



Exploration & Production

GENERAL SPECIFICATION

PIPING VALVES VESSELS

GS EP PVV 621

Piping components in material 2^{1/4} Cr-1% Mo

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1. Scope

This specification covers specific requirements applicable to pieces of materials used for piping weldable components (flanges, fittings, elbows, connectors) which are made of alloy 2¼ Cr-1% Mo at delivery state quenched and tempered, with reference to **ASTM A 182 Grade F22** modified, in heavy wall forgings, for high pressure conditions (> 1500#). The ruling design code is **ASME B16.5**.

Piping components include in particular: pipes, fittings, connectors, flanges, valves, etc... in the form of wrought products. Piping components shall be forged. Components machined from bars are not acceptable above 4".

The present document applies to the actual manufacturing procedure requirements of individual pieces, the assembly of these pieces to each other by welding and to the corrosion resistant overlays.

Any additional test required for sour service applications are not addressed by the present document.

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.

Since this specification brings additional requirements dealing with a specific material (i.e. **ASTM A 182 Grade F22** alloy), it is deemed to overrule any less stringent requirement appearing in any of the other contractual Reference Documents.

Standards

Reference	Title
EN 1043	Destructive tests on welds in metallic materials. Hardness testing Part 1: hardness test on arc welded joints
EN 10204	Metallic Products - Types of Inspection Documents
EN 10246-12	Non-destructive testing of steel tubes – Part 12: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections
EN 10228-3	Non-destructive testing of steel forgings – Part 3: Ultrasonic testing of ferritic or martensitic steel forgings
ISO 10474	Steel and steel products. Inspection documents.

Professional Documents

Reference	Title
(ASTM) AMERICAN SOCIETY FOR TESTING AND MATERIALS	
ASTM G 146-01	Standard Practice for Evaluation of Disbonding of Bimetallic Stainless Alloy Steel Plate for Use in High-Pressure, High-Temperature Refinery Hydrogen Service.
ASTM E 92	Standard Test Method for Vickers Hardness of Metallic Materials
ASTM A 182	Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A 370	Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E112	Test Methods for Determining Average Grain Size
(AWS) AMERICAN WELDING SOCIETY	
A 4.2	Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
(ASME) AMERICAN SOCIETY OF MECHANICAL ENGINEERS	
Section II, Part C	Welding Rods, Electrodes, and Filler Metals
Section II, Part D	Properties
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B31.3	Process Piping
SA 20	Specification for General Requirements for Steel Plates for Pressure Vessels
SA 182	Specification for forged or rolled alloy-steel pipe flanges, forged fittings, and valves and parts for high-temperature service
SA 264	Specification for stainless chromium-nickel steel-clad plate, sheet, and strip

Reference	Title
SA 336	Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts
SA 370	Test methods and definitions for mechanical testing of steel products
SA 387	Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum
SA 388	Specification for Ultrasonic Examination of Heavy Steel Forgings
SA 435	Specification for Straight-Beam Ultrasonic Examination of Steel Plates
SA 578	Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Application
SA 788	Specification for steel forgings, general requirements
(API) AMERICAN PETROLEUM INSTITUTE	
RP 934	Materials and Fabrication Requirement for 2 ¼ Cr-1Mo & 3Cr-1Mo Steel - Heavy Wall Pressure Vessels for High Temperature High Pressure Hydrogen Service
API 6A	Specification for Wellhead and Christmas Tree Equipment

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP PVV 611	Welding of pressure containing piping and equipment

3. Abbreviations

DAC	Distance Amplitude Correction
DT	Destructive Testing
MPI	Magnetic Particle Testing
NDT	Non Destructive Testing
HTMP	Heat Treatment for Mechanical Properties
PQR	Procedure Qualification Test Record
PT	Penetrant Testing



RT	Radiographic Testing
SPWHT	Simulated post Weld Heat Treatment
Mini/maxi SPWHT	Minimum/Maximum time for Simulated post Weld Heat Treatment
UT	Ultrasonic Testing
WPS	Welding Procedure Specification
WPQR	Welding Procedure Qualification Record

4. Base material requirements

4.1 Melting process

The steel shall be made using an electric furnace. It shall be aluminium-killed and vacuum degassed and shall be produced by low sulphur and low phosphorus refining process.

