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ADDENDUM 2

1 Scope

The 1st paragraph shall be changed to the following:

This specification defines the requirements for the design, manufacturing, materials, welding, quality control, assembly, testing, marking, documentation, and process controls of axial, ball, check, gate, and plug valves for application in the petroleum, natural gas and hydrogen gas industries.

The 4th paragraph shall be changed to the following:

Annexes A, B, D, E, F, J, L and M are informative and contain optional requirements used in this specification.

2 Normative References

The following shall be added:

API Standard 6ACRA, Age-hardened Nickel-based Alloys for Oil and Gas Drilling and Production Equipment

ASME B16.38, Large Metallic Valves for Gas Distribution: Manually Operated, NPS 2 1/2 (DN 65) to NPS 12 (DN 300), 125 psig (8.6 bar) Maximum

ASME B31.12, Hydrogen Piping and Pipelines

ISO 2782-1, Rubber, vulcanized or thermoplastic — Determination of permeability to gases — Part 1: Differential-pressure methods

ISO 2782-2, Rubber, vulcanized or thermoplastic — Determination of permeability to gases — Part 2: Equal-pressure method

ISO 23936-1, Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 1: Thermoplastics

ISO 23936-2, Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 2: Elastomers

NORSOK

M-710, Qualification of non-metallic sealing materials and manufacturers

3.2 Acronyms and Abbreviations

The following shall be added:

FAT	factory acceptance test
FE	fugitive emissions

HE hydrogen embrittlement

HSL hydrogen specification level

4.2 Conformance and General Performance Requirements

The 5th paragraph shall be changed to the following:

The supplemental requirements in Annex L and Annex M shall apply when specified by the purchaser.

Note 3 shall be changed to the following:

NOTE 3 Annex L and Annex M identify allowable additions or supplements over the requirements in Section 4 through Section 14 that may be applied to valves when specified by the manufacturer or purchaser. Valves manufactured with any allowed addition or supplement in accordance with Annex L and/or Annex M conform to this specification.

4.5.1 Process Control

Table 2: The table shall be changed to the following:

Table 2—Process Control Requirements

Item No.	Process Control Activity	Performed by:	
		Manufacturer[1]	Outsourced[2]
1	Product design and validation	X	X
2	Material procurement	X	X
3	Verification of externally provided products or activities	X	Not permitted
4	Machining	X	X
5	In-process inspection	X	X
6	Welding	X	X
7	Assembly	X	Not permitted
8	Factory acceptance testing (Section 10)	X	Not permitted
9	Additional specified requirements per Annexes I, J, K, or L[3]	X	X[3]
10	Marking/tagging/nameplate	X	Not permitted
11	Coating/painting[4]	X	X
12	Corrosion protection and preparation for transport	X	X
13	Final inspection	X	Not permitted

FOOTNOTES
[1] See 3.1.21.
[2] See 3.1.28.
[3] For conformance to Annex M, requirements of L.9, L.10, L.11 and/or L.12 shall be performed by the manufacturer and shall not be outsourced.
[4] See Annex G.
X = when performed

5.6.1 Vents and Drains

The 1st paragraph shall be changed to the following:

All double-seated valves that provide a seal against the pressure source with the upstream seat shall be equipped with a drain or vent connector except when specified in conformance to M.3.2.

8.1 Pressure-Boundary Bolting

The section shall be changed to:

Pressure boundary bolting shall conform to:

— API 20E, BSL-1 for alloy and carbon steel bolting or API 20F, BSL-2 for corrosion-resistant bolting when the specified bolting materials are listed in API 20E or API 20F; or

— the manufacturer's documented material specification and design code listed in 5.1 when the specified bolting materials are not listed in API 20E or API 20F.

NOTE 1 Use of bolting that conforms to API 20E and API 20F does not require that the bolting be supplied from a facility that has been licensed to API 20E or API 20F.

NOTE 2 Use of bolting that conforms to API 20E and API 20F includes identification of the bolts in accordance with the specified marking requirements.

NOTE 3 See API 21TR1 for guidance on the selection of bolting materials.

Low-temperature carbon and alloy steel bolting shall conform to ASTM A320/A320M for the specific grade of material.

9.6 Valve Assembly

Note 2 shall be changed to the following:

NOTE 2 For guidance on restriction of assembly lubricant, see K.12.

10.1.1 Procedure

The Note shall be changed to the following:

NOTE For testing one-piece bodies in non-assembled condition, see K.13.

10.4.1 Hydrostatic Seat Test Preparation, Method, and Acceptance Criteria

The Note shall be changed to the following:

NOTE See K.14 for guidance on performing alternate seat testing.

