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KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	<b>MATERIAL AND EQUIPMENT CONSTRUCTION  STANDARDS FOR PIPE LINE PROJECTS  (PROJECT STANDARDS AND SPECIFICATIONS)</b>	

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## SCOPE

This Project Standard and Specification provides pipeline specifications suitable for conveying gas and oil in both the oil and natural gas industries.

## REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. API (American Petroleum Institute)
  - 5L - 42 nd. Edition, Jan 2000 "Specification for Line Pipe"
2. ASTM (American Society for Testing and Materials)
  - 7 "Definition of Terms Relating to Metallography"
  - E - 7 "Definition of Terms Relating to Metallography"
  - E - 112 "Standard Test Methods for Determining Average Grain Size"
  - E - 165 "Practice for Liquid Penetrant Examination"
  - E - 309 "Standard Practice for Eddy Current Examination of Steel Tubular Products Using Magnetic Saturation"
  - E - 570 "Standard Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products"
  - E - 709 "Practice for Magnetic Particle Examination"
  - F - 21 "Standard Test Method for Hydrophobic Surface Films by the Atomizer Test"
3. DIN (German Standard)
  - SEL - 072 "Ultrasonically Tested Heavy Plates Technical Delivery Specifications"
4. ISO (International Standard)
  - 1027 "Radiographic Image Quality Indicator for NonDestructive Testing"
  - 2566-1 "Steel, Conversion of Elongation Values Part 1 Carbon and Low Alloy Steels"

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- 9001 "Quality Systems-Model for Quality Assurance in Design/Development, Production, Installation and Servicing"
- 9712 "Non-Destructive Testing, Qualification and Certification of Personnel"
- 10474 "Steel and steel products, Inspection Documents"

5. NACE (National Association of Corrosion Engineers)

- TM 0177-96 "Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in H2S Environments"
- TM 0284-96 "Evaluation of Pipeline Steels for Resistance to Stepwise Cracking"

**DEFINITIONS AND TERMINOLOGY**

**Executor** - The executor is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The company may undertake all or part of the duties of the executor.

**Inspector** - The inspector is the representative of the Company or the purchaser who is entrusted with the inspection of the products during and/or after manufacturing as well as production records, observance of manufacturing operations, witnessing the quality control and checking other requirements for compliance with the purchase order and this Project Standard and Specification.

**Minimum Operating Temperature** - The minimum temperature to which the pipeline or part of the pipeline and/or piping system may be exposed during normal operational activities, including start-up and shut-down operations and controlled blowdown, but excluding abnormal situations such as pipeline ruptures.

**SYMBOLS AND ABBREVIATIONS**

<u>SYMBOL/ABBREVIATION</u>	<u>DESCRIPTION</u>
Add.	Addition
Ap	Action required by purchaser
CE	Carbon equivalent
Del.	Deletion
CTOD	Crack tip opening displacement
DN	Diameter nominal

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DWTT	Drop weight tear test
EMT	Electromagnetic testing
FBH	Flat bottomed hole
FCAW	Flux cored arc welding
GMAW	Gas metal-arc welding
HAZ	Heat affected zone
HFI	High frequency induction
HFV	High frequency electric welding
HIC	Hydrogen induced cracking
Mod.	Modification
MT	Magnetic particle testing
NDT	Non-destructive testing
OD	Outside diameter
PCM	Material cracking parameter
NPS	Nominal pipe size (inch)
PT	Liquid penetrant examination
RDH	Radial drilled hole
RT	Radiographic (or radiological) testing
SAW	Submerged arc welding
SMLS	Seamless
SPW	Spiral welding
SS	Sour service
Sub	Substitution
TMCP	Thermomechanically controlled process
UT	Ultrasonic testing

### **INFORMATION TO BE SUPPLIED BY THE PURCHASER**

Additional Information to be Supplied by the Purchaser to the Manufacturer at the Time of Order are:

- Minimum design temperature
- Pipeline category (offshore or onshore) for length requirement
- The requirements for testing in the simulated heat treated condition
- The requirement for color code or marking to identify pipe mill and wall thickness
- The requirement for bevel protectors
- The requirements for pre-production welding procedure qualifications
- Higher absorbed energy requirements for Charpy test
- The requirements for DWTT

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- Purchaser inspection, if required and to what extent
- Suitability of Line pipe for sour conditions.

