Specification for Gas Lift Equipment

API SPECIFICATION 11V1
SECOND EDITION, FEBRUARY 1, 1995

American Petroleum Institute
1220 L Street, Northwest
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Exploration and Production Department

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This specification shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution. This edition of API Specification 11V1 supercedes the first edition dated July 1, 1994 and includes items approved by letter ballot through February, 1995.

Specification for Gas Lift Equipment

1 Scope

1.1 PURPOSE

This specification was formulated to provide gas lift valves, reverse flow (check) valves, orifice valves, dummy valves and wireline retrievable valve mandrels (WRVM) that are consistently manufactured to a predictable level of quality. Technical content provides requirements for design, materials, tests and inspecting, welding, marking, storing and shipping. This specification is intended as a quality based specification and does not assure dimensional interchangeability between manufacturers.

1.2 APPLICATIONS

1.2.1 Equipment

This specification is for gas lift valves, reverse flow (check) valves, orifice valves, dummy valves and the WRVM's used as a receiver for these valves or other devices used to enhance oil well production or treat oil or gas wells. This specification is compiled such that the requirements for gas lift valves and WRVM's are in separate sections and unless indicated do not overlap requirements.

1.2.2 Service Classification

1.2.2.1 Valve Service Class

For gas lift valve class of service conditions refer to 4.3.3.

1.2.2.2 WRVM Service Class

For WRVM class of service conditions refer to 5.1.1.2.

2 References

2.1 GENERAL

This specification includes by reference, either in total or in part, the latest edition of other API, industry and government standards listed below.

2.2 REQUIREMENTS

Specific requirements, as outlined in the text, of other standards included by reference in this specification are essential to quality.

API

5CT *Casing, Tubing, and Drill Pipe*
5B *Threading, Gaging, and thread inspection of Casing, Tubing and Line Pipe threads*

ASME

Boiler and Pressure Vessel Code, Section V, "Non-Destructive Examination", Section VIII, "Rules for Construction of Pressure Vessels", Section IX, "Welding and Brazing Qualification"

ASME/ANSI

Std. B 1.20.1-1983 (R1992) Pipe Threads, General Purpose
Std. B 1.20.5-1991 Gaging for Dryseal Pipe Threads

ASTM

A370 *Mechanical Testing of Steel Products*
D-1415 *Test Method for Rubber Property—International Hardness*
D-2240 *Test Method for Rubber Property—Durometer Hardness*
E10 *Brinell Hardness of Metallic Materials*
E18 *Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*
E94 *Guides for Radiographic Testing*
E140 *Standard Hardness Conversion Tables for Metals*
E165 *Practice for Liquid Penetrant Inspection Method*
E709 *Practice for Magnetic Particle Examination Military Standards*
H-6875 *Heat Treatment of Steels—Aircraft Practice Process*
413C *Visual Inspection Guide for Elastomeric O-Rings*
105E *Sampling Procedures and Tables for Inspection By Attributes*
120 *Gage Inspection*

NACE

MR-01-75 *Sulfide Stress Cracking Resistant Metallic Material for Oil Field Equipment*

SAE

AS-568A *Aerospace Size Standards for O-Rings*

SNT

TC.1A *Personnel Qualification and Certification Nondestructive Testing*

3 Abbreviations and Definitions

ABBREVIATIONS

API American Petroleum Institute
AQL Acceptable Quality Level as defined in MIL-STD-105E
ASME American Society of Mechanical Engineers
ASTM American Society for Testing and Materials
AWS American Welding Society

HAZ	Heat Affected Zone
HTS	Heat Treatment Specification
MIL-STD	Military Standard, U.S.A.
MSC	Mandrel Service Classification
NACE	National Association of Corrosion Engineers
NDE	Non Destructive Examination
PQR	Procedure Qualification Record
Ra	Microinch Roughness Average
SAE	Society of Automotive Engineers
SNT	Society for Non-Destructive Testing
WPQ	Welder/Welding Operator Performance Qualification
WPS	Welding Procedure Specification
WRVM	Wireline Retrievable Valve Mandrel

DEFINITIONS

3.1 coating: Internal and/or external application of a material for corrosion protection, paraffin control, etc.

3.2 class 1 or standard service: This class of equipment shall be designed for use in wells which do not exhibit the detrimental effects caused by stress corrosion cracking.

3.3 class 2 or stress corrosion cracking service: This class of equipment shall be designed for use in wells where corrosive agents could be expected to cause stress corrosion cracking. Class 2 equipment shall be manufactured from materials which are resistant to stress corrosion cracking in accordance with NACE Std MR-01-75, latest revision.

3.4 date of manufacture: The date of manufacturer's final acceptance of finished equipment.

3.5 deflector or discriminator: A section designed into WRVM's that will allow passage of sidepocket devices but will prevent entry of through tubing equipment of larger diameter.

3.6 end connections: Threads integral to the mandrel, male or female, used to connect the mandrel to the tubing string.

3.7 external test pressure: The differential pressure between applied external pressure and internal atmospheric pressure at which a mandrel is tested for collapse resistance during manufacturing or design verification testing.

3.8 heat (cast lot): Material originating from a final melt. For remelted alloys, a heat shall be defined as the raw material originating from a single remelted ingot.

3.9 high range valves: Valves intended to operate in the P_{vcT} pressure range from 1200 psi [8274 kPa] and above.

3.10 internal test pressure: The differential pressure between applied internal pressure and external atmospheric pressure at which a mandrel is tested for burst resistance during manufacturing.

3.11 job lot: a group or quantity of a piece part, subassembly or assembly which is grouped or processed together during the manufacturing process.

3.12 low range valves: Valves intended to operate in the P_{vcT} pressure range from 400 psi [2758 kPa] to 800 psi [5516 kPa].

3.13 manufacturer: As used in this text shall be the gas lift equipment manufacturer unless otherwise specified.

3.14 mid range valves: Valves intended to operate in the P_{vcT} pressure range from 800 psi [5516 kPa] to 1200 psi [8274 kPa].

3.15 orienting sleeve: A section designed into WRVM's that acts together with certain wireline tools to aid in radial and vertical alignment of tools used to install and remove sidepocket equipment.

3.16 painting: External application of paint for cosmetic purposes.

3.17 yensile load (pounds-force) [newton]: The load carrying capability in pounds of load in tension that may be applied to a WRVM as defined by the manufacturer.

3.18 test pressure: The maximum differential pressure between applied pressure and atmospheric pressure during the process of equipment acceptance or design verification testing.

3.19 traceability, job lot: The ability for individual components to be identified as originating from a job lot which identifies the included heat(s).

3.20 wireline: Equipment and techniques used to perform various operations in a well using a long, continuous length of solid or stranded wire and appropriate spooling equipment at the surface and weight and specialized tools attached to the well end of the wire. See "Wireline Operations and Procedures", API book 5, Vocational Training Series, 1983.

3.21 wireline retrievable valve mandrel (WRVM): A gas lift valve mandrel that provides access to the gas lift valve or other sidepocket device by wireline methods.

3.22 yield strength: The stress level measured at room temperature, expressed in pounds per square inch of loaded area, at which material plastically deforms and will not return to its original dimensions when the load is released. All yield strengths discussed in this standard shall be considered as being the 0.2% yield offset strength per ASTM A370.

4 Gas Lift Valves, Reverse Flow (Check) Valves, Orifice Valves and Dummy Valves

4.1 GAS LIFT VALVE DESIGNATION

4.1.1 WIRELINE RETRIEVABLE valves (Fig. 1) are run and retrieved by wireline and are set in a receiving "pocket" inside a WRVM. TUBING RETRIEVABLE valves (Fig. 2) are mounted on the outside of the tubing on a tubing retrievable valve mandrel and are retrieved by pulling the tubing. The reverse flow valve for a TUBING RETRIEVABLE valve may or may not be an integral part of the gas lift valve. Gas lift valves are described in 4.1.2 API Valve Designation.

4.1.2 API Valve Designation

API 11V1 VALVE DESIGNATION

XXX X X X X X

- Service Class
  - 1 —Standard Service See Table 2.
  - 2 —Stress Corrosion Cracking. See Table 2.
- Flow Configuration
  - 1 —See Figure 3.
  - 2 —See Figure 3.
  - 3 —See Figure 3.
  - 4 —See Figure 3.
- Valve Type
  - P —Injection Pressure Operated.
  - F —Production Pressure Operated.
  - X —Pilot Operated.
  - Z —Other.
  - D —Dummy.
  - O —Orifice.
- Closing Force
  - G —Gas Charge.
  - S —Spring Loaded.
  - C —Combination Spring and Gas Charge.
  - N —None.
  - Z —Other.
- Valve Retrieval Method.
  - W—Wireline Retrievable.
  - T —Tubing Retrievable.
  - Z —Other Retrieval Method.
- Valve Size
  - 062-0.625 inches [15.9 mm] OD
  - 100-1.000 inches [25.4 mm] OD
  - 150-1.500 inches [38.1 mm] OD

For example, if Figure 4 is a 1.5 inch [38.1 mm] OD tubing retrievable valve for standard service the designation would be:

150 T S P 1 1

If Figure 5 is a 1.5 inch [38.1 mm] OD wireline retrievable valve for stress corrosion cracking service the designation would be:

150 W G P 1 2

If Figure 6 is a 1.5 inch [38.1 mm] OD tubing retrievable valve for standard service the designation would be:

150 T G X 11

4.2 DESIGN

4.2.1 General

Gas lift valves, orifice valves, reverse flow valves and dummy valves designed and manufactured in accordance with this specification shall be constructed of materials in compliance with 4.3 of this specification.

4.2.2 Interchangeability

Components and sub-assemblies of each type, model and size shall be designed, manufactured and identified to provide interchangeability within the product line of any one manufacturer. Stem and seats lapped to form matched pairs are considered as a single component under this section.

4.2.3 Dimensions

Dimensional tolerance of components or subassemblies shall be such that cumulative tolerances will not preclude proper operation described in the testing requirements of 4.4 of this Specification.

4.2.4 Packing

The diameters of the external packing on all WIRELINE RETRIEVABLE valve types (4.1.2) shall be designed using the polish bore dimensions in Table 1. Material requirements for the packing are not addressed by this specification.

4.2.5 Attachment

TUBING RETRIEVABLE gas lift valves and reverse flow valves shall be connected to the mandrel using National Pipe Thread (NPT) connections according to ASME/ANSI standard B1.20.1-83 or ASME/ANSI standard B1.20.5-78.