10.4.4 Additional Seat Testing

The following sentence shall be added as the last paragraph:

For conformance to Annex M, requirements of L.9, L.10, L.11 and/or L.12 shall be performed by the manufacturer and shall not be outsourced.

12.1 General (Marking)

Table 11: The table shall be changed to the following:

Table 11—Valve Marking on Body

Item No.	Marking	Section	Format Example

1	Manufacturer's name [a, c]		—[e]	Per manufacturer requirements
2	Unique serial number [b]		14.1	Per manufacturer requirements
3	ASME Pressure Class Rating [b] or Intermediate Pressure Rating [b]		4.3.1 4.3.2	150, 300, 600, 900, 1500, or 2500 PN155, 2250 psi
4	Body/end-connector material designation [b, f, g, j]		6	Material grade
5	Body/end-connector melt identification [f g]		—[e]	Cast or heat number
6a	Nominal valve size [b d]	Full-opening valves: nominal valve size	4.4.2	8 or DN 200
6b		Reduced-opening valves with circular opening: [d]	4.4.3	8 × 6 or DN 200 ×150 or 8R x bore or DN 200R x bore
6c		Reduced-opening valves with noncircular opening	4.4.4	8R (DN200R)
7	SMYS (units) of valve ends [h]		5.1	SMYS 40 KSI or SMYS 276 MPa
8	Ring joint groove number [i]		—[e]	R49
9	Flow direction (for check valves only)		12.1	Flow → or ← Flow

[a] Shall be on *either* the body or the nameplate at a minimum; may be on both.
[b] Shall be on *both* the body and the nameplate.
[c] Additional use of trademark/brand names with the manufacturer's name is optional.
[d] Bore may be marked in in. or (mm).
[e] No specific document reference identified.
[f] When the body is manufactured from more than one type of material, all materials of the body and end-connector shall be identified—MSS SP-25 gives guidance on marking.
[g] Body includes body/end connector.
[h] On body weld ends only.
[i] On flange OD for Flanged Connectors Conforming to 5.2.3.1.1.
[j] Where the grade and class does not uniquely identify the material specification, the material specification, grade, and class shall be marked. Example: A516-70 or A537 CL2.

Annex I
(normative)

Quality Specification Level (QSL) and Supplemental Testing

I.1 General

The section shall be changed to:

This annex shall apply to requirements for QSL in accordance with I.1 through I.4 and supplemental testing in I.5 through I.10, when QSL 2, 3, 3G, 4, or 4G is specified by the purchaser. When any of the QSLs are specified, all requirements of a specific QSL shall apply.

NOTE The QSLs increase in stringency of requirements with the QSL numbers 2, 3, 3G, 4, and 4G.

This annex specifies the requirements for NDE, documentation, and pressure testing and other supplemental requirements that shall be performed by the manufacturer when specified by the purchaser for a given QSL.

The results of testing or other requirements performed to satisfy requirements in Sections 4-14 shall also satisfy all or part of identical requirements of this Annex.

If the valve was not previously tested, the QSL pressure testing and documentation requirements of this annex shall apply in lieu of the related requirements of Sections 4-14. When NDE is performed as part of Section 7 and Section 9, repeating of identical tests shall not be required per this annex

I.3 Production Material Requirements

The section shall be changed to:

Production material requirements shall conform to Table I.3 for the specified QSLs and the use of the following:

- API 20A for castings
- API 20B for open-die forgings
- API 20 C for closed-die forging,
- API 20E for alloy and carbon steel bolting or API 20F for corrosion-resistant bolting when the specified bolting materials are listed therein.
- The manufacturer's documented material specification, design code listed in 5.1, and Section 5 of API 20E for alloy and carbon steel bolting or API 20F for corrosion-resistant bolting when the specified bolting materials are not listed in API 20E or API 20F.

NOTE 1 Use of materials or services that conform to API 20A, API 20B, API 20C, API 20E, or API 20F does not require the material or service to be provided by a facility that is specifically licensed to API 20A, API 20B, API 20C, API 20E, or API 20F, respectively.

NOTE 2 Use of materials or services that conform to API 20A, API 20B, API 20C, API 20E, or API 20F includes identification of resulting products in accordance with the specified marking requirements.

Table I.3: The table shall be changed to the following:

Table I.3—Production Materials Requirements

Level	Applicable Reference	Applicable BSL-CSL-FSL
QSL 2	Section 6 Section 8.1	N/A (see 8.1 for details)
QSL3/3G	API 20A	CSL 2
	API 20B	FSL 2
	API 20C	FSL 2
	API 20E[a,b, c]	BSL 2
	API 20F[a,b, c]	BSL 2
QSL4/4G	API 20A	CSL 3
	API 20B	FSL 3
	API 20C	FSL3
	API 20E[a,b, c]	BSL 3
	API 20F[a,b, c]	BSL 3

FOOTNOTES

[a] When materials listed in API 20E or API 20F are used, the bolts shall confirm fully to the BSL and be marked in accordance with API 20E or API 20F,

[b] When non-listed materials are used, requirements per BSL level in Section 5 of API 20E or Section 5 of API 20F shall apply.