4.2 Chemical analyses

For each heat, the steelmaker shall supply a ladle analysis certified by the mill manager or his duly accredited representative.

In addition, he shall provide two product analyses, one of which shall be performed on a specimen taken at the top of the ingot and the other on a specimen taken at the bottom of the ingot, on material in the finished heat-treated conditions.

The chemical composition of ladle and on product shall be in accordance to the **ASTM A 182 Grade F22** specification with the additional requirements given in Table 1 below:

Table 1

	ASTM A 182 Grade F22 modified		
		Ladle Analysis wt%	Product Analysis wt%
Alloying elements ¹	Max. Carbon	0.15	0.18
	Manganese	0.30 - 0.60	0.30 - 0.60
	Max. Silicon	0.30	0.30
	Chromium	2.00 - 2.50	2.00 - 2.50
	Molybdenum	0.87 - 1.13	0.85 - 1.15
	Max. Nickel	0.15	0.15
	Copper	0.20	0.20
	Max. Vanadium	0.005	0.005
	Max. Aluminium	0.04	0.04
	Max. Phosphorus	0.010	0.010
	Max. Sulfur	0.006	0.006
	Max. Nitrogen	0.013	0.013
	Max. Boron	0.0018	0.0018
	Max. Calcium	0.006	0.006
	Max. Tin	0.010	0.010
	Max. Arsenic	0.020	0.020
	Max. Tantalum	0.030	0.030
	Max. Antimony	0.005	0.005

4.3 Manufacture

All forgings shall be supplied seamless and shall be hot forged or hot formed. All items must be supplied in the finished heat-treated conditions, in accordance with the following requirements.

Parameters which the Supplier considers to be "major parameters" since they directly affect product quality shall be specified and listed in a manufacturing programme.

Prior to the beginning of any operation of the manufacturing sequence, a manufacturing programme shall describe:

- Manufacturing operations in chronological order:
 - Melting process
 - Forging

¹ Elements not considered in the table shall be considered as residual.

- Machining
- Heat treatments
- Sampling
- Non-destructive examination
- Raw materials
- Melting process
- Aimed chemical composition
- Weight (and type) of ingot
- Minimum top and bottom end discard percentages
- Dimensional sketch of part with overall forging ratio of reduction
- Drawings of the part showing the rough forging profile, the profile for heat treatment and as-delivered profile
- Intermediate heat treatment and final heat treatment (for mechanical properties)
- Position in the part of test samples for acceptance tests
- Drawing showing position of test specimens within test samples.

4.4 Forging

Material shall be forged at an elevated temperature (i.e. above its recrystallisation temperature) utilizing one or more dies, according to a written procedure specified by the material supplier. There shall be sufficient discard of the ingot to ensure elimination of shrinkage cavities and most segregation. A record of ingot weight and discard percentages shall be kept at the disposal of the Company.

Overall calculated reduction ratio of must be greater than 3 (hot dimensions).

All items must be hot forged closely as possible to the as-delivered profiles. Theses profiles shall be kept at the disposal of the Company.

4.5 Machining

4.5.1 Before heat treatment for mechanical properties

Forgings shall be machined before heat treatment in such a way that maximum thickness to be machined after quenching shall be less than 8 mm, unless specified by writing by the Company.

4.5.2 After heat treatment for mechanical properties

The part shall be machined as closely as possible to permit 100% volumetric examination of the forging.

4.6 Delivery Condition - Heat Treatment

The forgings shall be austenitised/quenched and tempered.

Holding time shall be sufficient to attain a uniform temperature throughout the thickness. Cooling from the austenitising temperature by water quenching shall be employed in such a

manner as to ensure the required mechanical properties level and a homogeneous structure throughout the wall thickness of the forging.

