wall thickness stated in the PPS (basically, this specified minimum WT is that of the related portion of pipeline of same steel grade to which the bend will be connected later on). The wall thickness plus its tolerance at bend ends (taking into account of the specified nominal (ID) shall be such that the mismatch between internal surfaces of bend and line pipe does not exceed 4 mm (refer to section 4 of this specification). Excess material shall be machined back to obtain a taper angle of 10° max. at inside and 14° max. at outside.

7.2 Diameter at bend ends

Diameters shall be checked against the specified Nominal Inside Diameter (NID) defined in the PPS. The tolerance on nominal ID at bottom of root face of bend ends shall not exceed ± 1.6 mm.

$$\text{nominal ID} = \text{nominal OD} - 2 \times \text{nominal WT}$$

Internal diameter shall be checked by internal circumferential tape or diameter tape. When caliper gauge is used, measurement shall be made according to 4 equispaced diameters from bottom of root face and the average value shall give the actual inside diameter.

7.3 Out-of-roundness

At any point throughout the body of bend, the difference between the maximum and minimum Outside Diameters shall not exceed 2.5% (3% for 3D bends) of the agreed nominal Outside Diameter. At ends of bend, the internal out-of-roundness shall not exceed 1.5% of the specified nominal Inside Diameter when there are no tangential ends or welded pup pieces, and 1% otherwise.

Nominal Inside Diameter shall be as defined in § 7.2 hereabove.

7.4 Radius of curvature

Radius of curvature of bend shall be correct to within $\pm 0.6\%$ of the nominal radius, with a maximum of ± 15 mm.

7.5 Bend angle

Bend angle shall be measured as the deviation of the straight portions at the ends from a straight line (i.e. bend angle is not the included angle). Bend angle shall be accurate to within $\pm 0.5^\circ$ of the nominal bend angle.



7.6 Off-plane

The bend off-plane shall be measured by placing the bend on a level surface. Off-plane (in mm) shall not exceed $\frac{A}{9}$ in mm, where A is the required bend angle in degrees. When the calculated result is less than 5 mm, then max. off-plane shall be 5 mm.

7.7 Centre-to-end dimension

Tolerances shall be ± 5 mm max. for O.D. $< 16''$ and ± 10 mm max for O.D. $\geq 16''$.

7.8 Bend end preparation

Bend shall have both ends bevelled to the profile and angle as stated in the P.P.S. or otherwise agreed with the COMPANY. The root face shall be $1.6 \text{ mm} \pm 0.6 \text{ mm}$. Beveling and taper (if any) shall be carried out by straight machining only.

Taper angle to be max 10° (i.e. 1 in 6 taper) at bend inside and 14° (i.e. 1 in 4) at bend outside.

7.9 Squareness

Ends of bend shall be machined perpendicular to the longitudinal axis of the bend. The maximum deviation, as measured with a square, shall be 2 mm across any diameter for OD up to 24" and 2.4 mm otherwise. Only a slight reaming of pipe ends may be permitted with prior approval of the Inspector.

7.10 Pig gauge trial

A pig gauge shall be passed freely through full length of each bend. The gauge shall have two equispaced and parallel 6 mm thick circular plates, each at least 96% of the connected pipeline nominal ID, separated by a rigid bar of total length once the specified Nominal ID. If the gauging plates are damaged during the test, the test shall be considered failed and the bend rejected.

7.11 Bulges, Dents and Flat Areas

Deviations from the original contour of the bend shall not exceed 3 mm in depth nor shall they exceed 25% of the outside diameter in length. Sharp edged grooves shall be ground out by approved procedures before applying these criteria. Minimum wall thickness requirements shall not be compromised. Bends containing deviations as above shall be rejected.

8. Production tests

8.1 General

Unless otherwise stated in the PPS or agreed at the bid stage, the following destructive tests shall be carried out once per lot of ten bends in each steel source, grade/size combination, cast of steel and heat treatment batch. Those tests shall be repeated on tangent lengths as defined in § 6.4 of this specification.