[c] Conforming bolts from materials not listed in the bolting specification are not marked 20E or 20F unless all of the bolting specification requirements have been satisfied.

I.8.2.1 Method

The first dash shall be changed to:

— Method 1: Valves shall have a high-pressure gas shell test performed using air or nitrogen, with the valve submerged in a water bath during testing.

Annex K
(normative)

Purchaser-specified Customization—Permissible Deviations to Specified Design and Manufacturing Requirements

Section K.12 shall be deleted and the subsequent sections shall be renumbered.

Annex L
(informative)

Specified Customization—Supplemental Options to Specified Design and Manufacturing Requirements

L.9 Double Block and Bleed (DBB) Valves

The following sentence shall be added as the last paragraph:

For conformance to Annex M, requirements of L.9 shall be performed by the manufacturer and shall not be outsourced.

L.10 Double Isolation and Bleed DIB-1 (Both Seats Bidirectional)

The following sentence shall be added as the last paragraph:

For conformance to Annex M, requirements of L.10 shall be performed by the manufacturer and shall not be outsourced.

L.11 Double Isolation and Bleed DIB-2 (One Unidirectional and One Bidirectional Seat)

The following sentence shall be added as the last paragraph:

For conformance to Annex M, requirements of L.11 shall be performed by the manufacturer and shall not be outsourced.

L.12 Operations Testing—Valves Required for Double Isolation and Bleed (DIB-1 or DIB-2)

The following sentence shall be added as the last paragraph:

For conformance to Annex M, requirements of L.12 shall be performed by the manufacturer and shall not be outsourced.

L.20.2.1 Method

The first dash shall be changed to:

— Method 1: Valves shall have a high-pressure gas shell test performed using air or nitrogen, with the valve submerged in a water bath during testing.

The following shall be added as Annex M **Annex M**
(informative)

Valves in Hydrogen Gas (H_2) Service

M.1 General

For a valve designed for use in hydrogen gas (H_2) service a manufacturer shall satisfy all applicable requirements from Section 4 through Section 14 for the valve with allowable modifications or supplements to those requirements as identified in this Annex.

M.2 Hydrogen Specification Level

Hydrogen Specification Level (HSL) for valves for hydrogen service shall be specified. The requirements of Table M.1 shall apply to the specified HSL.

NOTE The following topics may be used for the determination of desired HSL:

1. Location of valve (confined space, buried, open air, rural/remote)
2. Percentage H_2 in gas
3. Chemical elements in gas that could impact materials.
4. Design pressure
5. Cyclic Pressure service

Table M.1—Summary of Hydrogen Specification Level Requirements

Item	Requirement	HSL1	HSL2	HSL3	HSL4
1	Minimum QSL level	See Footnote a	QSL2	QSL3G	QSL4G
2	Validation	5.10.4	5.10.4	M.3.3.4	M.3.3.4
3	Validation: High-pressure gas shell test	M.3.3.2	M.3.3.2	M.3.3.4	M.3.3.4
4	Validation: High-pressure gas seat test	M.3.3.3	M.3.3.3	M.3.3.4	M.3.3.4
5	Validation: Dynamic gas pressure test	N/R	M.3.3.5	M.3.3.4	M.3.3.4
6	Validation: Fugitive emission test (ISO 15848-01)	N/R	M.3.3.6	M.3.3.6	M.3.3.6
7	Validation: Anti-static testing	M.3.3.7	M.3.3.7	M.3.3.7	M.3.3.7
8	Validation: Fire safe design	M.3.3.8	M.3.3.8	M.3.3.8	M.3.3.8
9	FAT: Pressure tests with hydrostatic end load	N/R	N/R	N/R	M.8.5
10	FAT: High Pressure Gas shell test	N/R	M.8.2	per QSL	per QSL
11	FAT: High Pressure Gas seat test	N/R	M.8.3	per QSL	per QSL
12	FAT: Fugitive Emissions production test	N/R	N/R	M.8.4	M.8.4
13	FAT: Anti-static test	M.8.6	M.8.6	M.8.6	M.8.6
14	HSL marking (see M.9)	HSL1	HSL2	HSL3	HSL4

FOOTNOTE
[a] For HSL1 the quality requirements of Section 4-14 apply.

N/R = not required

M.3 Design

M.3.1 Plug Valve Sealant/Lubricant

Lubricated plug valves shall be furnished with hydrogen resistant sealant/lubricant capable of performing up to the maximum rated design temperature of the valve.