Table 1—Nominal Polish Bore Diameters for Wireline Retrievable Valve Mandrels

Nominal Valve OD	Upper Seal	Lower Seal
In Inches		
1	1.027 ± 0.005	1.027 ± 0.005
1$^1/_2$	1.558 ± 0.005	1.496 ± 0.005
In Millimeters		
1	26.086 ± 0.127	26.086 ± 0.127
1$^1/_2$	39.573 ± 0.127	37.984 ± 0.127

4.3 MATERIAL REQUIREMENTS

4.3.1 Certification

Components shall be traceable to heat(s) or other material manufacturer's report or supplier certification report, except for the following components where a certificate of compliance to the manufacturer's written specification is required:

— bellows
— copper gaskets

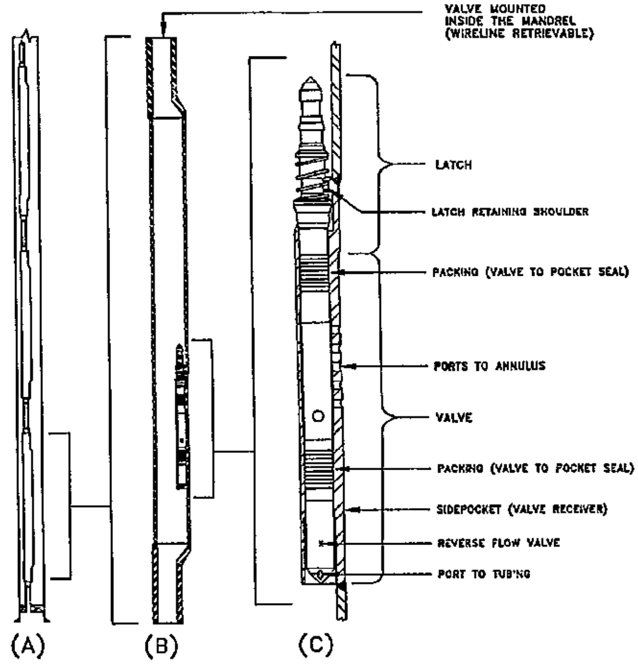

Figure 1—Examples of Wireline Retrievable Valve

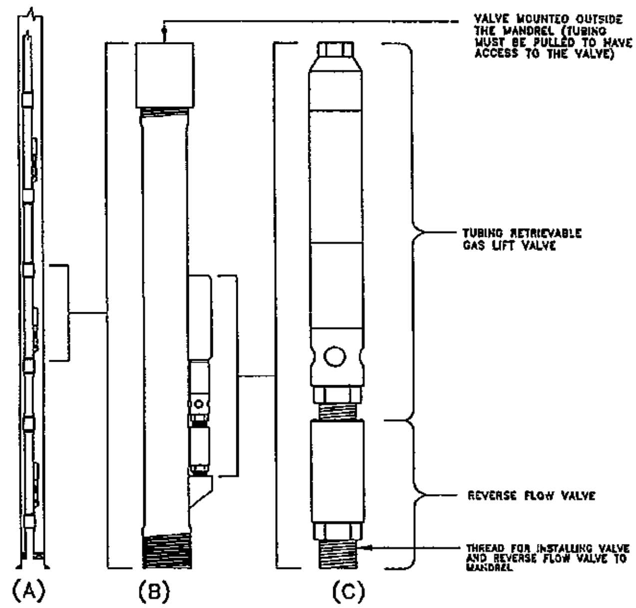

Figure 2—Examples of Tubing Retrievable Valve

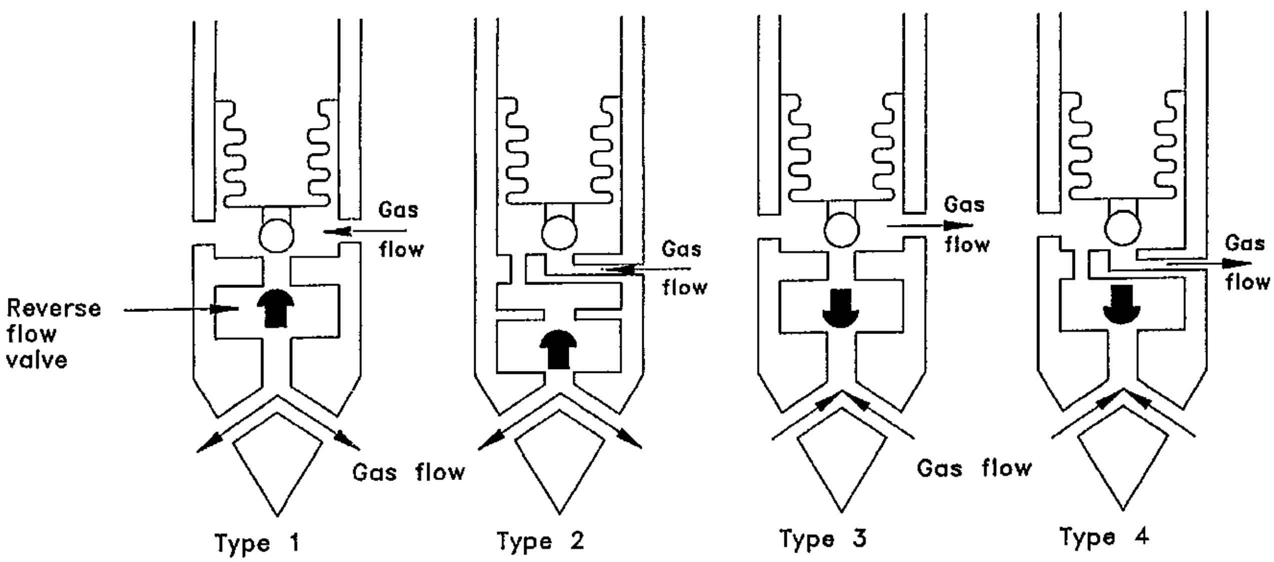

Figure 3

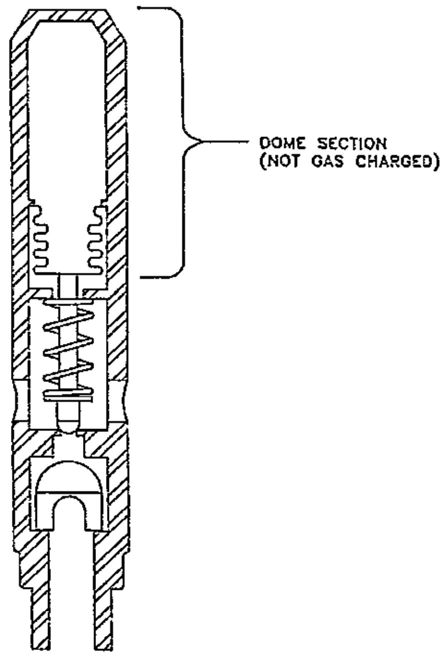

Figure 4—Typical Injection Pressure Operated Spring Loaded Valve

Note: The case of a combination spring and gas charged closing force valve the valve will also have a gas charge.

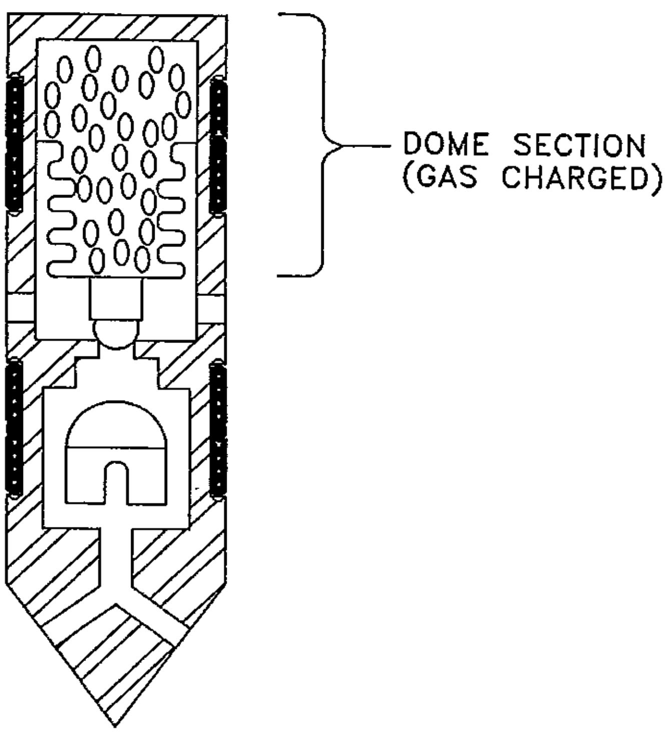

Figure 5—Typical Injection Pressure Operated Gas Charged Valve

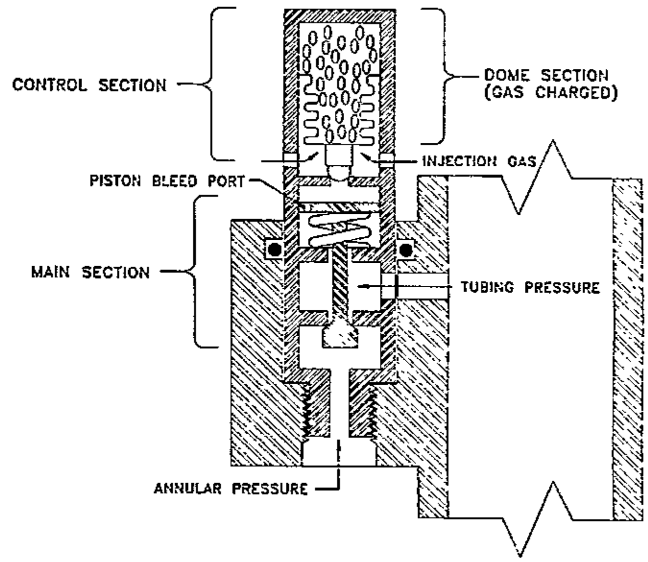

Figure 6—Typical Pilot Operated Gas Charged Valve

— core valves
— carbide balls and seats
— ceramic balls and seats
— snap rings
— brazing and solder material
— elastomeric materials
— plastic or polymeric materials
— pulsation dampening fluids
— common hardware items such as nuts, bolts, shear pins, set screws, fittings, and shear screws.

4.3.2 Metals

Metallic components supplied under this specification shall comply with the manufacturer's written specifications. Except for items listed in 4.4, manufacturer's specifications shall define:

a. Chemical composition limits
b. Heat treatment conditions
c. Mechanical property limits
   1. Tensile strength
   2. Yield strength
   3. Elongation
   4. Hardness

4.3.3 Service Classification

Equipment manufactured in accordance with this specification shall conform to one or more of the following classes of service:

4.3.3.1 Class 1. Standard Service

This class of equipment shall be designed for use in wells which do not exhibit the detrimental effects caused by stress corrosion cracking. Metals such as stainless steels and monel are in general use and are considered acceptable for standard service.

