



Exploration & Production

## GENERAL SPECIFICATION

### PIPELINES - RISERS

#### GS EP PLR 211

**Fabrication of seamless pipes for pipelines  
(mild, intermediate and severe sour service)**

| 09   | 01/2011 | General review                                                                       |
|------|---------|--------------------------------------------------------------------------------------|
| 08   | 10/2009 | General review (API Spec 5L - ISO 3183 / DNV-OS-F101)                                |
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## Contents

|                                                           |           |
|-----------------------------------------------------------|-----------|
| <b>1. Scope .....</b>                                     | <b>4</b>  |
| <b>2. Reference documents.....</b>                        | <b>4</b>  |
| <b>3. General.....</b>                                    | <b>7</b>  |
| 3.1 Definitions .....                                     | 7         |
| 3.2 Project Particular Specification (PPS) .....          | 7         |
| 3.3 Quality Assurance/Quality Control .....               | 8         |
| <b>4. Inspection by the Company .....</b>                 | <b>8</b>  |
| <b>5. Pipe manufacture .....</b>                          | <b>9</b>  |
| 5.1 General requirements .....                            | 9         |
| 5.2 Process of manufacture .....                          | 10        |
| 5.3 Billet manufacture .....                              | 10        |
| 5.4 Pipe manufacture.....                                 | 11        |
| 5.5 Pipe Manufacturing Procedure Specification (MPS)..... | 11        |
| 5.6 Qualification of pipe manufacturing procedure .....   | 12        |
| 5.7 Chemical properties .....                             | 17        |
| 5.8 Mechanical properties.....                            | 18        |
| 5.9 Dimensional, weight and surface condition .....       | 18        |
| <b>6. Mill hydrostatic testing .....</b>                  | <b>21</b> |
| <b>7. Inspection and testing .....</b>                    | <b>22</b> |
| 7.1 General requirements .....                            | 22        |
| 7.2 Production tests .....                                | 23        |
| 7.3 Visual and NDT .....                                  | 25        |
| 7.4 Residual magnetism .....                              | 27        |
| 7.5 Mill certificates .....                               | 27        |
| <b>8. Repair of defects .....</b>                         | <b>27</b> |
| <b>9. Marking of pipes.....</b>                           | <b>28</b> |
| <b>10. Protection of bevels .....</b>                     | <b>29</b> |
| <b>11. Handling, transport and storage of pipes .....</b> | <b>29</b> |



|            |                                                                     |           |
|------------|---------------------------------------------------------------------|-----------|
| 11.1       | General.....                                                        | 29        |
| 11.2       | Handling and storage.....                                           | 29        |
| 11.3       | Transport .....                                                     | 29        |
| <b>12.</b> | <b>Documentation .....</b>                                          | <b>29</b> |
| 12.1       | When the bids are submitted .....                                   | 29        |
| 12.2       | Upon completion of pipe production .....                            | 30        |
| 12.3       | Schedule.....                                                       | 31        |
| <b>13.</b> | <b>Storage of mechanical test specimens .....</b>                   | <b>31</b> |
| <b>14.</b> | <b>Fabrication Pipe History System (PHS).....</b>                   | <b>32</b> |
| <b>15.</b> | <b>Technical Queries/Non-Conformance Reports.....</b>               | <b>32</b> |
| <b>16.</b> | <b>Other references .....</b>                                       | <b>32</b> |
| Appendix 1 | Chemical composition.....                                           | 33        |
| Appendix 2 | Tensile and impact properties.....                                  | 34        |
| Appendix 3 | Automatic ultrasonic testing .....                                  | 35        |
| Appendix 4 | Weldability tests (SMAW and GMAW).....                              | 38        |
| Appendix 5 | Applicable DNV Particular Requirements .....                        | 41        |
| Appendix 6 | Specification for Sulphide Stress Cracking tests (SSC Tests).....   | 42        |
| Appendix 7 | Specification for Hydrogen Induced Cracking tests (HIC tests) ..... | 46        |



## 1. Scope

This specification defines the Company's requirements for the manufacture and supply of bare carbon steel pipes to be used in the construction of onshore or underwater pipelines, for crude oil, gas, multiphase or condensate effluents, operating in "Mild sour service", "Intermediate Sour Service" or "Severe Sour Service" (i.e. corresponding respectively to areas 1, 2 and 3 in design specification **GS EP COR 170**).