Manufacturer shall validate suitability of the sealant/lubricant for use in hydrogen service.

The sealant/lubricant shall be capable of maintaining viscosity for tight sealing and lubricity for ease of operation in hydrogen service.

M.3.2 Body Penetrations

If specified, body penetrations (see 5.6), including ports provided for test purposes, may be blocked by plug, weld, flange or other.

If the body penetration is blocked and cavity venting is no longer possible, the valve shall not be marked for DBB or DIB-1 or DIB-2.

M.3.3 Design Validation

M.3.3.1 General

Design validation shall be performed as specified in Table M.1 for all valves conforming to Annex M.

NOTE Valves which have been validated to Annex F may not meet the requirements of Table M.1.

M.3.3.2 High-pressure Gas Shell Test

For HSL1 and HSL2, a high-pressure gas shell test shall conform to I.8.2, with the following exceptions:

a) Valves NPS 24 and smaller shall be tested with, and satisfy the acceptance criteria of, Method 1.

b) Valves larger than NPS 24 shall be tested and satisfy the acceptance criteria of either Method 1 or Method 2.

c) The test duration shall be two times the minimum duration that is specified in Table I.5.

M.3.3.3 High-pressure Gas Seat Test

For HSL1 and HSL2, a high-pressure gas seat test shall conform to I.8.3, with the following exceptions:

a) The test duration shall be two times the minimum duration that is specified in Table 10.

b) The acceptance criteria for metal-seated valves, except metal-seated check valves shall not exceed ISO 5208 Rate C.

c) The acceptance criteria for metal seated check valves shall not exceed five times ISO 5208 Rate D.

NOTE See I.8.3.2 for the acceptance criteria for other valve types not identified in M.3.3.3

M.3.3.4 HSL3 and HSL4 Requirements

If HSL3 or HS4 is specified, design validation shall be performed conforming to the requirements specified in Annex F, using nitrogen as the test media, and with the following exceptions:

a) Duration for tests shall be as follows :

   1) Body pressure tests as per F.17.1, F.21 and F.24 : minimum of 2 hours

   2) Body pressure tests as per F.25 : two times the minimum duration of Table I.5

   3) Seat tests as per F17.2, F.22 and F.23 : minimum of 2 hours

   4) Seat tests as per F.26 and F.27 : two times the minimum duration of Table 10

b) Acceptance criteria for seat test per F.17.2, F.22 and F.23 shall be in accordance with M.8.3.

c) Acceptance criteria for seat test per F.26 and F.27 shall be as follows:

   1) Leakage for soft-seated valves shall not exceed ISO 5208, Rate B.

   2) Leakage for lubricated plug valves shall not exceed ISO 5208, Rate A.

   3) For metal-seated valves, the leakage shall not exceed ISO 5208, 5 times Rate C.

   4) For metal-seated check valves, the leakage shall not exceed ISO 5208, 5 times Rate E.

Actual leakage shall be recorded for all seat tests.

M.3.3.5 Dynamic Pressure Gas Test

For HSL2, a cycle test shall be performed in conformance with F.19 followed by seat testing in conformance with F.26 and F.27. The test medium shall conform to F.7.

M.3.3.6 Fugitive Emissions Test

Valves without an external stem or shaft (e.g., swing check or axial check valve) the fugitive emissions test shall:

1) include thermal cycles required by ISO 15848-1, and

2) not include the mechanical cycles required by ISO 15848-1.

For HSL2, valves with an external stem or shaft (e.g., ball, check valve with external shaft, gate or plug valve) shall conform to ISO 15848-1, minimum tightness of Class CH, and endurance class C01 for the design temperature range of the valve.

For HSL3, valves with an external stem or shaft (e.g., ball, check valve with external shaft, gate or plug valve) shall conform to ISO 15848-1, minimum tightness of Class BH, and endurance class C01 for the design temperature range of the valve.

For HSL4, valves with an external stem or shaft (e.g., ball, check valve with external shaft, gate or plug valve) shall conform to ISO 15848-1, minimum tightness of Class AH, and endurance class C01 for the design temperature range of the valve.

For valves with ancillary valves (e.g., vent valve, drain valve, relief valve), fugitive emissions testing shall be performed on the ancillary valve separately or shall be included in the valve's fugitive emissions testing.

M.3.3.7 Anti-static Feature

For all HSL designations, anti-static testing shall conform to L.5.

Valve with graphite seals shall be tested with the graphite seals removed.

M.3.3.8 Fire Safe Design

Valve shall be fire safe tested in conformance with L.27.

M.3.3.9 Scaling

The scaling for temperature, size and pressure class per Annex F shall be permitted.

The scaling of fire tests and fugitive emission tests shall be permitted in conformance with the testing standard used.