4.3.3.2 Class 2. Stress Corrosion Cracking Service

This class of equipment shall be designed for use in wells where corrosive agents could be expected to cause stress corrosion cracking. Class 2 equipment shall be manufactured from materials which are resistant to stress corrosion cracking in accordance with NACE Std MR-01-75, latest revision.

Table 2—Valve Service Classifications

Classifications	Characteristics
Class 1—Standard Service	Non Sour Service
Class 2—Stress Corrosion Cracking	Stress Corrosion Cracking[1]

[1]Per NACE MR-01-75

4.3.4 Elastomeric Materials

Each elastomeric component shall comply with the manufacturer's written specifications. Manufacturers providing equipment to this specification shall be responsible for the following.

4.3.4.1 Tolerances

The tolerances of O-rings shall be in compliance with SAE AS 568A, latest revision. Other packing elements shall meet dimensional tolerances of the manufacturer's written specifications. Sampling procedures for inspection, and the basis for acceptance or rejection of a batch lot, shall be in accordance with MIL STD 105D, latest revision, General Inspection Level II at a 2.5 AQL for O-rings and at a 1.5 AQL for other packing elements.

4.3.4.2 Hardiness

The durometer hardness of O-rings shall be measured in accordance with ASTM D-2240 or D-1415, latest revision. The preferred method is to conduct the hardness test on a test specimen from each batch and cure cycle rather than testing individual seals. In the event such tests are to be conducted on individual seals, sampling procedures for inspection, and the basis for acceptance or rejection of a batch lot, shall be in accordance with those cited in 4.3.4.1 above for O-rings or other packing elements respectively.

4.3.4.3 Visual Inspection

O-rings shall be visually inspected in accordance with MIL STD 413C, latest revision. Other packing elements shall be visually inspected according to the manufacturer's written inspection procedures and includes such items as lip damage, flashing, breaks, cracks, or other visible damage. Sampling procedures for inspection, and the basis for acceptance or rejection of a batch lot, shall be in accordance with those cited in 4.3.4.1 above for O-rings or other packing elements respectively.

4.3.4.4 Handling and Storage

Many of the elastomeric materials used for O-rings or other packing elements require special handling and storage procedures. Manufacturer's written specifications shall include handling and storage requirements including shelf life appropriate for each specific compound.

4.3.5 Other Materials

Non-metals other than elastomers shall comply with the manufacturer's written specifications.

4.3.6 Traceability

Traceability requirements shall be documented by the manufacturer and shall be sufficient to ensure that all piece parts are manufactured from materials that satisfy the manufacturer's written specifications. Traceability of piece parts is required only until the parts are used in subassemblies or assemblies. The traceability of subassemblies or assemblies is not required by this specification.

4.3.7 Bellows Attachment

The method and materials used for attachment of the bellows shall be as defined in the manufacturer's written specifications.

Some of the methods of bellows attachment are listed in Appendix C.

4.4 TESTING

4.4.1 Production Run Test

All valves shall successfully complete the following requirements.

4.4.1.1 Bellows Assembly Test

Each bellows assembly shall be tested in accordance with the manufacturer's written specifications to assure bellows integrity in accordance with 4.4.1.5 and B3.1 and B3.2 in Appendix B of this specification.

4.4.1.2 Valve Pressure Test

Each gas lift valve shall be set and pressure tested in accordance with the manufacturer's written specifications and tested in accordance with Section B3 in Appendix B.

4.4.1.3 Stem-Seat Leakage Test

Each gas lift valve shall be tested for leakage across the stem and seat in accordance with B4 in Appendix B and the manufacturer's written specifications. The leak shall not exceed 35 std cu ft/day [1 std cu m/day] when the downstream pressure on the valve is zero psig [0 kPa (ga)] and the upstream pressure on the valve is greater than PvcT with the valve in the test fixture. (P_{vcT} is defined in B4.3 in Appendix B.)

4.4.1.4 Reverse Flow Valve Leakage Test

Reverse flow valves shall be tested with air, nitrogen, helium, or other compressed gas for leakage in accordance with the manufacturer's written specifications. The leak shall not exceed 35 std cu ft/day [1 std cu m/day] with a 100 psi [689 kPa] ± 10% differential pressure across the reverse flow valve.

Note: For safety considerations, non-flammable gases such as the ones suggested should be used for all valve testing.

4.4.1.5 Shelf Test

Before delivery to the user each pressure charged valve shall be set with a minimum test rack opening pressure of 800 psig [5516 kPa (ga)] at the manufacturer's specified reference temperature, the test rack opening pressure recorded, and the valve then placed on the shelf for a minimum of 5 days. After 5 days on the shelf, the set pressure of each valve shall be checked at the manufacturer's reference temperature and any valve whose set pressure has changed more than one percent shall be rejected.

4.4.2 Valve Design Verification Tests

All valve designs must pass the test listed below in addition to the manufacturer's written specifications. A change in seat size is not considered a change in valve design for this section unless it also changes the calculated stem travel and bellows position from initial starting position to the mechanical stop by greater than 5%.

4.4.2.1 Production Run Tests

All tests under 4.4.1 of this specification are required as part of the valve design verification tests.

4.4.2.2 Probe Test

A probe test to determine the effective stem travel and valve load rate shall be made on a minimum of five gas lift valves of each bellows and/or dome configuration. The results shall be retained in accordance with B5 in Appendix B. The tests shall be conducted with P_{vcT} pressures (± 5%) of 400 psig [2758 kPa (ga)], and 600 psig [4137 kPa (ga)], and 800 psig [5516 kPa (ga)] for low range valves; 800 psig [5516 kPa (ga)], 1000 psig [6895 kPa (ga)], and 1200 psig [8274 kPa (ga)] for mid range valves; 1200 psig [8274 kPa (ga)], 1500 psig [10.34 MPa (ga)], and 1800 psig [12.41 MPa (ga)] for high range valves so long as the pressure does not exceed that recommended for the valve by the manufacturer. In case the P_{vcT} probe test pressure does exceed the valve manufacturer's recommended limit, the maximum test pressure will be the manufacturers maximum recommended value as one of the test pressures. (P_{vcT} is defined in B4.3 in Appendix B.) Probe test procedure is described in B5 in Appendix B of this specification.

4.4.2.3 Valve Insertion Test

Valve insertion test shall be conducted on wireline retrievable valves. A minimum of 5 valves shall be tested in the vertical position. The set pressure of each of the 5 valves shall not change more than one percent after being set in the pocket for the valve design to be acceptable.

The valve insertion test procedure is described in B6 in Appendix B, of this specification.

4.4.2.4 Reverse Flow Valve Closure Test

A minimum of five reverse flow valves shall be tested with water in accordance with the manufacturer's specifications to establish the minimum flow rate for closure and the results shall be recorded. Form 3 of Appendix B is available as a convenient place to record the data.

4.5 MARKING

4.5.1 Assemblies

All complete assemblies furnished under this Specification shall be marked in accordance with NACE STD MR-01-75, latest revision as follows:

Manufacturer's name or trademark.
Spec 11V1.
Date of manufacture.

4.5.2 Parts

There is no requirement for marking individual parts.

4.5.3 Superseding of 4.5.1

This section shall be superseded by Appendix E of this specification when applicable.

5 Wire Line Retrievable Valve Mandrels

5.1 GENERAL REQUIREMENTS

5.1.1 Design Requirements

5.1.1.1 Pressure and Load

5.1.1.1.1 Some WRVM's, particularly those constructed with oval pipe, have a test pressure that is lower than the test pressure of the tubing string in which they are installed.

5.1.1.1.2 Temperature and the various tensile, compressive and bending loads that may reduce the pressure rating are beyond the scope of this specification.

5.1.1.1.3 The tensile load in pounds force [newton] shall be specified by the manufacturer.

5.1.1.2 Service Classification

Mandrel Service Classification (MSC) will indicate the acceptable service for a particular WRVM. WRVM's shall be designed to operate in a mandrel service classification as shown in Table 3.

Table 3—Mandrel Service Classifications

Classifications	Characteristics
Class 1—Standard Service	Non Sour Service
Class 2—Stress Corrosion Cracking	Stress Corrosion Cracking[1]

[1]Per NACE MR-01-75

5.1.1.3 General

5.1.1.3.1 It is considered good design practice for all exterior protrusions to be well rounded and/or beveled to prevent hanging as the mandrels are lowered into or retrieved from the well.

5.1.1.3.2 It is considered good design practice for all interior surfaces to be free of sharp shoulders and crevices that have no design function but which may cause undesired hanging of properly designed wireline tools or result in trapping the wireline wire.

5.1.1.4 Packing Bores (WRVM'S)

5.1.1.4.1 The offset of the center lines of one packing bore to the other within a sidepocket shall be such that they not exceed 0.005 inches [0.127 mm] or a total indicator reading of 0.010 inches [0.254 mm].

5.1.1.4.2 The sidepocket bore(s) designed to accommodate the valve packing shall have an as-machined finish of 63 Ra maximum. Sections of the sidepocket I.D. not designed for packing-to-bore sealing but through which the packing must move shall have an as machined finish of 63 Ra maximum or an I.D. at least 0.050 inches [1.225 mm] larger than the maximum packing O.D. of the valve.

5.1.1.4.3 The dimensions in Table 4 shall be utilized as the minimum and maximum packing bore diametral dimensions.

Table 4—Nominal Polish Bore Diameters for Wireline Retrievable Valve Mandrels

In Inches		
Nominal Valve OD	Upper Seal	Lower Seal
1	1.027 ± 0.005	1.027 ± 0.005
1 1/2	1.558 ± 0.005	1.496 ± 0.005
In Millimeters		
Nominal Valve OD	Upper Seal	Lower Seal
1	26.086 ± 0.127	26.086 ± 0.127
1 1/2	39.573 ± 0.127	37.984 ± 0.127

5.1.1.5 Weld Joint

Joint designs shall be documented in the manufacturer's written specifications. The strength of the weld joint as determined by the Procedure Qualification Record (5.1.3.3) shall meet the design criteria of the manufacturer.

5.1.1.6 Design Methods

5.1.1.6.1 WRVM bodies are designed using all or some of the following: finite element analysis, proprietary equations, standard equations, experimental stress analyses and proof test analysis. This specification does not dictate the methods, equations or procedures for design purposes.

5.1.1.6.2 All pressure containing parts shall be designed to satisfy the manufacturer's test pressures and the service conditions requirements in Section 5.1.1.2 and the assumptions, calculations, and/or other design criterion shall be detailed in the appropriate design file.