The part shall be delivered in the as-treated condition. This treatment, which is called heat treatment for mechanical properties, shall consist, at least, of the following operations:

- Austenitising at a selected temperature between 900°C and 980°C
- Quenching by immersion in water (time transfer between the furnace and the quenching tank with circulating water process and water jetting, shall be less than 1'30" unless documented with AR3 calculation and Temperature monitoring during transfer)
- Tempering at a temperature selected so as to obtain the required properties, followed by still air cooling.

Nominal holding temperature for tempering shall be between 660°C and 700°C, and such that nowhere in the part the temperature outside this range.

Temperatures shall be measured by means of thermocouples placed on the part. Thermocouples shall be installed at several locations on the part with one thermocouple at least per part and two thermocouples at least if the charge consists of only one part. Thermocouple locations shall be clearly specified and kept at disposal of the Company. The position of each part of a same charge in the furnace shall be clearly identified, recorded and kept at disposal of the Company.

Records shall be evaluated by the Supplier.

If the part is to be retreated, the re-treatment shall be performed in accordance with the same instructions as above.

4.7 Mechanical properties

4.7.1 Required Values

Tensile test shall be carried out respectively at room and design temperature. They are mandatory at room temperature and are given for information at design temperature.

Required values for forging for DN ¾" to 8", at HTMP, HTMP+ mini or maxi SPWHT:

Table 2

Properties	Mini $R_p \leq 2\%$ (MPa)	Mini R_m (MPa)	Maxi R_m (MPa)	$R_p \leq 2\% / R_m$	Mini Elongation (A%)
Tension (Room Temperature)	415	550	690	0,85	20

Charpy V- Notch tests shall be performed at or below the test temperature indicated here above. Specimens are full size. Their orientation is in accordance with Tables 4, 5 and 6.

Table 3

	-46°C		-29°C		0°C	
	Min. Aver. value	Min. Indiv. value	Min. Aver. value	Min. Indiv. value	Min. Aver. value	Min. Indiv. value
KV Impact tests	42 J	33 J	55 J	47J	100 J	80 J

Energy values in table 3 shall be upgrade by 30J for properties in the welded joint.

4.8 Qualification Testing

If needed, the Company may ask to perform a qualification program, prior to any manufacturing activities. This qualification is used to check that a product or part, manufactured in accordance with a specified programme, will respond satisfactorily to fabrication operations and service conditions. Qualification report shall be completed by the associated workshop qualification.

Product qualification is the time when the characteristics of the product may be determined, particularly singularities and testability. The extent of tests in the case of a qualification program shall be developed in function of the application, but shall consist in, at least:

- Charpy V-Notch Transition Curve with samples selected in transverse direction with, at least, five different temperatures, in such a way to test the brittle and ductile behaviour of the material. Shear fracture shall be reported
- Charpy V-Notch tests shall also be performed at the Upper Shelf, at 100% of shear fracture. In this case with a minimum individual value of 150J is required for each sample
- Tensile properties at high temperature (maximum design temperature) in transverse and longitudinal direction. In this case, properties are given for information
- In the case of test ring of forgings with a thickness > 200 mm, mandatory tests of Tables 4, 5 shall be duplicated in order to be performed at mid-thickness
- Mandatory tests of Table 4 performed after HTMP + Maximum time of SPWHT shall be duplicated to be performed also at HTMP + Minimum time of SPWHT
- For test rings > 200 mm, mandatory Tests of Table 4 performed after HTMP + Maximum time of SPWHT shall be duplicated to be performed at quarter outer surface.

4.9 Sampling

The samples shall be taken from one part per batch, in a test ring consisting of the thickest prolongation attached to the part. Exception is made for flanges, where the test ring shall be close to the welding neck. Sampling shall be performed as described in Appendix 1.

Samples shall be taken after the part has been heat treated for mechanical properties, they shall be clearly identified and their direction of maximum extension shall be indicated.

The size of the test samples shall be such that they can provide enough test specimens for all tests and retests.

These profiles shall be those of the part at the time of heat treatment for mechanical properties. The notch axes of impact test specimens shall be oriented radially with respect to the parts, except for the radial test specimens, for which the notch axis must be oriented tangentially.