The COMPANY reserves the right to check tests carried out by the SUPPLIER. For this purpose, the COMPANY may request the delivery of the corresponding samples or specimens to be analysed in an independent laboratory chosen by the COMPANY.

There are no HIC and SSC tests to be made as production tests, unless otherwise stated in the PPS.

8.2 Tensile tests

Tensile specimens shall be removed as follows:

- One longitudinal specimen from the external radius of bend (for information only, unless otherwise stated in the PPS)
- One transverse specimen from the external radius of bend
- One transverse specimen across the weld of bend (from welded bend only).

Specimens shall be prepared and tested in accordance with **API 5L Std.** Unless otherwise agreed, strip specimens shall be used.

All specimens shall meet the minimum yield strength, tensile strength, elongation requirements and the ratio of yield strength to tensile strength, as stated in the related pipe specification (refer to Section 4).

8.3 Bends tests transverse to weld (if any weld)

Two guided bend tests shall be made.

8.4 Impact tests

1. A set of three Charpy V-notch impact specimens shall be extracted from the base material of bend with the longitudinal dimension of the specimens transverse to the axis of bend. These shall be taken from the external radius of bend as indicated in Figure 1 or 2. Specimens shall exhibit the minimum absorbed energy values required in related COMPANY specification for line pipes at the routine test temperature stated herein.
2. For longitudinally welded bends, an additional three sets of three Charpy specimens shall be removed from the weld and tested. Notch positions shall be as shown in Figure 3 of this specification. The sets of specimens shall be taken from the weld centreline, fusion line + 2 mm and fusion line + 5 mm. Charpy test results shall meet the same acceptance criteria as those given in § 8.4.1 above.

8.5 Hardness tests

8.5.1 Hardness in weld (welded bends)

One transverse macrosection shall be removed from the weld after final heat treatment and be subject to VICKERS (5 kg load) hardness testing. Location of macrosection shall be as indicated in Figure 2. Hardness survey shall be conducted in accordance with Figure 4.

Hardness shall not exceed the maximum values stated in Table below. The use of portable hardness testing equipment is not acceptable.

Sour Service	Weld Root	Weld Cap
Intermediate	280	300
Severe	250	275

8.5.2 Hardness in base material (seamless and welded bends)

Hardness testing using an equipment and procedure approved by the COMPANY shall be carried out on each bend after final heat treatment, if any. The hardness measurements shall be

conducted on the outside surface of bend, at four uniformly spaced points around the bend circumference (including intrados and extrados locations), at start, middle and stop of bent heating area, and also on the straight portions. Hardness shall not exceed 250 HV5 or HV10 (or 237 Brinell B or 22 Rockwell C).

8.6 Micrography on base material

(for qualification of bend manufacturing procedure only)

a) In the bent portion, 2 specimens of 30 mm long in the rolling direction, shall be extracted from base material,

- for SAWL mother pipe, one at 20 mm from the weld toe and one at 180° to the weld seam
- for seamless, one from extrados and one from intrados.

They shall be properly polished and etched. They shall be examined at 5 mm from the external and internal surfaces and at mid thickness, every 10 mm in the rolling direction, with a magnification of X 100. The microstructure shall not show banded structure in terms of segregated bands of carbides or carbide components. Photography and interpretation of micrography shall be provided.

b) In the tangent length heat affected by the bending start and by the bending end, one micrography shall be carried out in each one of these areas. The area heated in the "intercritical" zone shall be searched for investigation.

They shall be properly polished and etched. They shall be examined longitudinally to tangent axis at 2 mm from the external and internal surfaces and at mid thickness, with a suitable magnification.

No crack shall be acceptable.

No martensite nor any untempered structure shall be present.

8.7 Failed tests

The Inspector will only permit a retest if there is reason to believe that failure was due to some fault in preparation or testing, and that the result was not representative of the test sample. Otherwise, the failed test shall be carried out on every bends in the heat or lot, or alternatively the entire heat or lot shall be re-heat treated and the full set of tests carried out on one bend.