5.1.2 Metallic Material Requirements

5.1.2.1 General

Materials may include but are not limited to low alloy steels, martensitic stainless steels, duplex stainless steels and high nickel alloys. Metallic components shall comply with the manufacturer's written specifications which shall define:

Chemical Composition Limits
Heat Treatment Conditions
Mechanical Property Limits (Determination in accordance with ASTM A370 practices)
Tensile Strength (psi) [kPa]
Yield Strength (psi) [kPa]
Elongation (%)
Hardness BHN (HRC)

5.1.2.2 Material Chemical Composition

Material chemical composition shall be determined on a heat of material basis.

5.1.2.3 Material Certification

Original material manufacturer's mill test certificate or supplier certification of test results is acceptable if the certifications include test results for mechanical properties and chemical composition for that heat of material. If the material will be altered by subsequent processes which changes it properties, then acceptance will be based on either hardness or mechanical properties per ASTM A-370 from the heat of material in question. These tests will be completed using the heat treat cycle for which the material is to be qualified. If the initial test specimen fails, then two additional tests shall be successfully performed in order to qualify the material. The material shall be rejected if the results of either of two additional tests do not meet specified requirements. If hardness is used for final acceptance, then Hardness-Strength correlations will be documented by the manufacturer for that type of material.

5.1.2.4 Heat Treatment Processing

5.1.2.4.1 All heat treatment operations shall be performed utilizing equipment qualified in accordance with the requirements specified by the manufacturer which shall include the requirements of Appendix D of this specification.

5.1.2.4.2 Written manufacturer's heat treating specifications shall include:

Furnace Loading
Temperatures and Time at Temperature
Thermal Cycle
Quenchant
Special Processing if Required

5.1.3 Welding

5.1.3.1 General

All welding procedures, welders and welding operators shall be qualified in accordance with Section IX, ASME Boiler and Pressure Vessel Code. Base metals that are not classified under the ASME P-number grouping shall be qualified as unassigned metals in accordance with QW-424.1, ASME Section IX.

5.1.3.2 Welding Consumables

Welding consumables shall conform to AWS or manufacturer's written specifications. The manufacturer shall have a written procedure for storage and control of welding consumables. Materials of low hydrogen type shall be stored and used as recommended by the consumable manufacturer to retain their original low hydrogen properties.

5.1.3.3 Welding Procedure Specification (WPS) Qualification and Procedure Qualification Record (PQR)

5.1.3.3.1 Welding shall be performed in accordance with Welding Procedure Specifications written and qualified in accordance with Article II of ASME Section IX. The WPS shall describe all the essential and nonessential variables as defined in ASME Section IX.

5.1.3.3.2 The Procedure Qualification Record shall record all essential variables as defined in ASME Section IX of the weld procedure used for the qualification test(s). Both the WPS and the PQR shall be maintained as records per the requirements of 5.1.4.6 of this specification.

Note: Hardness Testing. The test weldment for hardness testing shall have the same type of post-weld heat treatment as the final product. For mandrel service classification 2, hardness tests across the weld, base material and heat affected zone (HAZ) cross section shall be performed per ASTM E-18 and recorded as part of the PQR. Maximum hardness values for class 2 service shall not exceed NACE MR-01-75 requirements.

5.1.3.4 Welder/Welding Operator Performance Qualification (WPQ)

5.1.3.4.1 Welders and welding operators shall be qualified in accordance with Article III of ASME section IX.

5.1.3.4.2 Records of Welding Performance Qualifications (WPQ) test shall include all welding parameters as detailed in ASME Section IX.

5.1.3.5 Welding Requirements

Welding shall be performed using WPS(s) qualified to the requirements of this specification. Welders/welding operators shall be qualified per 5.1.3.4 of this specification prior to welding all WPS(s)

5.1.3.6 Welding Controls

5.1.3.6.1 The manufacturer's welding control system shall include requirements for monitoring, updating, and controlling the qualifications of welders/welding operators and the use of welding procedure specifications.

5.1.3.6.2 Instruments utilized to verify temperature, voltage, and amperage shall be serviced and calibrated in accordance with the mandrel manufacturer's written procedure.

5.1.4 Quality Control

5.1.4.1 Pressure Measuring Devices

5.1.4.1.1 Test pressure measuring devices shall be either pressure gages with a 3.93 inch (100 mm) minimum face diameter or pressure transducers. Pressure transducers, digital readouts and gauges shall be readable to at least ± 0.5% of full scale range.

5.1.4.1.2 Pressure measuring devices shall be calibrated to ± 2% full scale accuracy.

5.1.4.1.3 Pressure measurements shall be made at not less than 25% nor more than 75% of the full span of the pressure gage. Pressure transducers shall be used within their calibrated range.

5.1.4.1.4 Pressure measuring devices shall be calibrated with a master pressure measuring device or a dead weight tester. Pressure gauges shall be calibrated at 25% ± 2.5%, 50% ± 2.5%, and 75% ± 2.5% of scale and pressure transducers shall be calibrated over their intended range of use as specified in manufacturer's documents.

5.1.4.1.5 Calibration intervals shall be established for calibration based on repeatability and degree of usage. Calibration Intervals shall be a maximum of three months until recorded calibration history can be established. Intervals may be lengthened and shall be shortened based on calibration history. The calibration interval cannot be increased by more than twice the previous interval.

5.1.4.2 End Connection Measuring Equipment

Equipment necessary for measuring API thread form shall be calibrated per the requirement of API 5CT and 5B. Equipment used to measure threads other than API shall be calibrated in accordance with thread manufacturer's written procedures.

5.1.4.3 Other Equipment

Other equipment used for final acceptance shall be identified, controlled, calibrated and adjusted in accordance with 5.1.4.1.5.

5.1.4.4 Quality Control Personnel Qualifications

5.1.4.4.1 Non-destructive examination personnel shall be qualified in accordance with requirements specified in Recommended Practice SNT.TC.1A., Level II.

5.1.4.4.2 Personnel performing visual examinations shall have an annual eye examination in accordance with SNT.TC.1A, as applicable to the discipline to be performed.

5.1.4.4.3 Personnel performing visual inspection of welding operations and completed welds shall be qualified and certified as follows:

- AWS certified welding inspector, or
- AWS certified associate welding inspector, or
- Welding inspector certified by the manufacturer's documented training program which is equivalent to AWS certified welding inspector program.

5.1.4.5 Quality Control Equipments

5.1.4.5.1 Nondestructive examination (NDE) instructions for examination of welds shall be detailed in manufacturer's written procedures and comply with the requirements of this specification. All NDE instructions shall be approved by the applicable manufacturer's accepted SNT.TC.1A Level III examiner.

5.1.4.5.2 Acceptance of all materials shall be indicated either on the materials or in the records traceable to the materials.

5.1.4.5.3 Hardness testing shall be performed in accordance with the procedures specified in ASTM E-10 (Brinell) or ASTM E-18 (Rockwell): Standard Test Methods for Hardness on Metallic Materials.

5.1.4.5.4 The hardness acceptance criteria shall be in accordance with the manufacturer's specifications and Table 3. All hardness conversions shall be per ASTM E-140 or in accordance with documented test results performed on a particular material.

5.1.4.5.4 Other dimensions shall be verified according to the manufacturer's written specifications.

5.1.4.5.5 NDE shall be performed and accepted according to the manufacturer's written specification that shall include the requirements defined in this paragraph.

5.1.4.5.5.1 Examination shall be on a sample basis and the minimum sample lot shall be 5% of the job lot with a one mandrel absolute minimum.

5.1.4.5.5.2 All welds and adjacent heat-affected zones of the sample lot shall be non-destructively examined by one or more of the following methods: radiography, magnetic particle, ultrasonic, or liquid penetrant as designated in the manufacturer's specification.

5.1.4.5.5.3 When the examination produces an unacceptable indication, one additional mandrel from the job lot shall be examined. If it also is found to be unacceptable, then 100% of the produced quantity shall be examined. Any unacceptable indications shall be removed, repaired, and reexamined using the original NDE method.

5.1.4.5.5.4 NDE personnel shall be qualified Level II minimum for evaluation and interpretation in accordance with ASNT Recommended Practice, SNT-TC-1A.

5.1.4.5.5.5 The following definitions shall apply:

- A linear indication is any indication in which the length is equal to or greater than three (3) times the width.
- A rounded indication is any indication which is circular or elliptical, with its length less than three (3) times its width.
- Relevant indications with either magnetic particle or liquid penetrant shall meet the following. Only those indications with major dimensions greater than 1/16 inch [1.6 mm] shall be considered relevant. Inherent indications not associated with a surface rupture (for example, mag-

netic permeability variations, non-metallic stringers) are considered non-relevant.

5.1.4.5.5.6 The radiographic method shall be per ASTM E-94. The acceptance criteria shall be per ASME Boiler and Pressure Vessel Code, Section VIII, Division I, UW-51.

5.1.4.5.5.7 The ultrasonic testing shall be per ASME Boiler and Pressure Vessel Code Section V, (Nondestructive Examination), Article 5. The acceptance criteria shall be per ASME Boiler and Pressure Code, Section VIII, Division 1, Appendix 12.

5.1.4.5.5.8 Magnetic particle inspection shall be in accordance with ASTM E-709. The acceptance criteria shall be:

- Any relevant linear indication in the base metal 3/16 inches [4.8 mm] or greater is unacceptable. No relevant linear indications are allowed for weldments or heat affected zones.
- No more than 10 relevant indications in any 6 square inch [3871 square mm] area.
- Relevant rounded indications greater than 3/16 inch [4.8 mm] are unacceptable.
- Four (4) or more relevant rounded indications in a line separated by 1/16 inch [1.6 mm] or less are unacceptable.
- Any indication of an imperfection may be larger than the imperfection that causes it; however the size of the indication is the basis for acceptance evaluation.
- Non-relevant indications shall be examined by liquid penetrant surface NDE methods, or removed and reinspected, to prove their non relevancy.

5.1.4.5.5.9 Liquid penetrant examination shall be in accordance with ASTM E-165. The acceptance criteria shall be:

- Any relevant linear indication in the base metal 3/16 inch [4.8 mm] or greater is unacceptable. No linear indications are allowed for weldments or heat affected zones.
- No more than 10 relevant indications in any 6 square inches [3871 square mm] area.
- Relevant rounded indications greater than 3/16 inch [4.8 mm] are unacceptable.
- Four (4) or more rounded relevant indications in a line separated by 1/16 inch [1.6 mm] or less are unacceptable.
- Any indication of an imperfection may be larger than the imperfection that causes it; however the size of the indication is the basis for acceptance evaluation.