M.3.3.10 Gaskets/Seals

A change in the material or dimension of the following seals shall require validation to M.3.3:

a) lip seal

b) v-pack/chevron type

c) delta seal

d) bellows seal

e) die formed graphite seal.

A change in seal raw material manufacturer where material or dimension has changed, validation to M.3.3.2 through M.3.3.6 as applicable shall be required.

M.4 Materials

M.4.1 Requirements for Metallic Materials

M.4.1.1 General

CAUTION – The materials requirements in this Annex are written for a valve with a maximum allowable temperature up to 347°F (175°C). For valves requiring a maximum allowable temperature greater than 347°F (175°C) see API RP941 for guidance.

All metallic materials shall conform with one of the following:

a) NACE MR0175 / ISO 15156 which are listed in M.4.1.2; or

b) The requirements of M.4.1.3, including the results of performance testing required therein.

NOTE The material groups of Annex M are as defined by NACE MR0175 / ISO 15156.

M.4.1.2 Materials Permitted

The following materials shall be permitted for pressure-containing parts and pressure-controlling parts in hydrogen service:

a) Carbon steel per M.4.1.4, or

b) Low alloy carbon steel, or

c) Austenitic stainless steel, or

d) Nickel-based alloys per M.4.1.5, or

e) Precipitation hardened nickel-based alloys per M.4.1.5.

M.4.1.3 Material Permitted with Additional Testing

CAUTION – Materials listed in section 4.1.3 are not necessarily immune to failure mechanisms under all service conditions. It is the purchaser's responsibility to select the materials suitable for the intended service.

The following materials shall be permitted for pressure-containing parts, pressure-controlling parts and bolting in hydrogen service if materials are acceptable based on testing protocols and acceptance criteria as agreed between the manufacturer and the purchaser:

a) Highly alloyed austenitic stainless steel, or

b) Cold worked solution annealed or cold worked annealed nickel-based alloys, or

c) Ferritic stainless steel, or

d) Martensitic stainless steel, or

e) Duplex stainless steel, or

f) Precipitation-hardened stainless steel.

NOTE: Guidance on material testing in hydrogen service can be found in ASTM G142, NACE TM0198, ASTM G129, ASTM G148, ASME BPVC VIII-Division 3 Section KD-10, ASME B31.12, and/or NACE MR0175/ISO 15156.

M.4.1.4 Carbon Steel

In addition to weld ends, the chemical composition and carbon equivalent of carbon steel pressure-containing parts and pressure-controlling parts shall conform to 6.3.

M.4.1.5 Nickel-based Alloys

Use of solution annealed or annealed nickel-based alloys shall be permitted for pressure-controlling parts and drive train parts.

Solution annealed or annealed nickel-based alloys in pressure-containing parts shall conform to M.4.1.3.

Cold-worked solution annealed, or cold-worked annealed nickel-based alloys shall conform to M.4.1.3.

Precipitation-hardened nickel-based alloys in conformance to API 6ACRA, shall be permitted for pressure-controlling parts and drive train parts. Precipitation-hardened nickel-based alloys in pressure-containing parts shall conform to M.4.1.3.

M.4.1.6 Springs

Materials used for springs shall be limited to the following alloy designations:

a) UNS N07750 (alloy X750), or

b) UNS R30003, or

c) UNS R00035.

If specified by the purchaser, the following materials per API 6ACRA shall be permitted:

d) UNS N06625 (alloy 625), or

e) UNS N07718 (alloy 718).

M.4.2 Non-metallic Materials

M.4.2.1 General

The requirements of M.4.2 shall apply to all non-metallic materials used in valves for hydrogen service.

M.4.2.2 Rapid Gas Decompression

Rapid gas decompression testing of elastomeric materials shall be performed in conformance with ISO 23936-2 or NORSOK M-710 as specified in L.6, except that the testing media shall be 100% hydrogen gas.

NOTE 1 Testing of elastomeric seals may be required using representative groove geometries, at agreed test conditions.

NOTE 2 Optional RGD testing for thermoplastics may be performed for applications with elevated pressures, and temperatures at the upper and lower limits of the material. Test conditions are typically representative of the valve application. Refer to API 17J and API 17B for guidance on RGD testing of thermoplastics.

M.4.2.3 Compatibility/ageing

Elastomeric seal material shall be tested using the procedures and acceptance criteria specified in ISO 23936-2 using 100% hydrogen as the test gas, with minimum total test duration of 28 days. Temperature classification per ISO 23936-2 shall be specified. Aging samples shall be taken at 2, 7, 14, and 28 days and properties evaluated for acceptance.

Thermoplastic seal material shall be tested using the procedures and acceptance criteria described in ISO 23936-1, “Level 2 – Material Stability (short term)” using 100% hydrogen as the test gas. Temperature classification per ISO 23936-2 shall be specified.