9. Inspection and testing

9.1 General

1. The SUPPLIER shall bear full responsibility for the conformity of its supply to all clauses of this specification. He shall, for this purpose, take all necessary measures, making use of suitable means, devices and qualified personnel, enabling him to ensure permanent and effective control at each stage of manufacture.
2. The SUPPLIER shall develop a Quality Control Plan (refer to § 3.4 of this specification) for Approval by COMPANY and shall carry out all inspections and tests required by this specification.

Any inspection made by the Inspector shall not absolve the SUPPLIER from his responsibility to exercise such quality control procedures so as to ensure that the requirements of this specification are satisfied.

3. The Inspector shall have access to the Mill at all times during which work is in progress and shall be at liberty to inspect the manufactured products at any stage and to reject any part not complying with this specification.
4. The inspector reserves the right to witness and stamp the test sampling, to require to keep his stamp traceable up to the testing and to witness the tests.
5. Before any dimensional surveys or mechanical testing is carried out, the Inspector shall be notified to enable him to witness the tests. Such notification shall be given at least five working days before the tests are to be performed.
6. Visual, dimensional and non-destructive testing for acceptance purposes shall be carried out following final heat treatment and bevelling.
7. All visual inspection, dimensional inspection and Non-Destructive inspection procedures shall have prior approval of the inspector and shall be subject to qualification tests at the first inspection stage. Further to acceptable results, qualification records shall be established by the supplier, duly signed by the Inspector and filed in the final documentation.

Note: A "Qualification" shall consist at the very start of production, to implement the approved written procedure in the presence of the mill QA/QC representative and of the Inspector. The Inspector and the mill QA/QC shall check that the working instructions are complete and correct, that the procedure has been implemented as it is written, that the environment (e.g. lighting, access way) is suitable, that tools, equipment are convenient, that the procedure is fully efficient for the inspection purpose in view of specification requirements, that recording and traceability are satisfactory etc.

8. All Non-Destructive procedures shall have prior approval of the COMPANY and may be subject to qualification tests prior to their use in production. Further to acceptable results, qualification records shall be established by the SUPPLIER where necessary, and duly signed and stamped by the Inspector.
9. All Non-Destructive inspection personnels shall be properly certified according to [EN 473 Std](#) or equivalent COMPANY approved standard and shall have also been approved by the Inspector before any involvement on the order. NDT operators shall be certified level two, as a minimum. The SUPPLIER shall supply the Inspector with copies of the qualification certificates and a list of inspection personnels showing their scope of qualification and date of certification.

9.2 Visual and non-destructive inspection

1. All bends shall be visually inspected internally to the maximum possible extent and 100% externally to ensure freedom from cracks, gouges, dents, grooves, wrinkles, bulges, kinks or surface spalling. Cosmetic grinding is to be made as necessary to ease visual inspection.

Gouges or grooves which do occur shall be removed by grinding providing that the wall thickness is not locally reduced below the specified minimum wall thickness.

Requirements relating to bulges, dents and flat areas are stated in § 7.11 of this Specification.

2. All bends shall be 100% externally inspected by wet Magnetic Particle Inspection over a longitudinal band covering 90° within the extrados plus any ground area. The SUPPLIER's procedure shall be in accordance with [ASME Section V](#), Article 7, using the yoke method.

Acceptance levels shall be in accordance with [ASME Section VIII](#), Division 1.

3. An ultrasonic inspection shall be carried out on body of all bends. It shall comprise a 100% survey on both intrados and extrados areas (over two opposite 90° sectors) of the bent portion of bends using both angle and compression probes.

The inspection with compression probes shall be carried out in accordance with [ASTM A 578 Std.](#) Any isolated laminar imperfection which is larger than 600 mm² for a welded bend or 480 mm² for a seamless bend shall not be acceptable.

The inspection with angle probes shall be carried out in accordance with [ASME Section V](#), the calibration being made using the N10 notch of [API 5L](#). No cracks or sharp bottom imperfections shall be acceptable, nor any imperfections showing a depth encroaching the specified minimum wall thickness of bend.