It applies to seamless pipes in steel Grade L290Q (X42Q) up to Grade L450Q (X65Q) of **API Spec 5L / ISO 3183 (modified)** Specification. It takes also into consideration **DNV-OS-F101** requirements (see Appendix 5).

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

Additional requirements are specifically stated in this specification for pipes to be used in pipelines to be laid using the reeling technique. The related pipes shall thus be suitable for cold forming operations involving spooling, un-spooling, straightening and bending.

Requirements are also provided in this specification for line pipes with Wall Thickness requiring a Post Weld Heat Treatment (PWHT), where the properties are to be ascertained after the PWHT is made.

No deviation from the requirements stated in the present specification shall be permitted unless prior written approval has been obtained from the DGEP/TDO/TEC/PLR Company department, the only authorised authority. Refer to Section 15 of this specification.

## 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 Purchase Order/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 shall be as stated 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 date 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. Approval of equivalent standards will not, in any way, remove responsibility from Supplier to meet the requirements of the standards referred to and amended herein, in the event of conflict.

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 inspection personnel involved on the work.

**Note:** The specification **GS EP COR 170** is mentioned herein only as a background to the definition of the types of sour services (i.e. Mild sour service, Intermediate Sour Service or Severe Sour Service) and corresponding “areas” on graph of the said specification (i.e. area 1, 2 or 3).

### Standards

| Reference    | Title                                                                                                                                                                                                              |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ASTM A 370   | Mechanical Testing of Steel Products                                                                                                                                                                               |
| ASTM E 23    | Notched Bar Impact Testing of Metallic Materials                                                                                                                                                                   |
| ASTM E 384   | Test Method for Micro hardness of Materials                                                                                                                                                                        |
| ASTM E 709   | Magnetic particle Examination                                                                                                                                                                                      |
| ASTM G 39    | Preparation and Use of Bent-Beam Stress Corrosion Test Specimens                                                                                                                                                   |
| EN 473       | Qualification and certification of NDT personnel                                                                                                                                                                   |
| EN 10204     | Types of inspection documents                                                                                                                                                                                      |
| ISO 148      | Charpy impact test (V-notch)                                                                                                                                                                                       |
| ISO 6507     | Hardness test - Vickers test - Part 1: HV5 to HV10                                                                                                                                                                 |
| ISO 7539     | Corrosion of Metals and Alloys - Stress Corrosion Testing                                                                                                                                                          |
| ISO 15156-2  | Petroleum and natural gas industries - Materials for use in H <sub>2</sub> S-containing environments in oil and gas production - Part 2: cracking-resistant carbon and low alloy steels, and the use of cast irons |
| ISO/TS 29001 | Quality systems: model for quality assurance in production, installation and servicing                                                                                                                             |

**Professional Documents**

| Reference                         | Title                                                                                                                                      |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| API Q1                            | Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry                                               |
| API RP 5L1                        | Railroad Transportation of Line pipe                                                                                                       |
| API RP 5LW                        | Transportation of Line pipe on Barges and Marine Vessels                                                                                   |
| API Spec 5L / ISO 3183 (modified) | Specification for Line Pipe                                                                                                                |
| EFC Publication no. 16            | Guidelines on material requirements for carbon and low alloy steels for H <sub>2</sub> S containing environments in oil and gas production |
| NACE MR0175                       | Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment                                                                |
| NACE TM0177                       | Testing of Metals for Resistance to Sulfide Stress Cracking at Ambient Temperature                                                         |
| NACE TM0284                       | Evaluation of Pipeline Steels for Resistance to Stepwise Cracking                                                                          |

**Regulations**

| Reference      | Title |
|----------------|-------|
| Not applicable |       |

**Codes**

| Reference   | Title                                        |
|-------------|----------------------------------------------|
| DNV-OS-F101 | Offshore Standard Submarine Pipeline Systems |

**Other documents**

| Reference      | Title |
|----------------|-------|
| Not applicable |       |



## Total General Specifications

| Reference     | Title                                                                        |
|---------------|------------------------------------------------------------------------------|
| GS EP COR 170 | Materials for Sour Service (Upstream Applications). Specification for design |
| GS EP PLR 231 | Induction bends for pipelines (mild, intermediate and severe sour service)   |