5.1.4.5.6 Metallic material traceability shall include traceability to actual mill certifications. The mill certification shall be reviewed and approved.

5.1.4.5.7 Job lot material traceability is required on individual components only until the individual component is accepted by the manufacturer's final inspection.

5.1.4.5.8 Identification shall be maintained on components to facilitate traceability until manufacturer's final inspection.

5.1.4.6 Quality Control Records Requirements

Records to be maintained by the manufacturer shall include the following:

- Specific Requirements:
  WPS Welding Procedure Specification (WPS)
  PQR Weld Procedure Qualification Record (PQR)
  WPQ Welder/Welding Operator Performance Qualification (WPQ)
  NDE NDE Personnel Qualification Records
- Mandrel specific requirements:
  MSC Mandrel Service Classification A or B
  Cert. of Compliance Heat Treatment Certification of Compliance

5.1.5 End Connections

End connections shall be gauged according to API 5CT and API 5B specifications unless the end connection used is not covered by API in which case the threading manufacturer's specifications apply.

5.1.6 Equipment Marking

5.1.6.1 Metallic Marking Requirements

The metallic markings shall be made using low stress marking devices which include interrupted dot or rounded vee cold die stamp or vibratory method. The following information shall be marked on each mandrel:

- Manufacturer's Name or Mark
- Date (month and year) of final acceptance by the Manufacturer.
- API Part Number as detailed in Table 5.
- Manufacturer's Mandrel Type Identification and Part Number.

Note: If manufacturer's part number does not include thread type, size and weight then it should be added as additional information.

5.1.6.2 Painted Marking Requirements

Painted marking requirements shall include an arrow pointing up and word "UP" adjacent to the arrow in capital letters on the flat of oval mandrels and the round of round mandrels toward the upper swage.

5.1.6.3 Superseding of Section 5.1.6

This section shall be superseded by Appendix E of this specification when applicable.

5.1.7 Storing and Shipping

Table 5—API 11V1 Part Number

XXXXX — XXXXX — XXXXX

- External Test Pressure (See Table 9)
- Internal Test Pressure (See Table 9)
- S—Fluid Passage from Casing at Undercut. See Fig. 11.
  E—Fluid Passage from Casing at Undercut. Exit thru Snorkel. See Fig. 12.
  C—Fluid Passage from Tubing at Undercut. Exit thru Snorkel. See Fig. 13.
  W—Fluid Passage from Top of Pocket. Exit thru Snorkel. See Fig. 14.
- Mandrel Drift Prior to Coating. See Table 8.
- Wireline Configuration:
  A—Without Guard or Orienting Sleeve. See Fig. 7.
  B—Without Guard, with Orienting Sleeve. See Fig. 8.
  C—With Guard, without Orienting Sleeve. See Fig. 9.
  D—With Guard and Orienting Sleeve. See Fig. 10.
- 1-1" [2.54 cm] Valve Receptacle
  2-1$^1/_2$" [3.81 cm] Valve Receptacle
- Material. See Table 7.
- Tubing Connection Size. See Table 6.

5.1.7.1 Storage Preparation

The processes for draining, cleaning and/or drying after testing shall be specified in the manufacturer's written procedures.

5.1.7.2 Threaded Connections and Packing Bores

All threaded connections and packing bores shall be protected as specified in the manufacturer's written procedures.

5.1.7.3 Painting

Painting of uncoated WRVM's shall be done in accordance with the manufacturer's written procedure and the procedure shall include:

- Protection of all threads from paint spray.
- Protection of sidepocket packing bores from paint spray.

5.1.8 Coating

Prior to coating, all permanent marking per 5.1.6.1 of this specification shall be completed. No coating is allowed on or in active threads or in the sidepocket packing bore other than coating, plating or other surface treatments that are specified for these surfaces.

5.2 TESTING

5.2.1 General

The manufacturer shall document procedures and perform the following testing as detailed in this section.

5.2.1.1 NDE Testing

NDE testing shall be performed per 5.1.4.5.5 of this specification.

5.2.1.2 Hardness Testing

Each WRVM shall have hardness tests performed per 5.1.4.5.3 and the manufacturer's written procedure. The test results shall meet acceptance criteria as detailed in 5.1.4.5.4. The results of these tests are to be documented.

5.2.1.3 Mechanical

Each WRVM shall have a valve or dummy valve installed in the sidepocket. The valve or dummy valve shall be re-

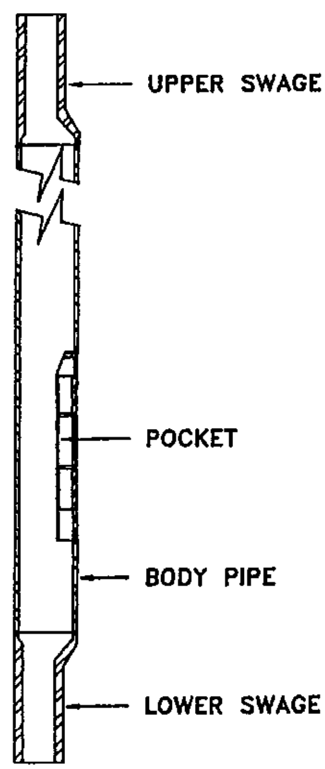

Figure 7—Without Guard/Deflector or Orienting Sleeve

moved from the WRVM sidepocket. Removal of the valve or dummy valve may be performed after the drifting procedure required in 5.2.1.5 of this specification.

5.2.1.4 Pressure Test

Each WRVM shall be hydrostatically tested in accordance with the following requirements.

5.2.1.4.1 Hydrostatic pressure test shall be conducted on all WRVM's after heat treatment.

5.2.1.4.2 The hydrostatic test shall consist of the following:

5.2.1.4.2.1 Apply pressure to test pressure level specified in the manufacturer's written procedures or to level as limited by the Special Considerations in this section.

5.2.1.4.2.2 Trap the pressure for a minimum of three minutes.

5.2.1.4.2.3 Bleed to zero.

5.2.1.4.3 One hundred percent (100%) of all mandrels shall be subjected to an internal hydrostatic test.

5.2.1.4.4 An external pressure test shall be conducted on at least one unit for design verification of the product.

5.2.1.4.5 Acceptance of the hydrostatic test shall be in accordance with the manufacturer's written procedures. The maximum permissible pressure drop shall be 0.5% of the test pressure.

5.2.1.4.6 The test pressure shall be that pressure specified in the manufacturer's written specification.

5.2.1.4.7 No hydrostatic pressure shall be greater than the maximum test pressure specified for the mandrel connecting threads when these threads are used for sealing the test pressure.

5.2.1.5 Drift

Each WRVM shall be drifted, with a valve and latch installed, with a minimum drift bar length of 42 inches [106.7 cm] and a specified drift bar O.D. for the specified tubing weight as detailed in API 5CT.

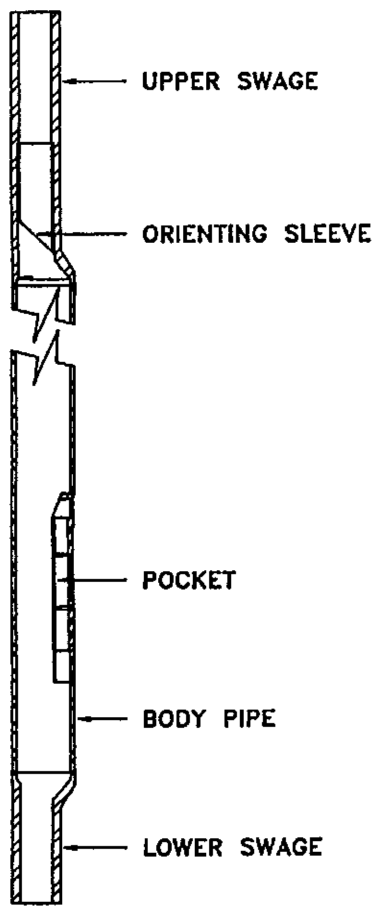

Figure 8—Without Guard/Deflector with Orienting Sleeve

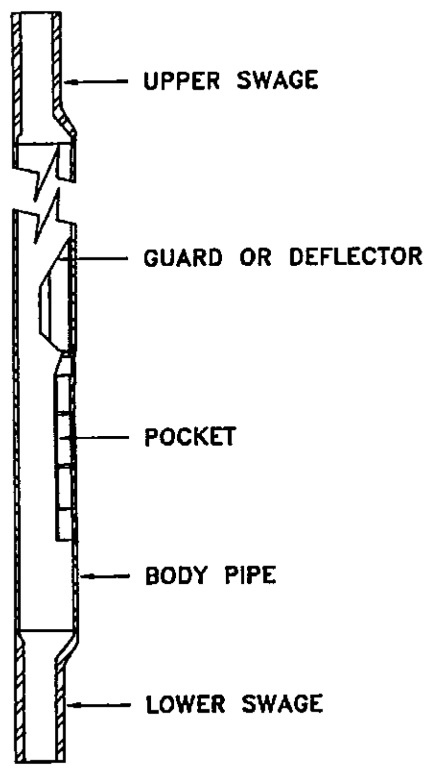

Figure 9—With Guard/Deflector without Orienting Sleeve

Table 6—Tubing Size

Tubing Size	(psi [cm])	Abbreviation
$2^1/_{16}$"	[5.24]	206
$2^3/_8$"	[6.03]	238
$2^7/_8$"	[7.30]	288
$3^1/_2$"	[8.89]	350
4.000"	[10.16]	400
$4^1/_2$"	[11.43]	450
5.000"	[12.70]	500
$5^1/_2$"	[13.97]	550
7.000"	[17.78] .	700

Table 7—Material/Service

Material	Class 1 Standard Service	Class 2 Stress Corrosion Cracking Service
4130/4140	A	L
9cr-1 mo	B	M
410 S.S.	C	N
13cr	D	P
718	E	Q
925	F	R
Other	Z	X