4. The portion of tangent length heat affected by the bending beginning and end shall be inspected 100% by angle probes and by MPI.
5. All bend ends shall be ultrasonically examined over 100% of the area within 100 mm of the bend end to check for laminations. Inspection procedure shall be as per [ASTM A 578 Std.](#) Any laminar imperfection exceeding an area of 60 mm² shall not be acceptable.
6. Longitudinal welded seams shall be 100% inspected by ultrasonics in accordance with [ASME VIII](#), Division 1, clause UW-53 and Appendix 12, for wall thickness exceeding 15 mm.
For wall thickness equal to or lower than 15 mm, 100% radiography (sensitivity to be 1.8% mini. and ISO wire penetrometer is to be used) shall be made in accordance with [ASME, Section V](#), Article 2, using fine grain films (AGFA type D5, or equivalent) and lead screens, and acceptance criteria contained in [ASME VIII](#), Division 1, clause UW-51, except that imperfections exceeding 6.4 mm in length are not acceptable.
7. All finished weld bevels shall be inspected by wet Magnetic Particle Inspection in accordance with [ASME Section V](#), Article 7. Any indication exceeding 3 mm in length shall not be acceptable.

10. Repair of defects

1. Repair by welding of bends is not permitted, unless specifically permitted by the COMPANY.
2. Defects including laps, shells and slivers may only be removed by grinding provided that the minimum specified wall thickness is maintained. Any grinding shall leave a smooth surface profile.
3. The locations of any repair work shall be recorded so that independent checks can be made at a later date.
4. A local MPI shall be carried out to verify that the defect has been completely removed and that the repair is acceptable. Wall thickness checks shall be made on the ground areas with ultrasonics to confirm that the specified minimum wall thickness is maintained. The above does not apply to cosmetic grinding.

11. Welded pup pieces

When it is agreed that straight pup pieces can be welded at bend ends (refer to § 6.1), they shall be fully checked for dimensional (inside diameter, wall thickness, out-of-roundness, peaking at weld, etc.), laminations in pipe body and defects in longitudinal weld (if any), as per COMPANY specifications stated in Section 4 of this specification (refer also to § 9.2.3 and 9.2.4 of this specification), before welding them to the bends.

The circular welds between bends and pup pieces shall be as stated in § 6.1.7. They shall be carried out at Mill in full compliance with the requirements of COMPANY Specification **GS PLR 421** (and relevant PPS) for site welding, including welding procedure qualification (notes: the weld reinforcements of transverse weld tensile specimen shall be ground flush; the SSC tests shall be included), welder qualification, non-destructive testing of weld, etc. Impact test temperature shall be that stated in the PPS. Welds shall be subject to 100% radiographic testing and 100% MPI (inside and outside).

Final inspection of bends shall include the welded pup pieces as parts and parcels of bends. Particularly, the pig gauge trial, the dimensional inspection, the ultrasonic inspection over 100 mm wide band at bend ends and the MPI of bevel surfaces shall be made. Acceptance criteria of present specification shall be met.

12. Hydrostatic testing

Unless otherwise stated in the PPS, Mill hydrostatic testing of fully fabricated bends is not required. However, the SUPPLIER shall certify in writing that all the produced bends can withstand a hydrostatic test pressure at a pressure which develops a hoop stress equal to 90% of the minimum specified yield strength of bend material (based on Barlow's formula and specified nominal wall thickness of bends) without failure, leakage or impairment of serviceability.

13. Test rings

The SUPPLIER shall supply test rings to the COMPANY for qualification of site welding procedures. The rings shall be heat treated with the bends and shall be of the same material and size. Test rings shall have a minimum length of 300 mm. Three rings are required for each steel source, bend size and material grade. Both ends of the rings shall have the same weld preparations as those required for the bends in the order.

Test rings are not required when tangent lengths are made of pup pieces welded to bends and selected among line pipes ordered for the Project (refer to § 6.1.7 of this specification).

Test rings are required when sourcing or chemical composition of mother pipes are different from that of line pipes of the Project or when a simulated PWHT is required by the PPS of bends.