M.4.3 Surface Treatments— Plating, Coating, and Lining

Use of a metallic coating (electroplated or electroless plated), HVOF, conversion coatings, plastic coatings and/or linings shall not be permitted to prevent hydrogen degradation of the base material or protect the base material from hydrogen exposure.

M.5 Welding

M.5.1 General

The following materials shall not be used for pressure-containing welds in hydrogen service:

a) solid-solution nickel-based alloys, or

b) precipitation-hardened nickel-based alloys.

The hardness of weld metal and HAZ shall conform to NACE MR0175 / ISO 15156.

For austenitic stainless steel, filler metal shall have a maximum carbon content of 0.03% mass fraction.

M.5.2 Overlay and Cladding

Use of overlay and cladding shall be permitted in conformance with the following:

a) Use shall not done to prevent hydrogen degradation of the base material or protect the base material from hydrogen exposure.

b) After application of the hard-facing material, the base materials shall conform to NACE MR0175 / ISO 15156.

M.5.3 Non-Destructive Examination (NDE)

For all pressure-containing welds, surface NDE shall be performed using one of the following methods:

a) Magnetic particle testing on pressure-containing welds shall conform to ASME BPVC, Section V, Article 7, and acceptance shall conform to ASME BPVC, Section VIII, Division 1, Appendix 6.

b) Penetrant testing on pressure-containing welds shall conform to ASME BPVC, Section V, Article 6, and acceptance shall conform to ASME BPVC, Section VIII, Division 1, Appendix 8.

For all pressure-containing welds, volumetric NDE examination shall be performed using one of the following methods:

c) Radiographic testing on 100 % of the welds in accordance with ASME BPVC, Section V, Article 2, and acceptance shall conform to ASME BPVC, Section VIII, Division 1, UW-51 for linear indications and ASME BPVC, Section VIII, Division 1, Appendix 4 for rounded indications.

d) Ultrasonic testing on 100 % of the welds in accordance with ASME BPVC, Section V, Article 4 and acceptance shall conform to ASME BPVC, Section VIII, Division 1, Appendix 12.

M.6 Bolting

All bolting (see 8.1 and 8.2) that can be directly exposed to the process fluid, used underground, covered with insulation, equipped with flange protectors, or otherwise denied direct atmospheric exposure (such as a face-to-face body joint on two/three-piece ball valve or gate valve bonnet with elastomeric or plastic seals) shall conform to NACE MR0175 / ISO 15156.

Material for bolting shall be limited to one of the following:

a) Carbon steel, or

b) Low alloy steel, or

c) Austenitic stainless steel, or

d) Precipitation-hardened nickel-based alloys per API 6ACRA, or

e) Other materials per M.4.1.3

M.7 Quality Control

If HSL1 is specified, the quality requirements of Section 4-14 shall apply.

If HSL2 is specified, QSL2 shall be applied at a minimum.

If HSL3 is specified, QSL3G shall be applied at a minimum.

If HSL4 is specified, QSL4G shall be applied.

M.8 Factory Acceptance Testing

M.8.1 General

Factory acceptance testing shall be performed in conformance with Table M.1.

M.8.2 High Pressure Gas Shell test

If required a high-pressure gas shell test shall conform to I.8.2, with the following exceptions:

a) Valves NPS 24 and smaller shall be tested with Method 1.

b) Valves larger than NPS 24 shall be tested using Method 1 or Method 2

c) The test duration shall be two times the minimum duration of Table I.5.

The sampling size for HSL2 shall be a minimum of one valve per type, per size and per pressure class in the purchase order shall be randomly selected and tested.

M.8.3 High Pressure Gas Seat Test

If required a high-pressure gas seat tested shall conform to I.8.3, with the following exceptions:

a) The test duration shall be two times the minimum duration of Table 10.

b) The leakage for lubricated plug valves shall not exceed ISO 5208 Rate A.

c) The leakage for metal-seated valves, except metal-seated check valves shall not exceed ISO 5208 Rate C.

d) The leakage for metal seated check valves shall not exceed five times ISO 5208 Rate D

The sampling size for HSL2 shall be a minimum of one valve per type, per size and per pressure class in the purchase order shall be randomly selected and tested.

M.8.4 Fugitive Emission Production Testing

M.8.4.1 Test Methods

For HSL3, HSL4 or when specified, fugitive emission production test shall:

a) conform to L.24.2 with acceptance criteria conforming to M.8.4.3, or

b) be tested using the method of ISO 15848-2 performed using forming gas (5% hydrogen/95% nitrogen) as the test medium.

When testing with forming gas the requirements of M.8.4.2 shall apply.