## 3. General

### 3.1 Definitions

|                           |                                                                                                                                                                                                                                                                                                                                            |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Inspector</b>          | 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.                                                                                                                                                                   |
| <b>Mill</b>               | The plants, mills, workshops, laboratories or other locations where the fabrication, inspection and testing of steel and pipes are to be performed complete or in part.                                                                                                                                                                    |
| <b>Contract Documents</b> | The material requisitions, material specifications, etc. issued by the Company and attached to the Contract or the Purchase Order.                                                                                                                                                                                                         |
| <b>Approval</b>           | 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. |
| <b>PPS</b>                | Designates the Project Particular Specification.                                                                                                                                                                                                                                                                                           |

### 3.2 Project Particular Specification (PPS)

The following information shall be provided in the PPS:

- Steel grade
- Pipe nominal dimensions (OD mm x WT mm)
- The sour service severity and type of pipeline effluent to clarify the H<sub>2</sub>S test conditions (see § 5.6.4, 5.6.5, Appendix 6 and Appendix 7).
- The type(s) of pipeline(s) onshore or offshore (applicable particular requirements of strain ageing for onshore)
- if it is a gas pipeline (applicable particular requirements for CVN)
- If Appendix 5 of the present specification: **DNV-OS-F101** "Particular Requirements" is applicable.
- Appendix 5 of the present specification: **DNV-OS-F101** "Supplementary Requirement" F, P, D or U is/are applicable.
- If the line pipes of the pipeline to be laid by the reeling technique (see § 5.6.3)

- i) If line pipe is subject to fatigue loading (see § 5.9.11)
- j) Wall thickness particular requirements in § 5.9.3.b) applicable (when automatic UT on girth welds is foreseen).
- k) Routine impact test temperature (see § 5.6.2.d)
- l) If welding tests results on similar pipe materials are required
- m) If weldability tests are required (see § 5.1 and 5.6.6)
- n) If PWHT test is required (see § 5.6.2.m)
- o) if spare bend mother pipes for contingency are to be added to bend order
- p) If pipes shorter than 11.60 meters are acceptable (where necessary) (see § 5.9.6)
- q) If coloured painted band on pipe is maintained or is pending
- r) If bevel protectors are confirmed (where necessary) (see section 10)
- s) If histograms are required (see § 12.2)
- t) Number of originals and copies of Mill certificates and final production report
- u) The required length for cut back coating
- v) If a bar code system is required or, otherwise, acceptable
- w) The Company/purchaser inspection scope.

The PPS shall include the pipeline Data Sheet, if it is not included elsewhere in another Project specification.

Before the mass production starts, (usually after the pre-inspection meeting), the PPS shall be revised for including all the particular production, inspection... topics/qualifications mutually agreed by both Mill and Company. Any further technical agreement, modification, major points, that occur during the production progress shall be reported in the PPS by Inspector.

### 3.3 Quality Assurance/Quality Control

1. The Supplier shall operate a Quality Assurance system in accordance with [ISO/TS 29001](#), or equivalent, approved by a Company recognised authority. The Quality Assurance Manual shall be submitted prior to the start of work.
2. Four weeks prior to the commencement of the pipe manufacture, the Supplier shall prepare and submit a Quality Control Plan which describes the inspections to be performed during the supply of pipes. The Quality Control Plan shall set forth "witness", "hold", "review", and "monitor" points.
3. 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. Inspection by the Company

1. All procedures shall have prior approval of DGEP/TDO/TEC/PLR **Company department**. All qualification tests shall take place under the supervision of the Inspector.



2. The Supplier shall notify the Inspector sufficiently in advance to enable him to be present at qualification tests and at all other tests or stages of manufacture subject to acceptance in accordance with this specification.
3. The Supplier shall ensure that the Inspector has full and free access to all parts of the Mill during all fabrication and inspection stages.
4. The Inspector shall ensure that materials and pipes are fabricated in accordance with all the specified requirements and Company's approved procedures.
5. At steel making mills, billet casting mills and pipe mills: offices, workshops, 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.
6. It shall be made available in the Inspector office, a free access to the mill computerised system:
  - Tracking system of production and inspection
  - All data and results of mechanical tests, NDE results
  - Billet input/pipe output, rejections status with causes, repairs
  - Any other information considered pertinent by the Inspector for his monitoring
  - Computer, software environment compatible with the mill software, software interface where necessary for data exploitation with EXCEL shall be made available by the Supplier
  - The Company's Inspector shall be provided with facilities/equipments for sending and receiving faxes, communicating by @mails and fast Internet access.
7. Inspection by the Inspector shall be carried out during pipe production in order to avoid any special or additional handling. Inspection will be made in such a manner to avoid delay in pipe production insofar as the pipes which are presented to him meet the specified requirements.
8. The Inspector shall finalise (when required) its inspection by the application of a special stamp (or indelible paint marking, when so previously agreed). Die stamping is permitted only on the bevel surface.
9. The Inspector shall notify the Company without delay of any difficulty, irregularity, problem or delay likely to occur during pipe production.
10. 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.