## **PROCESS OF MANUFACTURE AND MATERIAL**

### **Process of Manufacture**

#### 1. Seamless process

Cold sizing and straightening are only permitted if the total strain in the seamless pipe does not exceed 3.0%.

#### 2. Types of pipe

##### a. Continuous welded pipe

Pipe manufactured by this process is unacceptable.

##### b. Electric welded pipe

Only HFW pipe with a minimum welding frequency of 150KHZ, made from hot rolled coil is acceptable. A normalizing heat treatment of the weld and heat affected zone shall always be carried out, irrespective of grade and chemical composition. Full body normalizing, normalizing and tempering or quenching and tempering are also acceptable.

##### c. Laser welded pipe

This type of pipe is unacceptable.

##### d. Longitudinal seam submerged-arc welded pipe

The full length of the weld seam shall be made by automatic submerged arc welding, using run-on and run-off tabs. The welding procedure shall be approved by the Purchaser. Welding shall be checked at regular intervals to ensure that current, voltage and travel speed remain within the ranges of the approved welding procedure.

##### e. Gas metal-arc welded pipe

This type of pipe is unacceptable.

##### f. Combination GMAW and SAW pipe

GMAW is only acceptable for making a continuous tack weld in SAW pipe which is then considered as SAW pipe.

##### g. Double seam SAW pipe

This type of pipe is unacceptable, unless specifically ordered by the Purchaser.

##### h. Double seam GMAW pipe

This type of pipe is unacceptable.

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- i. Double seam combination GMAW and SAW pipe  
This type of pipe is unacceptable, unless specifically ordered by the Purchaser.
  - j. Helical seam SAW pipe (SPW pipe)  
This type of pipe is acceptable, in which case all the requirements indicated in this standard shall be applied.
3. Types of seam weld
- a. Joints weld  
Joints shall not be supplied.
  - b. Tack weld  
Tack welds shall be made in accordance with a qualified tack welding procedure using automatic SAW, GMAW, gas shielded FCAW, or shielded metal arc welding using low hydrogen electrodes from which the diffusible hydrogen content of the resulting weldment shall not exceed 10 ml/100g of deposited metal.

### **Cold Expansion**

Longitudinally SAW pipe shall be mechanically cold expanded between a minimum of 0.8% and a maximum of 1.5%. of diameter suitable means shall be provided to protect the weld from contact with the internal expander during mechanical expansion. Non-expanded SAW pipe shall not be supplied unless explicitly stated on the purchase order together with any supplementary test requirements.

HFW & SPW pipe shall not be cold expanded.

### **Material**

The steel shall be made in a basic oxygen or electric arc furnace and shall be fully killed and fine grained with a grain size of ASTM E-7 or finer, as defined in ASTM E-112.

For quenched and tempered pipe, this grain size requirement shall not apply.

For sour service, the steel shall be calcium treated and vacuum degassed.

### **Heat Treatment**

The heat treating process shall be performed in accordance with a documented procedure.

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SMLS pipe shall be furnished in the hot formed, normalized, normalized and tempered or quenched and tempered condition.

For hot formed pipe, the finishing temperature shall be greater than 780°C. Pipe finished at a lower temperature than 780°C shall be subjected to a further normalizing heat treatment, with a minimum holding time of 30 minutes.

SAW pipe shall be furnished in the as-rolled, normalized, thermomechanically controlled process or quenched and tempered condition.

HFW pipe shall be furnished from hot-rolled coil and the entire weld plus HAZ shall be normalised. Alternatively the pipe may be full body normalized, normalized and tempered or quenched and tempered.