14. Marking of bends

Each bend shall be stencilled in white paint with the following information at inside (whenever possible) surface of bend end, unless otherwise agreed with the COMPANY. A light clean coat of clear lacquer shall be sprayed over the stencilled area once the paint is dry.

- COMPANY's name
- Project name
- SUPPLIER's name/Brand mark/Logo of Mill
- Purchase Order no.
- Unique bend identification number
- Steel Grade and type of original pipe used (SAW, seamless)

- Inside Diameter and wall thickness
- Bend radius and angle (in degrees)
- Heat number
- Bend weight (calculated).

Digits shall not be less than 25 mm high.

The bevel ends shall be die stamped, using low stress stamps, with the unique bend number and the mother pipe heat number. The stamping shall be diametrically opposite to longitudinal weld, if any.

15. Handling, transport and storage

Care shall be taken to ensure that wire ropes, chains, etc., do not come into metallic contact with the bend. It is recommended that broad band non-metallic slings be used to load/unload and support bends when in transit. Bend shall be adequately supported to prevent damage during transit. Storage shall be arranged to avoid accumulation of water inside bends and to allow free circulation of air.

The SUPPLIER shall submit to the COMPANY for review and Approval a handling, transport and storage procedure detailing the proposed methods of handling, storing, and securing bends for transportation and shipment.

Weld end preparations shall be suitably protected against corrosion (e.g. peel-off varnish) and damage during transport and storage. Unless otherwise stated in the PPS, bends shall be delivered with bevel protectors or end caps. These shall be submitted with full details by the SUPPLIER at the bid stage.

16. Documentation

16.1 Mill certificates

Unless otherwise stated in the PPS, the required inspection test certificate to support the delivered bends shall be 3.2 according to [EN 10204 Std](#). Mill certificate shall be established by the bend Manufacturer.

Mill certificates shall make reference to [MSS SP 75](#) together with the present General Specification and related PPS.

Mill certificates shall also show the following:

- Type and origin of base material
- Ladle analysis including Carbon Equivalent and P_{cm}
- Bend no. with reference to heat no.
- Mechanical test results and product chemical analysis (including CE and P_{cm}), with reference to bend no.
- Dimensional inspections with results
- Non-destructive tests performed with results
- Any supplementary tests and inspections carried out.

16.2 Production report

Upon completion of bend manufacture, the SUPPLIER shall produce a final production report which shall include the following minimum information and documents:

- Mill test certificates of mother pipes and welded pup pieces, if any
- Manufacturing Procedure Specification of bends
- Report of bend manufacturing procedure qualifications tests
- Production test reports (mechanical tests, NDT reports, dimensional reports, etc.)
- Heat treatment batches with no. and temperatures of treatments
- HIC and SSC reports
- Mill certificates of bends (as per § 16.1 above)
- Mill hydrostatic test certificate of compliance
- Quality Control Plan
- Compilation of concessions/deviations, if any, granted by the COMPANY.

The PPS shall state the number of originals and copies of the production report which are to be supplied to the COMPANY.

The Inspector shall stamp (rubber-stamp), date and sign the original documents. The copies shall be stamped (as a minimum) by the Inspector.

16.3 Schedule

1. The bends shall be dispatched only after a Release Certificate has been issued by the Inspector.
2. Mill certificates shall be supplied at the time of dispatch of the bends.
3. The full production report as above shall be transmitted to the COMPANY without delay after completion of bend production. The latest date of submission of this report shall be three weeks max. after dispatch of bends.

16.4 Documentation to submit by the SUPPLIER at bid stage

1. Full technical features of mother pipes: sourcing, aimed tensile properties, aimed chemical composition (including Carbon Equivalent and Pcm), minimum wall thickness, etc.
2. A simplified Manufacturing Procedure Specification (MPS) giving the main features of machine and manufacturing process, parameters that are monitored and recorded (e.g. printed chart), etc.
3. Post-bending heat treatment details.
4. State if bends are (or are not) manufactured in one piece including tangent lengths, and if tangent lengths are subjected (or not subjected) to the same induction cycle as that of the bent portion of bend.
5. Nominated laboratory for conducting the H₂S embrittlement tests.
6. SSC and HIC test procedures (preliminary).