M.8.4.2 Alternative Method using Forming Gas

Test fluid for fugitive emissions test shall be forming gas.

The test shall be conducted using the helium sniffing method per ISO 15848-1 except as modified in M.8.4.2.1.2.

At the beginning of each test, a calibrated leak shall be measured to demonstrate that the sensitivity of the instrument is calibrated correctly.

M.8.4.2.1 Test Equipment

M.8.4.2.1.1 General

Fugitive emissions shall be measured with a mass spectrometer or a hydrogen leak detector.

Measuring equipment shall be capable of detecting a calibrated hydrogen leak in the magnitude of 10^{-6} mbar-l/s.

M.8.4.2.1.2 Mass spectrometers

Mass spectrometers shall have a nominal minimal sensitivity of 1 x 10^{-7} mbar-l/s for hydrogen in sniffer mode and be calibrated for use with hydrogen as the test medium.

Mass spectrometers shall:

a) not be used in vacuum mode;

b) not be used if the ratio between the maximum allowable leak rate and the hydrogen content measured in the atmospheric conditions is smaller than 10;

c) be calibrated using an external calibrated leakage.

M.8.4.2.1.3 Hydrogen Leak Detectors

Hydrogen leak detectors shall have a nominal sensitivity of at least 5 x 10^{-7} mbar-l/s and be calibrated for use with forming gas as the test medium.

Quantification of leakages shall be performed by placing the tracer probe tip against the point of leakage until a stable reading is shown. This shall be repeated three times, where the highest measured value is considered the test result. Tracer probes shall be removed from the testing surface and allowed to stabilize to a reading of 0 before repeating.

After connecting the detector probe to the instrument, the system shall be verified by passing the detector probe tip across the orifice of a calibrated leak. The probe tip shall be kept within 1/8 in. (3 mm) of the orifice of the calibrated leak. The speed of movement of the probe tip shall not exceed the speed at which the calibrated leak can be detected.

M.8.4.2.2 Calibration

Mass spectrometers and Hydrogen Leak Detectors shall be calibrated the day of the test, prior to testing, per the manufacturer’s operation and maintenance manual, using a permeation type leak or a micro capillary leak.

Calibration shall be performed prior to the first leakage measurement being performed and be repeated until it is accepted by the instrument.

Maximum deviation factor between current and previous calibrations shall be equal or less than 1.1.

Mass spectrometers calibration shall only be accepted if the background and calibrated leak rate are stabilized as per device manufacturers specification.

If a micro capillary leak is used, the set-up shall:

a) be free of leakage to the atmosphere;

b) be flushed with the test medium to eliminate air from the set-up;

c) be allowed to stabilize under pressure for a period of 10 minutes before calibration;

d) be measured using a calibrated pressure gauge or sensor;

e) not contain any fluoropolymer material.

M.8.4.3 Acceptance Criteria

Depending on the test gas used, one the following acceptance criteria shall be met:

M.8.4.3.1 Acceptance criteria helium or helium trace

Maximum leakage when testing with 100% helium shall be in accordance with Table M.2.

Table M.2 Fugitive Emission Test Acceptance Criteria – 100% Helium

Emission Tightness Class	Allowable leakage rate stem seal [a, c]	Allowable leakage rate body seal [b, c]
	mbar-l/s per mm diameter	mbar-l/s per mm diameter
A[d]	$\leq 1.78 \times 10^{-7}$	$\leq 1.78 \times 10^{-8}$
B[e]	$\leq 1.78 \times 10^{-6}$	$\leq 1.78 \times 10^{-7}$

FOOTNOTE

[a] For Stem seals; mm diameter shall be the stem diameter (in mm) at the point of measurement.

[b] For Body-to-bonnet or body-to-cover seals; mm diameter shall be the outer diameter of the gasket (in mm) at the point of measurement. For non-circular gaskets the equivalent diameter shall be taken as the perimeter divided by (pi).

[c] To be measured with helium tracer gas in mbar-l/s per mm diameter.

[d] Due to the constraints of the sniffer technique, stem seal diameters equal or smaller than 12 mm, the maximum leakage shall be 2.1×10^{-6} mbar-l/s and for body seal diameters equal or smaller than 120 mm, the maximum leakage shall be 2.1×10^{-6} mbar-l/s.

[e] Due to the constraints of the sniffer technique, stem seal diameters equal or smaller than 2 mm, the maximum leakage shall be 2.0×10^{-6} mbar-l/s and body seal diameters equal or smaller than 12 mm, the maximum leakage shall be 2.1×10^{-6} mbar-l/s.