## 5. Pipe manufacture

### 5.1 General requirements

1. The pipes shall be manufactured to Product Specification Level 2 (PSL 2) and all the requirements of **API Spec 5L**, unless otherwise indicated in the present specification, i.e.

API Spec 5L remains applicable for all matters not specifically mentioned or modified in the present specification.

2. HIC tests and SSC tests are required on a pipe selected by the Inspector at an early production stage (see § 5.6.4 and 5.6.5) and also as production tests (see § 7.2).
3. All inspections and tests required for qualification and pipe acceptance shall be performed at the manufacturing Mill or performed externally in a mutually agreed laboratory.
4. Mother pipes for bends shall be of the same source, same manufacturing procedure and of similar chemical composition as the line pipes, unless otherwise agreed. Any deviations to present specification shall be submitted to the Company (refer to **GS EP PLR 231** for induction bends). Mother pipe microstructure shall not exhibit banded structure in terms of carbon / carbides minor or major segregation. Micrography (X 100) in longitudinal direction shall be made available to Company Inspector before starting of production. In case of doubt on banded structure, micro hardness (5 or 10 g) evaluation can be required.
5. Pipe production shall not start without the approval of the Company and until a pre-production meeting has been held between the Company, the Supplier, the Manufacturer and the Inspector.

## 5.2 Process of manufacture

The pipes shall be seamless. They shall be manufactured from billets by the hot rolling process/hot finished process using the Plug Rolling Mill Process or the Mandrel Mill Process All others process are not acceptable (i.e.: Pilger Mill, etc.).

## 5.3 Billet manufacture

1. Steel shall be fully killed and manufactured to fine grain practice. Steel making shall be by the Basic Electric arc Furnace with double deslagging or Basic Oxygen Furnace steel making processes. The steel making process used shall result in the supply of steel pipes with a high resistance to H<sub>2</sub>S embrittlement and associated effects.

During its manufacture, the base steel shall undergo the following treatments:

- Vacuum degassing (where possible)
- Thorough desulphurisation treatment
- And specific treatment to control size, shape and distribution of oxide and manganese sulphide inclusions (e.g. Ca treatment).

The Company shall be provided with all ladle analyses (see § 5.7 of this specification).

2. Continuous casting process shall be used for billet manufacturing. The casting speed shall be that proposed by the Supplier and approved by the Company at the bid stage. The actual production casting speed range (speed max - speed min) shall not exceed 0.4 m/min. This parameter recording shall be made available to Inspector. The Supplier shall give full detail about the casting sequences (number of heats, tons, scrapping lengths ...). Electromagnetic stirring will be appreciated.

Where continuous casting line is of fully bent type, the Supplier shall provide, at the bid stage, a technical documentation concerning the implemented particular cares to overcome the inconvenience of a fully bent casting process in terms of inclusion segregations close to

the billet/pipe external surface. It shall be demonstrated that the process does not impact the final pipe quality (NDE, macro, micro, HIC... reports from past experience).

All billets shall be visually examined to ensure freedom from injurious surface defects. Billets shall be correctly marked and stored to avoid any confusion between heats of steel (e.g. heat no., casting strand and sequential no.).

3. The Supplier shall provide the Company at the bid stage with a technical specification giving full details of all the characteristics of the proposed steel, the steel making process, the billet manufacturing process and the inspection procedures.

The Supplier's specification shall include the following minimum information concerning the steel making process:

- Steel making process (Electric Furnace or Basic Oxygen Furnace)
- Killing/de-oxidisation method
- Special treatments for controlling residual elements and segregations
- Nominal weight of each heat and number of heats for one casting sequence.
- Aimed chemical analysis, together with minimum and maximum working limits (ladle and check) selected for the order.
- Aimed Casting speed and production range
- Electromagnetic stirring, if any

## 5.4 Pipe manufacture

Pipes furnished to this specification shall be manufactured by the hot rolling seamless process as stated in § 5.2 above.