7. Past experiences of SUPPLIER and laboratory on HIC and SSC tests as per this specification (including the laboratory's preliminary or typical procedures).
8. Details of bevel protection.
9. Details of bend packing.
10. Quality Assurance certification (ISO 9002, API Q1, etc.)
11. Deviations to present specification, if any.

17. Technical Queries/Non-Conformance Reports

1. Any SUPPLIER's requests for clarifications or deviations to COMPANY specifications shall be submitted to COMPANY only through Technical Queries (TQ), the format of which shall have prior approval of the COMPANY.

A deviation to specification shall not be considered as accepted if it has not been submitted to and accepted by COMPANY through a Technical Query.

2. Approval given by the COMPANY to any SUPPLIER's work procedures, specifications, equipment, etc. shall not release in any way the SUPPLIER from his obligation to meet the COMPANY specifications.
3. Any work performance or test result which is found, at a later date, not in conformance with COMPANY specifications or agreed procedure shall be subject to a Non-Conformance Report (NCR) to be issued by the SUPPLIER for submission to COMPANY. NCR report shall indicate corrective action intended by the SUPPLIER.

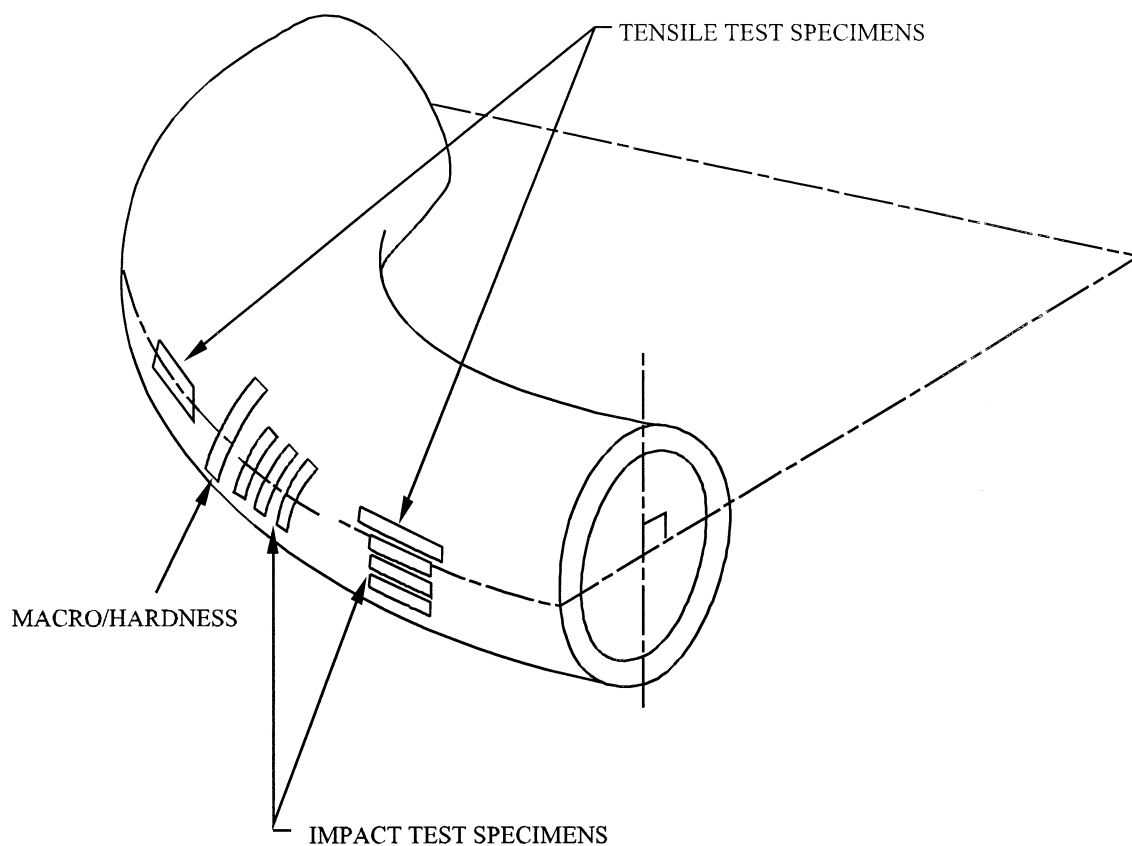


Figure 1 - Location of test specimens in seamless bends

Notes:

- (1) Tests on tangent lengths are not shown on sketch.
- (2) Longitudinal impact tests are to be made only where transverse specimens cannot be cut, with COMPANY prior approval.