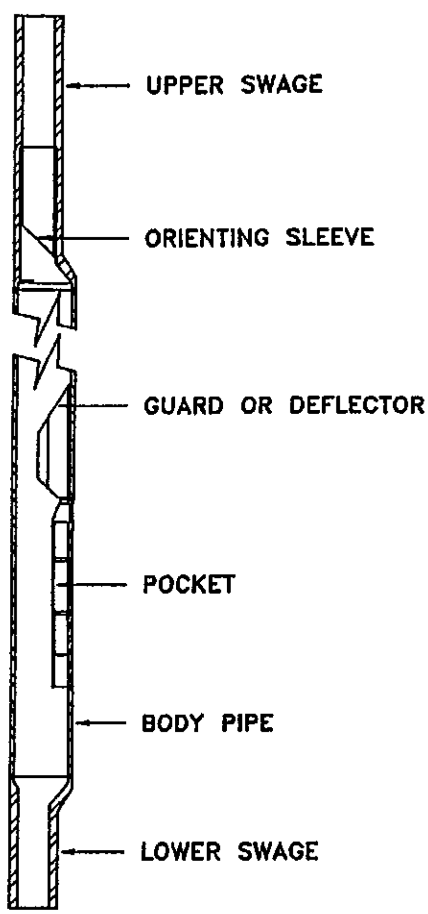

Figure 10—With Guard/Deflector with Orienting Sleeve

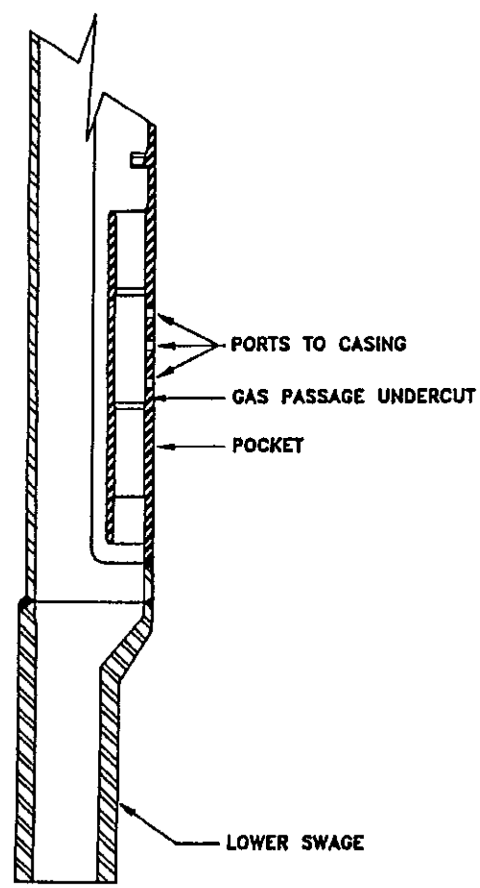

Figure 11—Fluid Passage from Casing at Undercut

Table 8—Drift Size

Drift Size	(psi [mm])	Abbreviation
1.656	[42.06]	1656
1.901	[48.29]	1901
2.347	[59.61]	2347
2.867	[72.82]	2867
3.351	[85.12]	3351
3.833	[97.36]	3833
4.283	[108.79]	4283
4.653	[118.19]	4653
6.059	[153.90]	6059

Note: The abbreviation is the actual drift size used in 5.2.1.5.
Example: Drift used in 5.2.1.5 of 2.229" [56.62 mm] will have an abbreviation of 2229.

Table 9—Minimum Test Pressure

Abbreviation	Minimum Test Pressure	(psi [MPa])
20	2000	[13.79]
30	3000	[20.68]
35	3500	[24.13]
40	4000	[27.58]
45	4500	[31.03]
50	5000	[34.47]
55	5500	[37.92]
60	6000	[41.37]
65	6500	[44.82]
70	7000	[48.29]
75	7500	[51.71]
80	8000	[55.16]
85	8500	[58.61]
90	9000	[62.05]
95	9500	[65.50]
10	10000	[68.95]
11	11000	[75.84]
12	12000	[82.74]
13	13000	[89.63]
14	14000	[96.53]
15	15000	[103.42]
16	16000	[110.32]
17	17000	[117.21]
18	18000	[124.11]

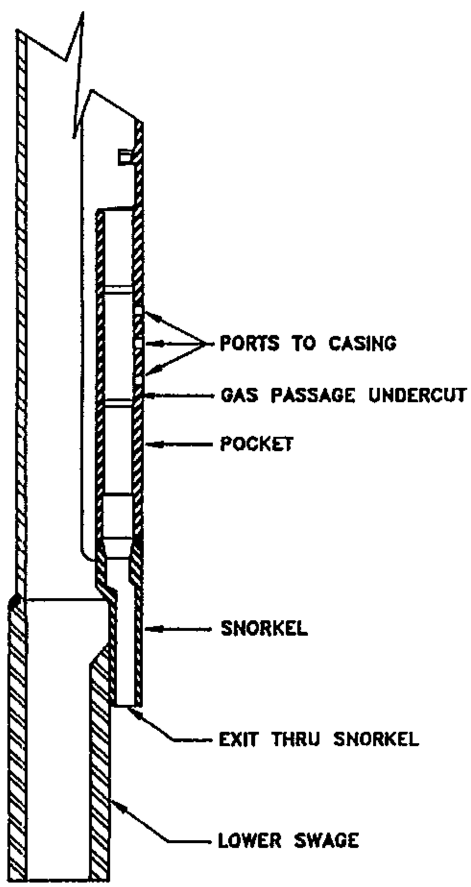

Figure 12—Fluid Passage from Casing at Undercut. Exit thru Snorkel

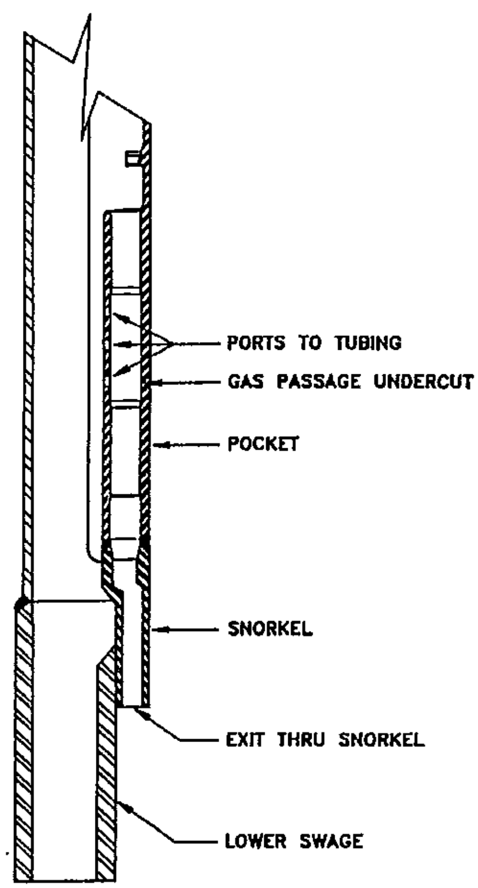

Figure 13—Fluid Passage from Tubing at Undercut. Exit thru Snorkel

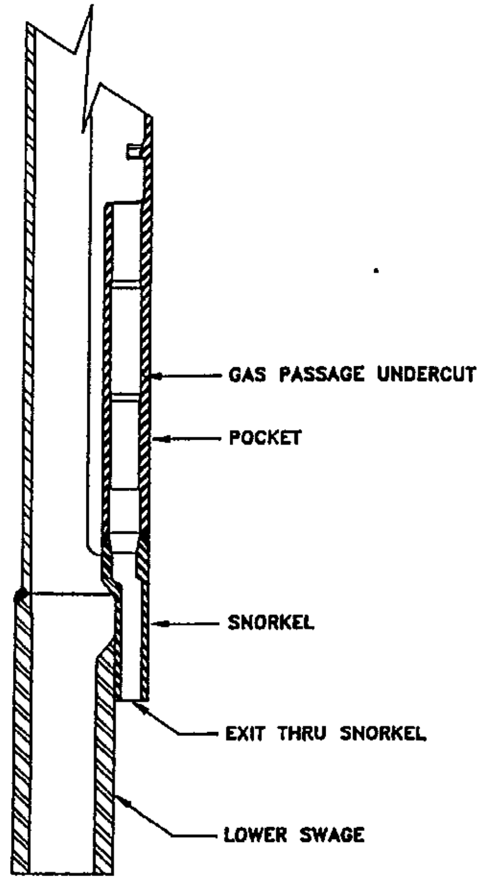

Figure 14—Fluid Passage from Tubing Thru Top of Pocket Exit thru Snorkel

APPENDIX A—QUALITY CONTROL

A.1 General

A.1.1 This appendix is mandatory as applied to API Specification 11V1 Specification for Gas Lift Equipment.

A.2 Measuring and Testing Equipment

A.2.1 Pressure gauges used for setting gas lift valves, probe testing, and valve insertion testing shall have a minimum $8^1/_2$" [216 mm] diameter face, a knife edge pointer, minimum divisions of 5 psi [1 kPa], and an accuracy of 0.25% of full scale. The pressure gauges shall be calibrated at least semi-annually. Typically, the effective range of a pressure gauge is 25% to 75% of full scale.

A.2.2 Pressure gauges used on the ager or pressure chamber shall have a minimum accuracy of 5% of full scale.

A.2.3 Pressure transducers used in lieu of pressure gauges shall have at least the same accuracy as the pressure gauge they replace.

A.2.4 Temperature measurement devices used in the water bath (see Appendix B, Paragraph B.2.2) shall have a maximum of 2°F [1°C] per division, shall be accurate to ± 1 division and shall be calibrated at least annually.

A.3 Quality Control Personnel Qualifications

A.3.1 All personnel performing quality control activities directly affecting material and product quality shall be qualified in accordance with the manufacturer's written requirements.

A.4 Quality Control Requirements

A.4.1 All quality control work shall be controlled by API Specification Q1 and by the manufacturer's written procedures which include appropriate methodology and quantitative or qualitative acceptance criteria.

A.4.2 Acceptance status of all raw materials shall be indicated on the raw materials or in the records traceable to the raw materials.

A.4.3 The manufacturer shall verify dimensions on all parts and assemblies according to the manufacturer's documented acceptance criteria.

A.4.4 The quality control requirements for assembled equipment shall consist of the tests outlined in the TESTING sections of this specification as detailed:

- Valves shall comply with 4.4.
- WRVM's shall comply with 5.2.

A.5 Quality Control Records Requirement

A.5.1 Records to be maintained by the manufacturer are listed below.

A.5.1.1 The results of all design verification tests.

A.5.1.2 Manufacturer's specifications, drawings, and bills of materials applicable to the verification tested gas lift equipment in effect at the time the equipment is tested.

A.5.2 These records shall be maintained for at least 5 years after equipment of that type, model, and size are discontinued from the manufacturer's product line.

APPENDIX B—TEST PROCEDURES FOR GAS LIFT VALVES AND REVERSE FLOW VALVES

B.1 General

B.1.1 This is a mandatory appendix as applied to API Specification 11V1 Specification for Gas Lift Equipment.

B.2 Apparatus

B.2.1 TEST RACK

This is the equipment used to set the opening and/or closing pressure of either a pressure charged or a spring loaded valve as specified by the manufacturer. There are two general types in use: the "sleeve" tester (Figure 15) and the "encapsulated" tester (Figure 16).