Details of heat treatment shall be agreed with the Purchaser prior to the start of production.

#### **Skelp End Weld in Helical Seam Pipe**

Skelp end weld is not acceptable.

#### **Preparation of Edges for Welding**

The edges of the plates or strip to be welded shall be profiled by machining and at least 10 mm or 1.5 times the wall thickness, whichever is greater shall be removed from each side of the plate or strip either by machining or shearing. The abutting edges of the plate or strip shall be aligned for welding and adequate provision shall be made to ensure that the alignment is maintained during the progress of the welding operation and that any root gap is controlled within limits approved in the procedure test. All surfaces to be welded shall be thoroughly cleaned of scale, oil and other foreign matter before welding is started. The weld shall be of uniform width and profile and shall merge smoothly into the surface of the strip without appreciable deviation from the line of the joint. The forming procedure must ensure that there is a minimum of peaking and this shall be demonstrated in the procedure test to be within the acceptable limits.

#### **Manufacturing Procedure Qualification**

The manufacturing procedure shall be recorded and qualified. The procedure qualification tests shall be witnessed by the Purchaser. The Purchaser may at his discretion, accept the results of previously authenticated tests. The Purchaser shall reserve the right to require requalification in the case of a change in the procedure specification.



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## **MATERIAL REQUIREMENTS**

### **Chemical Properties**

#### 1. Chemical composition

For each enquiry/order the manufacturer shall propose a chemical composition for the pipe to be supplied. The composition shall be contained in the manufacturing procedure specification and, as determined by product analysis, shall comply with the maximum allowable limits specified in Tables 1/1A given hereunder. The limitations on heat and product analysis shall be those agreed following acceptance of the manufacturing procedure specification.

The manufacturer shall propose a nominal product analysis in the manufacturing specification. The range of acceptable variations in the product analysis is given in Tables 1/1A of this Standard.

This shall be applied to the chemical composition proposed by the manufacturer in the manufacturing specification.

The maximum variation on agreed composition is allowed provided that the final maximum alloy content given in Tables 1/1A is not exceeded.

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**Table 1 - Chemical Requirements for Product Analysis by Percentage of Weight (Non-Sour Services)**

MAXIMUM PERMITTED ALLOY CONTENT, wt%										
Element	GR. B	X-42	X-46	X-52	X-56	X-60	X-65	X-70	MAXIMUM VARIATION ON AGREED COMPOSITION	NOTES
C	0.17	0.18	0.18	0.17	0.17	0.15	0.15	0.15	0.03	---
Mn	1.15	1.25	1.25	1.25	1.45	1.45	1.50	1.50	0.30	---
Si	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.25	---
P	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	---	---
S	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	---	1
V	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.02	2
Nb	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.02	2
Ti	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	2
Cr	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.05	3
Mo	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.05	3
Ni	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.10	3
Cu	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.10	3
Al	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	4
N	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	---	4
B	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	---	---
Ca	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	---	---
CE	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	---	5
Pcm	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	---	6

**Notes:**

- 1) For HFW pipes, sulphur content shall not exceed 0.005%
- 2) V + Nb + Ti shall not exceed 0.12%.
- 3) Cr + Mo + Ni + Cu shall not exceed 0.6%.
- 4) The total Al : N ratio shall not be less than 2 : 1.
- 5)  $CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + v)}{5} + \frac{(Ni + Cu)}{15}$  (in case of carbon content greater than 0.12%)

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$$6) P_{cm} = c + \frac{Si}{30} + \frac{(Mn + Cu + Cr)}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B \text{ (in case of carbon content less than or equal to 0.12\%)}$$

For sour services, table 1A shall be applied.