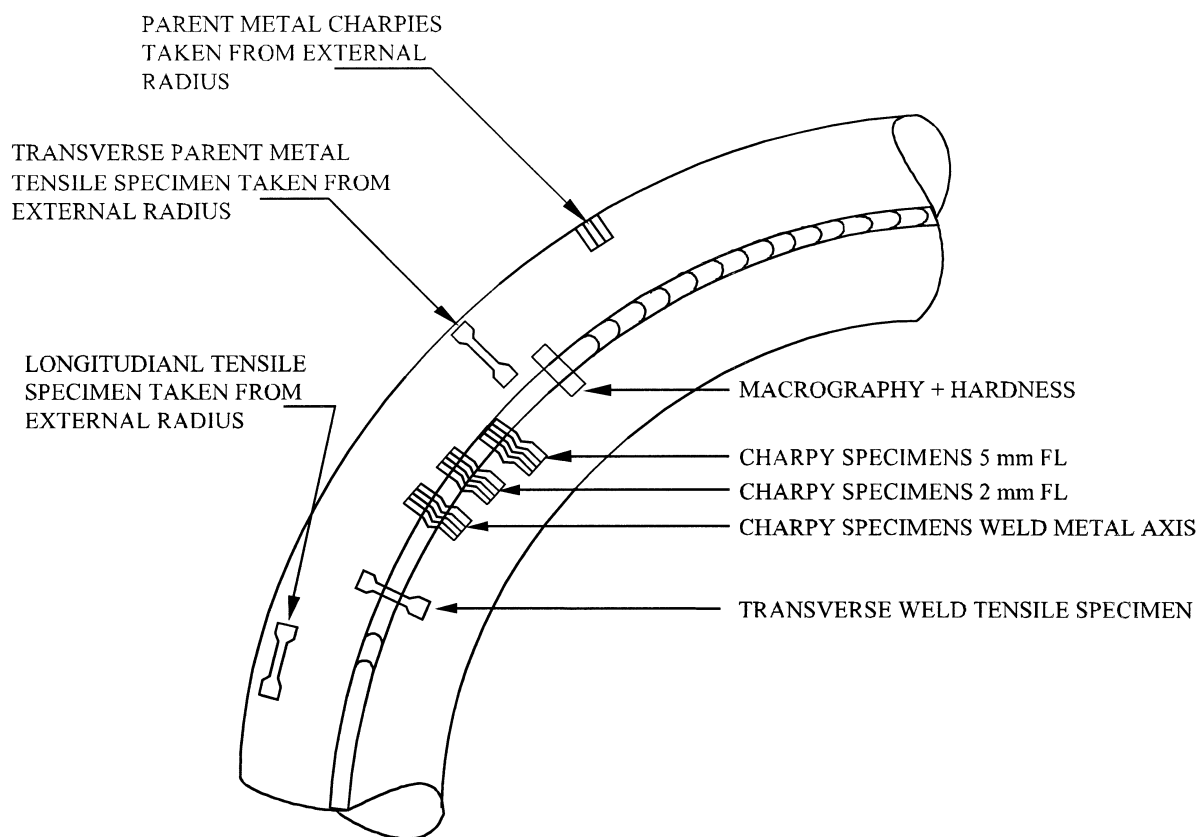


Figure 2 - Location of test specimens in welded bends

Notes:

- (1) Parent material Charpy specimens shall be taken from the external radius of the bend.
- (2) Tests on tangent lengths are not shown on sketch.