B.2.2 WATER BATH

This is a water filled container where several gas lift valves are immersed in the water to bring them to some predetermined controlled temperature. Since most gas lift installations calculate the gas lift set pressure at 60°F [15.5°C], the temperature of the water bath is usually controlled to 60°F [15.5°C]. If the water temperature is other than 60°F [15.5°C], then the pressure used for setting the gas lift valve must be corrected for the temperature of the water bath. This device is absolutely essential for pressure charged gas lift valves. It is not needed for spring loaded valves as they are essentially insensitive to temperature.

B.2.3 PRESSURE CHAMBER OR AGER

This device is a water filled chamber capable of at least 5000 psig [34.474 MPa (ga)]. The gas lift valves are inserted into the chamber and subjected to a predetermined external pressure for some predetermined length of time and number of cycles.

B.2.4 PROBE

This device is a micrometer to measure the stem travel as pressure is applied to the bellows. Figure 17 is a sketch of one such device. The rod of the probe is insulated electrically from the valve. A continuity tester determines when the rod touches the valve stem.

B.3 Valve Setting and Bellows Stabilization

B.3.1 PRESSURE CHARGED GAS LIFT VALVES

B.3.1.1 Remove the tail plugs, charge the dome to a pressure required by the manufacturer's written specifications. Put the valves in the water bath for a minimum of 15 minutes.

B.3.1.2 Remove a valve from the water bath and insert it in the tester. (CAUTION: Do not hold the valve by the dome as that will heat the dome and cause incorrect set pressure.) Apply gas pressure to open the valve. Measure and record the pressure required to open the valve (test rack opening pressure). If it takes longer than 30 seconds to measure the opening pressure, remove the valve from the tester and return it to the water bath for at least fifteen minutes and repeat B.3.1.2.

B.3.1.3 Install tail plugs and put all valves in the pressure chamber or ager. Bring the pressure on the chamber up to a gauge reading of 5000 psig ± 100 psi [34.474 MPa (ga) ± 689 kPa] and hold for a minimum of 15 minutes. Release the pressure and cycle the pressure to 5000 psig ± 100 psi [34.474 MPa (ga) ± 689 kPa] a minimum of three times without pausing more than one minute between cycles.

B.3.1.4 Remove the valves from the chamber and return them to the water bath for a minimum of 15 minutes.

B.3.1.5 Remove a valve from the water bath, install it in the tester, and check the opening pressure. If the opening pressure has changed 5 psi [34.5 kPa] or more, repeat B.3.1.3 through B.3.1.5 until the pressure does not change 5 psi [34.5 kPa] or more.

B.3.2 SPRING LOADED GAS LIFT VALVES

B.3.2.1 Put the valve in the tester and measure the opening pressure (or closing pressure.) Adjust the spring compression (tension), and check the opening pressure (or closing pressure). Continue until the pressure required by the manufacturer's written specification is achieved.

B.3.2.2 Put the valves in the pressure chamber, bring the pressure on the chamber up to a gauge reading of 5000 psig ± 100 psi [34.474 MPa (ga) ± 689 kPa] and hold for a minimum of 15 minutes. Release the pressure and cycle the pressure to 5000 psig ± 100 psi [34.474 MPa (ga) ± 689 kPa] a minimum of three times without pausing more than one minute between cycles.

B.3.2.3 Remove the valves from the pressure chamber. Check the opening pressure (or closing pressure). If the pressure has changed 5 psi [34.5 kPa] or more repeat B.3.2.2 and B.3.2.3 until the pressure does not change 5 psi [34.5 kPa] or more.

B.4 Valve Leakage Test

B.4.1 The test rack for this test shall have provisions for measuring low gas flow rates on the downstream side of the gas lift valve. Figure 19 and Figure 20 are sketches of two such devices.

B.4.2 This test is conducted at ambient temperatures.

B.4.3 Measure the test rack opening pressure (P_{voT}) at ambient temperature and calculate P_{vcT}.

$$P_{vcT} = P_{voT} (1\text{-}Ap/Ab)$$

Where:

P_{vcT} = Closing pressure of the valve at valve temperature when the injection gas pressure and the production pressure are equal at the instant the valve closes in a test rack. psig [kPa (ga)]

P_{voT} = Valve opening pressure in test rack at valve temperature. psig [kPa (ga)]

Ap = Effective pressure area of valve stem and seat contact. sq. in. [or mm²].

Ab = Effective area of the bellows. sq. in. [or mm²].

B.4.4 No visible oil, grease, water or other lubricating or sealing material shall be allowed on the stem and/or seat.

B.4.5 Install the valve in the fixture, open the valve with gas pressure above P_{voT}, and then reduce the gas pressure to a value greater than P_{vcT}.

B.4.6 Direct the downstream side for flow measurement.

B.4.7 If the flow rate is greater than 35 std cu ft/day [1 std cu m/day], the stem and seat shall be rejected.

B.5 Probe Test

B.5.1 INTRODUCTION

The purpose of the Gas-Lift Valve Probe Test is to determine the relative "stiffness" of a gas-lift valve and to determine the maximum available travel of the stem tip. When gas pressure is admitted to the tester, it acts on the full area of the valve bellows to lift the stem off the seat. When this pressure is increased, the stem tip lifts further from the seat. By using the Valve Probe Tester (reference Figure 17), an accurate measure of the stem tip travel per pressure increase can be determined and the results tabulated and plotted. The valve probe tester shown in Figure 17 is an example and is not intended to restrict the many possible devices which may be used to accomplish the test.

When the pressure is plotted as the ordinate and the stem tip travel as the abscissa, a relatively straight line will be generated for the majority of the stem tip travel. The slope of this line is an indication of the "stiffness" of the valve. The numerical value of the slope is called the Bellows Assembly Load Rate (B_{lr}) and is measured in psig/inch [kPa/mm]. In this context, the "bellows assembly" includes the bellows and the system which applies a load to hold the valve stem on the seat. The higher the load rate, the "stiffer" the valve and inversely, the lower the load rate, the "softer" the valve.

If the above is done with the same valve, except that opening pressure (dome charge or spring setting) is varied, then the effect of dome charge pressure or spring setting on the bellows assembly load rate can be compared for the same type valve when set for different opening pressures.

The bellows assembly load rate is a practical value that can be used to compare different types of valves or when evaluating the same valve under different load conditions and when designing the gas-lift installation.

B.5.2 EQUIPMENT REQUIRED

B.5.2.1 Gas Lift Valve Probe Test Fixture

The test fixture must have a means for controlling and measuring the pressure applied to the gas-lift valve sleeve. The apparatus shown in Figure B17 is an example of a suitable test stand for the probe test.

B.5.2.2 Gas Lift Valve Position Measurement Device

The measurement method must be capable of determining the stem position within ±.005 inch [0.127 mm].

The position measurement device shown in Figure 17 is a micrometer probe designed to measure the stem tip travel as a function of the pressure applied over the full area of the bellows. This device uses a micrometer in conjunction with an electrically conductive probe attached to the bottom of the valve. The electrically conductive probe contacts the end of the valve stem and must be electrically insulated from the valve body. The probe is attached to the barrel of the micrometer such that an adjustment of the micrometer will cause an equal adjustment of the probe. This device will meet the measurement accuracy requirements. Other methods of stem position measurement are also possible.

B.5.2.3 Pressure Gauge

The gauge used to measure pressure should have an accuracy such that measurement errors are no greater than ±0.25% of value.

B.5.3 PROBE TEST PROCEDURE

B.5.3.1 Prepare the Valve for Testing

Set P_{vcT} as specified in 4.4.2.2 of this Specification.

B.5.3.2 Assemble the Test Equipment

Attach the position measurement device (micrometer/probe assembly) to the valve. Insert the valve and position measurement device into the proper sleeve in the valve test stand.

With reference to the micrometer/probe assembly, attach the ohmmeter as shown in Figure 17 with one lead attached