**Table 1 A- Chemical Requirements for Product Analysis by Percentage of Weight (Sour Services)**

MAXIMUM PERMITTED ALLOY CONTENT, wt%										
Element	GR. B	X-42	X-46	X-52	X-56	X-60	X-65	X-70	MAXIMUM VARIATION ON AGREED COMPOSITION	NOTES
C	0.17	0.18	0.18	0.17	0.17	0.15	0.15	0.15	0.03	---
Mn	1.15	1.25	1.25	1.25	1.30	1.30	1.30	1.30	0.30	1
Si	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.25	---
P	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	---	---
S	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	---	---
V	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.02	2
Nb	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.02	2
Ti	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	2
Cr	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.05	3
Mo	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.05	3
Ni	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.10	3
Cu	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.10	3
Al	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	4
N	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	---	4
B	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	---	---
Ca	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	---	5
CE	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	---	6
<u>P<sub>cm</sub></u>	<u>0.21</u>	<u>0.21</u>	<u>0.21</u>	<u>0.21</u>	<u>0.21</u>	<u>0.21</u>	<u>0.21</u>	<u>0.21</u>	---	7

**Notes:**

- 1) For SAW pipes in X-70 grade the maximum MN content may be increased to 1.4 wt%.
- 2) V + Nb + Ti shall not exceed 0.15%.

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- 3) Cr + Mo + Ni + Cu shall not exceed 0.60%.
- 4) The total Al : N ratio shall not be less than 2 : 1.
- 5) Calcium shall be 2 times sulphur content for sulphur in the range 0.0015 - 0.003%.
- 6)  $CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + v)}{5} + \frac{(Ni + Cu)}{15}$  (in case of carbon content greater than 0.12%)
- 7)  $P_{cm} = c + \frac{Si}{30} + \frac{(Mn + Cu + Cr)}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$  (in case of carbon content less than or equal to 0.12%)

## 2. Elements analyzed

For Grade B pipe only C, Mn, Si, S and P levels shall be determined. For higher grades, analysis for all elements in Table 2 or Table 2A shall be performed.

## Mechanical Properties

### 1. Tensile properties

Grades B, x 42, x 46, x 52, x 56, x 60, x 65 and x 70 shall conform to the tensile requirements. For all pipes, the ratio of body yield strength to body ultimate tensile strength shall not exceed 0.90.

The yield strength shall be the tensile stress required to produce a total elongation of 0.5% of the gage length as determined by an extensometer. When elongation is recorded or reported, the record or report shall show the nominal width of the test specimen when strip specimens are used and the diameter and gage length when round bar specimens are used, or shall state when full section specimens are used.

### 2. Flattening test acceptance criteria

No cracks or breaks shall occur in either weld or parent metal during flattening of the test specimen to 50% of its original OD. The specimen shall be further flattened to 1/3 of original OD without cracks or breaks other than in the weld. The presence of lamination or burnt metal shall not become apparent during the entire test.

### 3. Fracture toughness tests

For all pipes, Charpy v-notch tests shall be performed on each test ring taken for tensile testing and tested. Evidence shall be required to show that the notch ductility of the pipe is adequate for service conditions.

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If stress relieving is required for field welds, Charpy testing is also required in the simulated stress relieved condition. The Purchaser/Company shall inform the manufacturer at the time of enquiry/order of the need for testing in the stress relieved condition.

For gas transmission lines with a pipe diameter of DN 400 (NPS 16) or greater and grade X-52 and higher DWTTs shall be carried out on one pipe from each heat of steel.

4. Metallographic examination

Specimens for metallographic examination shall be extracted from HFW and SAW pipe such that the weld, complete heat treated zone and parent material on both sides of the weld are visible over the full wall thickness. A minimum of one specimen under non-sour service and two specimens under sour service shall be microscopically examined from one pipe in each heat, or after each break in production, whichever is the more frequent. The examination shall determine the adequacy of microstructure and heat treatment. For HFW pipe and proper fusion throughout the full thickness of the joint for SAW pipe.

5. Hardness testing

The hardness of weld, HAZ and base material shall not exceed 280 HV10 for pipes under non-sour conditions and 248 HV10 for pipes under sour conditions.