M.8.4.3.2 Acceptance criteria forming gas

Maximum leakage when testing with forming gas shall be in accordance with Table M.3

Table M.3 Fugitive Emission Test Acceptance Criteria – Forming gas

Emission Tightness Class	Allowable leakage rate stem seal [a, c]	Allowable leakage rate body seal [b, c]
	mbar-l/s per mm diameter	mbar-l/s per mm diameter
A[d]	$\leq 5.93 \times 10^{-8}$	$\leq 5.93 \times 10^{-9}$
B[e]	$\leq 5.93 \times 10^{-7}$	$\leq 5.93 \times 10^{-8}$

FOOTNOTE

[a] For Stem seals; mm diameter shall be the stem diameter (in mm) at the point of measurement.

[b] For Body-to-bonnet or body-to-cover seals; mm diameter shall be the outer diameter of the gasket (in mm) at the point of measurement. For non-circular gaskets the equivalent diameter shall be taken as the perimeter divided by (pi).

[c] To be measured with forming gas tracer gas in mbar-l/s per mm diameter.

[d] Due to the constraints of the sniffer technique, stem seal diameters equal or smaller than 34 mm, the maximum leakage shall be 2.1×10^{-6} mbar-l/s and for body seal diameters equal or smaller than 340 mm, the maximum leakage shall be 2.1×10^{-6} mbar-l/s.

[e] Due to the constraints of the sniffer technique, stem seal diameters equal or smaller than 4 mm, the maximum leakage shall be 2.4×10^{-6} mbar-l/s and body seal diameters equal or smaller than 40 mm, the maximum leakage shall be 2.1×10^{-6} mbar-l/s.

M.8.4.4 Sample Strategy

For HSL3, the purchase order quantity determines how many samples (n) shall be drawn from each lot, as indicated in Table M.4. The samples shall be selected at random from each lot. When the lot consists of various sizes and pressure classes, then sampling shall be applied in such a way that it covers the entire production range from that lot.

Table M.4 – Sample Strategy for Production Testing

Purchase order size per tightness class	Minimum Sample size (n)
1	1
2 – 10	2
11 – 100	3
> 100	5
Note: Alternative sample sizes may be agreed between manufacturer and purchaser.	

For HSL4 100% of valves shall be tested.

M.8.4.5 Lot Acceptance

The lot shall be accepted when each tested valve meets the acceptance criteria.

In case a valve fails, the lot shall be rejected. The valve(s) that failed the test shall be repaired and retested. Additional valves equal to the minimum sample size shall be drawn from the failed lot for the retest. Upon subsequent rejection, the failed valve(s) shall be repaired and retested. The retest shall contain all valves from the lot.

Leakage of test equipment does not constitute a valve failure requiring the lot to be rejected. Test equipment shall be repaired or replaced, and the leakage test shall be repeated.

M.8.5 Pressure Testing Valves with Hydrostatic End Load

For HSL4, valve shall be pressure tested per L.28.

M.8.6 Anti-static Test

Valve shall have anti-static test per L.5.

M.9 Marking

Valve nameplate shall identify the HSL (see M.2) in addition to the applicable QSL and other marking required by section 4 through 14.

NOTE This information may be merged with the marking requirements of Section 12 or may be on a separate nameplate.

M.10 Minimum Documentation and Retention

In addition to the requirements of Section 14, the following documents shall be maintained by the manufacturer for a minimum of 10 years following the date of manufacture (see 3.1.12):

a) Certificate of conformance to NACE MR0175/ ISO 15156 for applicable metallic materials and welds.

b) Statement of conformance to Fugitive Emissions certificate as per ISO 15848-01.

c) Compliance with local directives and regulations (e.g., including but not limited to PED, ATEX, ASME, CRN certification) when applicable to the specific design.

d) Fire safe certificate.

e) RGD certificate for non-metallic materials.

f) Compatibility/Ageing certificate of non-metallic materials.

g) Statement of conformance to Anti-static requirements

h) Validation records.

i) Test procedure and material test report if materials per M.4.1.3 are used.

j) Test report fugitive emissions production test.

NOTE Purchaser or regulatory requirements can specify additional records or a longer record retention period.

Bibliography

The following shall be added to the end:

[30] *ASME* ATP-PT-003, Hydrogen Standardization Interim Report for Tanks, Piping, and Pipelines

[31] Hydrogen Embrittlement of steels in High pressure H2 Gas and Acidified H2S Saturated Aqueous Brine Solution (Anton Trautmann, Gregor Mori and Bernd Loder).

[32] Corrosion in the Petrochemical Industry (2nd edition) – 17.8.2.6 – Hydrogen embrittlement.

[33] CEN / TR 17797: 2022, *Gas infrastructure - Consequences of hydrogen in the gas infrastructure and identification of related standardisation need in the scope of CEN/TC 234*

[34] NASA / TM 2016-218602, *Hydrogen Embrittlement.*

[35] API RP 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants.*