Pipes shall be supplied Quenched and Tempered. Heat treatment: heating by Induction is forbidden. Before quenching, the soaking time at "Ac3" +50°C or higher, shall not be less than 7mn.

Pipe shall be sized, straightened and hydrostatically tested.

The Supplier shall also refer to the provisions of § 5.9.11 of this specification for pipe surface condition.

A higher steel grade of **API Spec 5L** shall not be substituted to the grade specified on the Purchase Order.

## 5.5 Pipe Manufacturing Procedure Specification (MPS)

The Supplier shall establish a detailed specification for the manufacture and inspection of pipes, describing all proposed operations in their correct sequence together with their parameters of execution. The proposed specification shall include, but not be limited to, all information concerning:

- Billet heating
- Equipment for pipe rolling, sizing, straightening
- Heat treatment of pipes with mainly the heating temperatures (for Q and T) and the soaking time

- Aimed chemical analysis, minimum and maximum working limits (ladle and product)
- Typical metallographic structure of base metal with supporting documentation, such as microphotographs, grain size, definition of the microstructure, etc.
- Visual inspection
- NDT procedures
- Dimensional inspections with frequencies of execution
- HIC and SSC test procedures.

This document shall also mention the characteristics of equipment and procedures used to carry out these operations.

## 5.6 Qualification of pipe manufacturing procedure

### 5.6.1 General

1. One finished pipe among the first pipes produced in each size (each diameter and each wall thickness), grade and steel source (first shift production) shall be subject to the inspections and tests as described below in order to qualify the pipe manufacturing procedure. This pipe shall be selected by the Inspector. In order to get mechanical tests results earlier, a second pipe can be selected during the same shift just after tempering.
2. The Supplier shall submit to the Company the pipe manufacturing procedure qualification test report giving the results of all tests required by the present specification.  
The report shall be approved, signed and dated by the Inspector who attended the tests.
3. The Supplier is allowed to proceed with the pipe manufacture without waiting for the test results, as long as the Supplier is accepting the risk and responsibility of the consequences of any test failure, as stated hereafter.
4. In case of qualification test results which do not comply with the requirements of this specification, the pipe tested as well as all preceding pipes shall be rejected. The causes of failure shall be investigated by the Supplier and reported to the Inspector. Manufacture shall resume only after the procedure has been suitably revised to the satisfaction of the Inspector and after a new pipe has successfully completed the qualification tests laid down in this specification.

### 5.6.2 Essential Variables (as per **DNV-OS-F101** modified as follows)

The following changes to the manufacturing processes shall require a new qualification:

1. Any change in steel making practice
2. Any change in casting speed exceeding the min-max range of 0.4 m/mn
3. Any changes beyond the allowable variation of pipe rolling temperatures
4. Any changes in heat treatment beyond the allowable variation of heating temperature and soaking time and/or quenching process
5. Any change in nominal wall thickness exceeding +5% to -10%



6. Any change in ladle analysis outside  $\pm 0.02\%$  C,  $\pm 0.02$  CE and/or  $0.03\%$  in Pcm,  $\pm 20\%$  in the percent of elements intentionally added
7. Any change in pipe forming process.

### 5.6.3 Destructive and non-destructive tests

The selected pipe shall be visually inspected for compliance with dimensional tolerances for wall thickness, diameters, out-of-roundness, straightness, surface defects, etc. (see § 5.9).

Then, the said pipe shall be tested as follows. Note that tests according to § i) through l) hereafter are required only for pipelines to be laid by the reeling technique.

When the pipeline will be laid by the reeling technique then the impact tests and tensile tests under § j) hereafter shall be sampled from a line pipe submitted to a full scale bending test simulating the successive bending of pipeline from first spooling to final laying. The bending scheme and equipment shall be mutually agreed with the Company.

- a) The entire pipe shall be ultrasonically examined for longitudinal and transverse oblique defects including laminations. The external and internal pipe surfaces shall be electromagnetic (EMI) examined for longitudinal and transverse defects. For offshore pipeline application, the entire pipe shall be also ultrasonically examined for oblique defects (parallel to rolling direction).
- b) A chemical analysis shall be carried out on the pipe. At this stage, one cast shall be analysed for residual elements as shown at notes of Table 1. Results shall be in accordance with Table 1 of Appendix 1. However, the ruling composition shall be that proposed by Supplier and approved by Company at the bid stage (see § 5.3 above).
- c) Two tensile specimens (one longitudinal and one transverse to pipe axis) shall be removed from each pipe end. Strip specimens shall be used unless round bar specimens are found more practicable (see § 7.2.1).