6. Preparation of samples

Samples removed for the determination of tensile, toughness or microstructural properties shall be prepared by machining. Where thermal cutting has been used to remove pipe coupons from which test specimens are prepared, the full extent of the heat affected region shall be removed during machining of the specimen.

7. For pipes under sour condition HIC and SSC tests shall be performed.

**DIMENSIONS, WEIGHTS, LENGTHS, DEFECTS AND END FINISHES**

**Diameter**

The outside diameter of the pipe body, as measured by taping the circumference, shall not more than the tolerances given below:

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SIZE DESIGNATION	MINUS TOLERANCE	PLUS TOLERANCE
< DN 60 (NPS 2 3/8)	0.8 mm.	0.4
≥ DN 60 (NPS 2 3/8) and ≤ DN 400 (NPS 16)	0.75% OD	0.75% OD
>DN 400 (NPS 16)	3 mm.	3mm

For a length of 100 mm from each pipe end, the average internal diameter shall not deviate from the nominal internal diameter by more than the tolerances given below:

SIZE DESIGNATION	TYPE OF PIPE	MINUS TOLERANCE mm.	PLUS TOLERANCE mm.
≤ DN 250 (NPS 10)	Welded	0.5	1.5
	SMLS	1.0	2.0
>DN 250 (NPS 10) and ≤ DN 500 (NPS 20)	Welded	1.0	1.5
	SMLS	1.5	2.0
> DN 500 (NPS 20)	Welded	1.5	1.5
	SMLS	2.0	2.0

**Notes:**

- 1) The nominal internal diameter is defined as the outside diameter D minus twice the nominal wall thickness.
- 2) The internal diameter shall be measured using an internal gage or a measuring tape inside the pipe. The method and equipment shall be approved by the Purchaser/Company. For pipe of DN 200 (NPS 8) and smaller, the internal diameter may be calculated by measuring the outside diameter with a circumference tape and subtracting twice the actual wall thickness from this value.
- 3) The end of each pipe shall be tested for out-of-roundness using an internal ring. For 32" and higher the diameter of ring shall be 0.6 percent of nominal O.D. less than nominal inside diameter and for less than 32" the diameter of ring shall be 5mm less than nominal inside diameter of pipe. The gage shall pass freely into each end of the pipe through 100 mm distance when held normal to the pipe axis.
- 4) On welded expanded pipe, the internal diameter of one end of the pipe shall not differ by more than 2 mm from that of the other end.

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Any pipe found to be out of tolerance shall be the cause for individual diameter measurement of all pipe back to the last, and up to the next, two sequential pipes measured and found to be within tolerance.

### Wall Thickness

Each length of pipes shall be measured for conformance with the specified wall thickness requirements. For all sizes and grades of welded pipe, the wall thickness at any place in the pipe measured during inspection shall not deviate from the nominal wall thickness by more than the tolerances specified in the following Table (except that the weld area shall not be limited by the plus tolerance):

WALL THICKNESS, t (mm)	MINUS TOLERANCE	PLUS TOLERANCE
$t \leq 7$	0.35 mm	10%
$7 < t \leq 10$	5%	10%
$t > 10$	0.5 mm	10%

For all sizes and grades of seamless pipe, the wall thickness at any point shall not deviate from the nominal thickness by more than + 15% or -10%.

### Length

Unless otherwise indicated in the purchase order, pipe shall be supplied in the following lengths:

- The average length of pipes in one order shall be not less than 11.6 m with a minimum of 95% of pipes between 11 and 12.2 m in length.
- No pipe shall be less than 10 m in length.
- No pipe shall be greater than 12.8 m in length.

Note:

For heavy wall seamless pipe, where supply of the pipe lengths stated above may not be possible, the Purchaser and the Manufacturer shall agree on an alternative pipe length.

### Straightness

Deviation from a straight line shall not exceed 0.15 percent of the length.