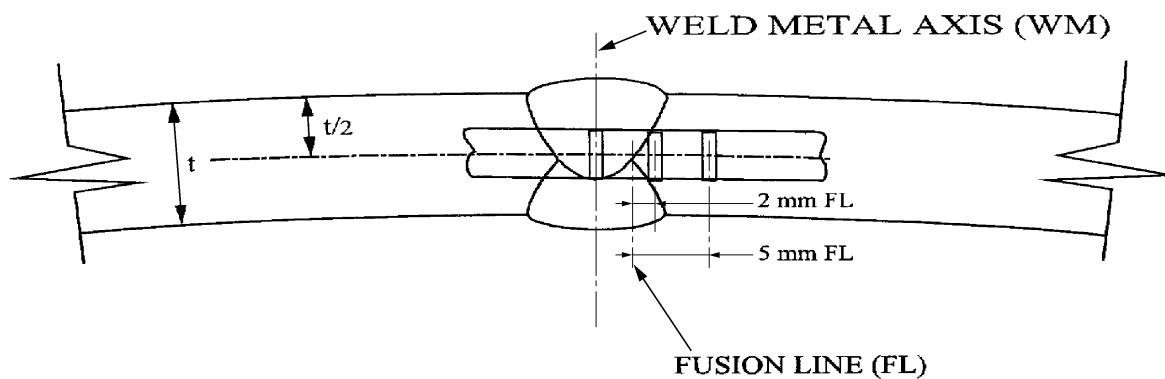
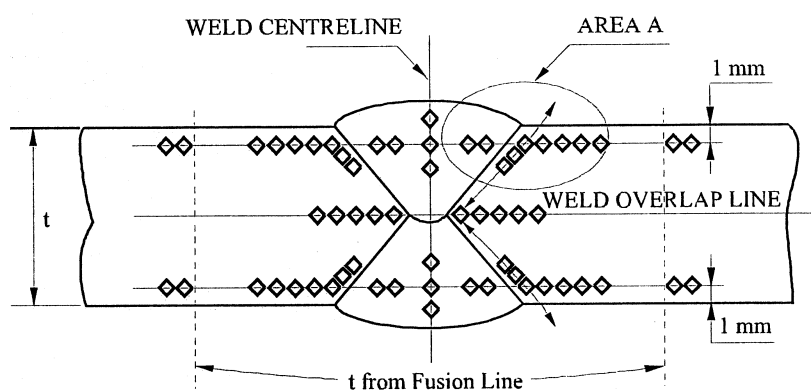


Figure 3 - Location of Charpy-V impact tests in weld



ENLARGEMENT OF AREA A (TYPICAL)

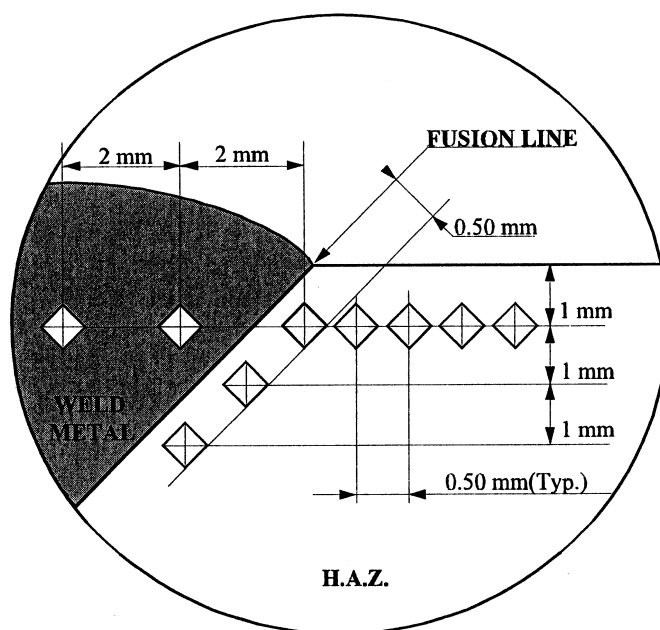


Figure 4 - Vickers hardness survey in weld