The Yield and Tensile Strength plus percentage Elongation shall be determined according to **API Spec 5L**. The Yield Strength (YS) to Ultimate Tensile Strength (TS) ratio shall be calculated. The results shall conform to Table 2 of Appendix 2 of this specification. The "Uniform Elongation" (UE) on the tensile test in longitudinal direction shall be measured and recorded. The UE shall not be less than 8%.

- d) Two sets of three Charpy V-notch specimens shall be removed, one set at each end of the pipe. The specimens shall be cut transverse (for pipe OD equal to or above 4.5") to the pipe axis and the axis of notch shall be perpendicular to pipe surface. Required impact values are given in Appendix 2, Table 3. Where Charpy-V tests are impracticable in the transverse direction, they shall be carried out in the longitudinal direction, with Company prior approval, and then the figures to be met for 10 mm x 10 mm specimens shall be those indicated in Table 3 increased by 50% (KVL).

The required impact test temperature (i.e. the so-called routine test temperature) shall be that stated in the PPS, but in no way this temperature can be above 0°C.

As far as possible, full size specimens (10 x 10 mm) are to be used. If sub-size test specimens are found necessary, to the satisfaction of Company, absorbed energy figures required shall be those for full size specimens (see Appendix 2) multiplied by the corresponding factors given in the following table.

| Specimen (mm) | Multiplying factor |
|---------------|--------------------|
| 10 x 10       | 1                  |
| 10 x 7.5      | 5/6                |
| 10 x 6.7      | 7/9                |
| 10 x 5        | 2/3                |

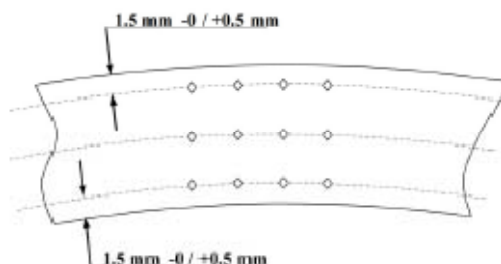
Charpy tests are not required for nominal wall thickness less than 6.35 mm. In that case, a check of microstructure and grain size shall be made instead. Grain size of 8 minimum is required.

- e) Charpy V-notch tests shall be conducted in the base metal to determine full Charpy energy and shear area transition curves to [ASTM A 370](#). The tests shall be carried out in the transverse direction (or longitudinal direction, when so agreed for the routine test) at temperatures 10°C and 20°C above and 10°C and 20°C below the routine test temperature. The temperatures of testing shall be extended, when necessary, in order to get sufficient data for representing properly a transition curve showing the transition area. The tests with test temperatures below the routine temperature test will be for information only, but the transition temperature shall not be higher than the specified routine test temperature y. For pipeline to be laid by the reeling technique, transition curves (energy and shear) shall be supplied for both the longitudinal and transverse directions.

Size of Charpy V-notch specimens shall be as per § d) above.

**For WT > 25 mm**, the same Charpy V-notch tests, as stated above, shall be repeated at ID. Then the Charpy V-notch specimen location for production tests shall be the one of the above 2 testing which gives the highest transition temperature.

- f) At both ends of the pipe three cross sections (at 120°) shall be sampled for micrography and hardness. They shall be polished and etched to show the metallurgical microstructure. Photographs of microstructure shall be supplied at three locations minimum, namely at mid-thickness and below internal and external surface. No banded structure or untempered bainite or untempered martensite shall be present in the steel microstructure. On each section, Vickers 10 kg Hardness measurements shall be carried out (see sketch below). Hardness shall not exceed 220 HV10. In case of doubt on "banded structure", micro hardness (5 or 10g) evaluation can be required.



- g) Longitudinal micrography is required (including mother pipes for bends). One specimen of 30 mm long in the rolling direction shall be extracted. 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 bands of minor or major segregation **of carbon/carbides components**.
- h) Vickers 10 kg Hardness measurements shall be carried out on pipe surface (where a slight grinding can be made) at each pipe end and at  $\frac{1}{4}$ ,  $\frac{1}{2}$  and  $\frac{3}{4}$  length of pipe (two readings per location). Hardness shall not exceed 220 HV10.
- i) The pipe wall thickness shall be measured using ultrasonic in three longitudinal planes displaced by 90°. The measurements shall be carried out at minimum intervals of one metre along the pipe length.

At Mill's option, wall thickness may be measured by automatic ultrasonic tester examining spirally the pipe with a minimum coverage of 20% of the pipe body area. Recordings shall be made available to the Inspector at the Mill.

The minimum required wall thickness shall be met at any location in pipe.

- j) (For reeling technique only) One bend test specimen shall be removed from each pipe end. The bend test specimens shall be cut longitudinally to the pipe axis and shall include the full wall thickness of the pipe. They shall be bent through 180 degrees using a plunger with maximum diameter of four times the specimen wall thickness. A liquid penetrant test (LPT) shall be performed on the whole bent area. There shall be no cracks on the outside surface of the bent portion of the specimen.
- k) (For reeling technique only) a ring flattening tests is requested. A section of cold pipe not less than 100mm in length shall be flattened cold between parallel plates without cracks or breaks on the inside or outside pie surface, until the distance between the plates is less than the value H calculated by following formula:

$$H = \frac{(1 + C) \times t}{C + t/d}$$

C Constant = 0.1

H Distance between parallel plates in mm

T Specified nominal wall thickness of the pipe in mm

D Specified outside diameter of the pipe in mm

- l) (For reeling technique only) Mechanical testing shall be performed on specimens removed from each pipe end. The specimen shall be taken from a full scale bending test simulating the successive bending of pipeline from first spooling to final laying. The bending scheme and equipment shall be mutually agreed with the Company. The plastic strain shall be, at least, equal to the plastic strain introduced during installation and service.

The Supplier shall submit to Company approval, a procedure for locating the maximum straining on the pipe.

Then all testing specimen shall be extracted from this maximum strained area.

The mechanical testing shall be carried out on specimens before straining and after straining and ageing. Ageing shall be 250°C for one hour.

The testing shall include:

- Longitudinal tensile testing
- Hardness testing
- Charpy V notch testing on specimens cut longitudinally at routine test temperature.

Full Charpy energy and shear area transition curves shall be carried out in the strained condition and in the strained plus aged condition at temperatures 10°C and 20°C above and 10°C and 20°C below the routine test temperature. The temperatures of testing shall be extended when necessary in order to get sufficient data for representing properly a transition curve showing the transition area. The tests with test temperatures below the routine test temperature will be for information only, but the transition temperature shall not be higher than the specified routine test temperature.

The following requirements shall be met after straining and ageing (specimens before straining shall meet what is required in the other sections of the present specification).

- Yield strength, tensile strength and Charpy V notch shall meet the requirements of Appendix 2
- The uniform elongation shall be 6% minimum
- The YS to TS ratio shall be recorded for information only
- The hardness requirements shall not exceed 250 HV10.

**Note:** When the required straining is reached, the specimen/sample/pipe shall be maintained under stress for at least 5 minutes before relieving.

m) HIC and SSC tests shall be as per 5.6.3 & 5.6.4 here after.

n) Post Weld Heat Treatment tests, when required in PPS, tensile tests (as per § 5.6.3c) above) and Charpy-V notch impact tests (as per § 5.6.3e).d above) shall be repeated after a simulated Post Weld Heat Treatment (PWHT) is made. These tests shall also be acceptance tests. PWHT procedure shall be mutually agreed (basically, soaking temperature of 600°C for one hour per 25 mm WT).

#### 5.6.4 SSC tests

SSC tests as per Appendix 6 shall be carried out in pipe material per each pipe size (diameter and W.T.), steel source, steel grade and manufacturing process. SSC tests shall be performed during qualification of pipe manufacturing procedure for 720 hours. Production tests shall then be carried out at  $\frac{1}{4}$  th,  $\frac{1}{2}$  th,  $\frac{3}{4}$  th and end of pipe production, still according to provisions of Appendix 4, except that test duration shall be 360 hours only (15 days).

In case of reeling, SSC tests shall be performed before and after reeling simulation (see 5.6.2.j). SSC shall be sampled as per Appendix 6 at compression and extension areas (intrados and extrados).

SSC tests are not required on mother pipes for bends (because those tests are required on finished bends).

SSC tests are not required for mild sour service.