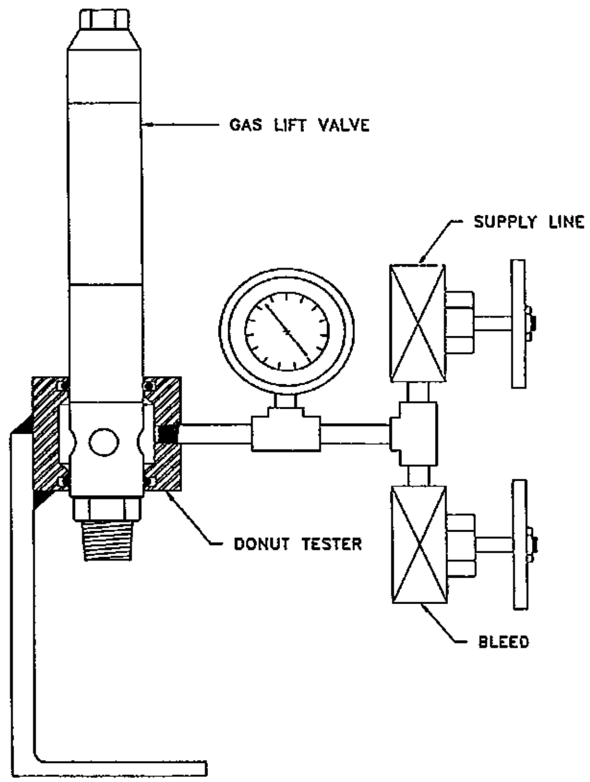

Figure 15—Typical Sleeve Tester

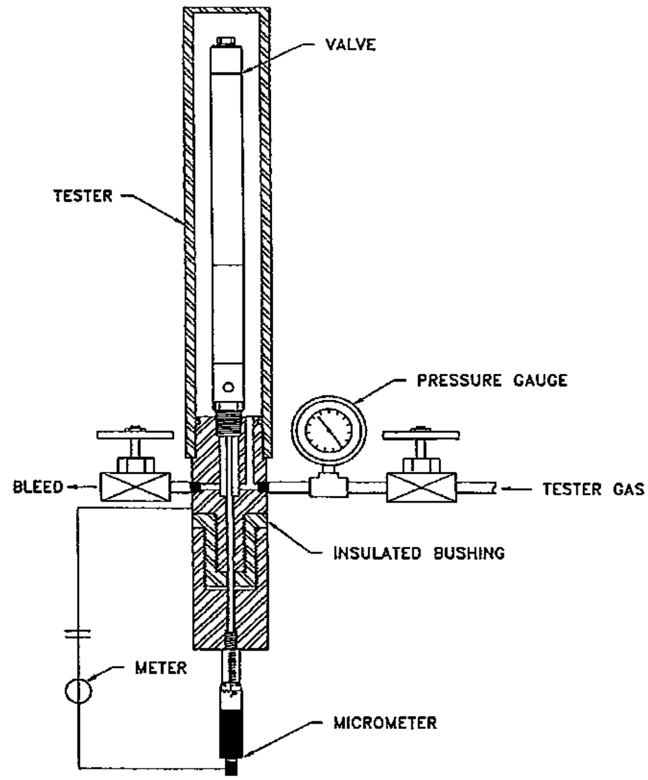

Figure 17—Typical Gas Lift Valve Probe Test Fixture

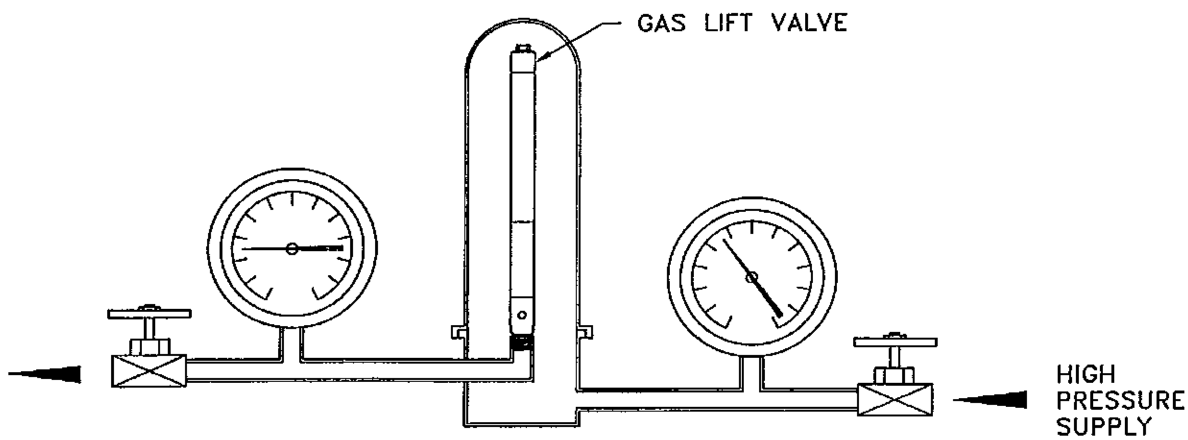

Figure 16—Typical Encapsulated Tester

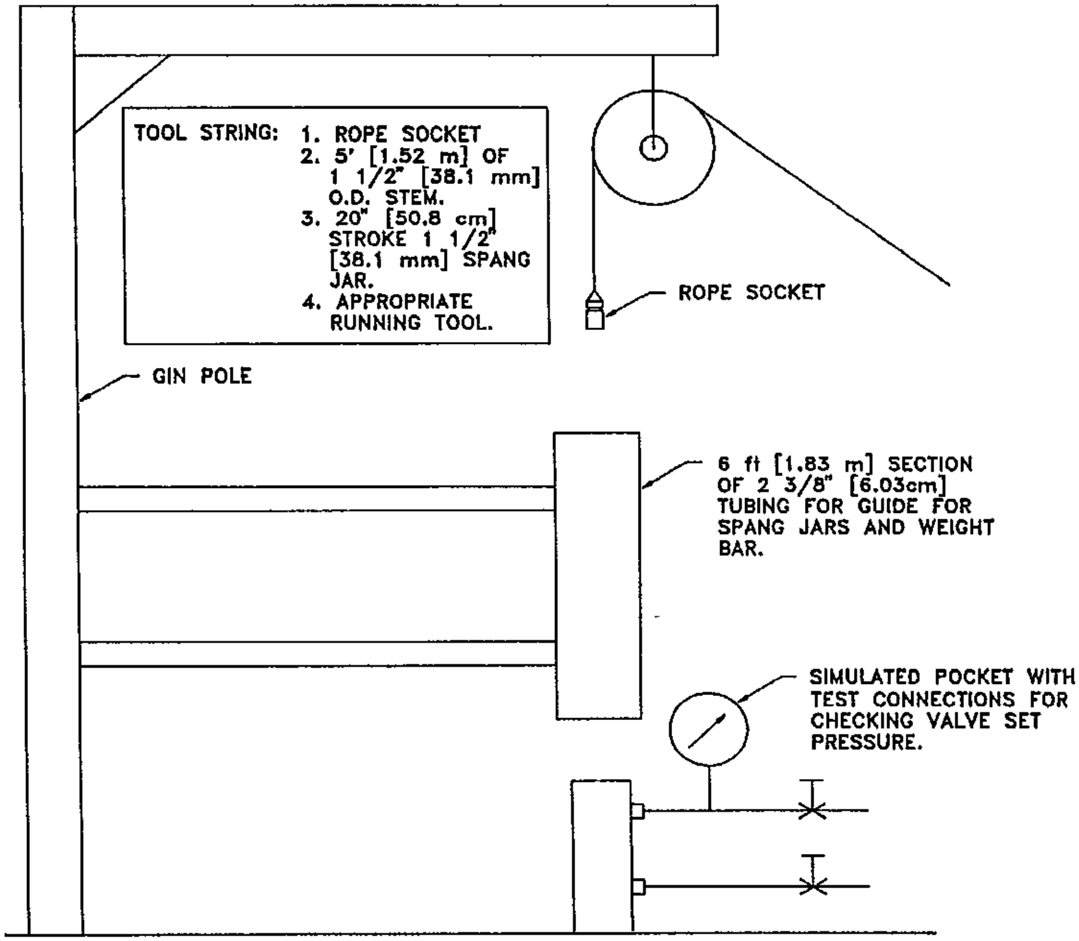

Figure 18—Typical Vertical Valve Insertion Test Stand

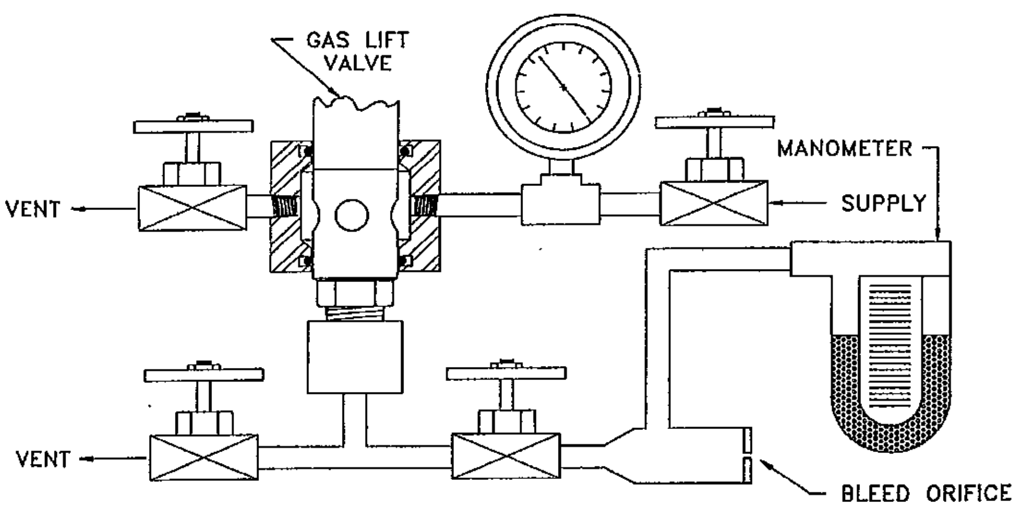

Figure 19—Typical Stem and Seat Leakage Testers

to the micrometer barrel and the other lead attached to the gas-lift valve.

B.5.3.3 Calibrate the Position Measurement Device

Adjust the position measurement device such that it reads 0.0 inch [0.0 mm] of travel when the valve stem is on the seat and no pressure is applied to the test sleeve.

With reference to the micrometer/probe assembly, loosen the probe-rod collet cap and set the micrometer barrel to zero. Slide the probe rod up until the resistance reading on the ohmmeter is zero or near zero. This is the point where the probe rod is just touching the valve stem. Securely tighten the collet cap to prevent the rod from being pushed out when gas pressure is applied to the valve. Retract the probe rod using the micrometer barrel and then advance it until contact is just made. Read the micrometer. If the reading is not zero, repeat B5.3.3 until a zero reading is obtained.

Note: If, after four attempts, the zero micrometer reading is not obtained, it is acceptable to use the micrometer set to a readable value near zero. Record this micrometer reading opposite the zero pressure value on the data sheet. The stem travels will be adjusted by subtracting this micrometer reading for zero pressure from each of the recorded readings on the data sheet.

B.5.3.4 Perform the probe test

B.5.3.4.1 Increase pressure to the test sleeve until the position measurement device indicates the stem is no longer touching the seat. This is the pressure at which the valve just opens when test pressure is applied across the full area of the bellows (P_{vcT}). Record this pressure.

With reference to the micrometer/probe assembly, this is indicated on the ohmmeter as a significant increase in the resistance reading.

B.5.3.4.2 Increase the pressure to the test sleeve in a convenient increment such as determined by B.5.3.4.5.

Note: If the test pressure inadvertently exceeds the target pressure DO NOT REDUCE to the target pressure; instead, record the pressure obtained and continue with the test.

B.5.3.4.3 Adjust the position measurement device to determine the new stem position.

With reference to the micrometer/probe assembly, advance the probe with the micrometer barrel until it contacts the tip of the valve stem. This will be noted by a significant decrease in the ohmmeter resistance reading.

B.5.3.4.4 Record the pressure and the stem position using Form 1 of this Specification.

B.5.3.4.5 Repeat steps in B.5.3.4.2 through B.5.3.4.4 using the same (within ±5%) pressure increment until the valve stem no longer moves or the increments of movement are very small for three or four pressure increases and at least 10 stem positions have been recorded. At least 5 of the recorded values must be in the straight line portion of the graph. Several preliminary tests may need to be conducted to establish a suitable pressure increment to use.

B.5.3.4.6 Decrease the pressure to the test sleeve in a convenient increment such as determined by 6.3.4.9.

With reference to the micrometer/probe assembly, before decreasing the pressure, retract the probe rod by reversing the micrometer barrel far enough to prevent stem tip contact during pressure decrease.

Note: If the test pressure is inadvertently allowed to drop to a value less than the target pressure DO NOT INCREASE to the target pressure; instead, record the pressure obtained and continue with the test.

B.5.3.4.7 Adjust the stem position measurement device to determine the new stem position.

With reference to the micrometer/probe assembly, advance the probe with the micrometer barrel until it contacts the tip of the valve stem. This will be noted by a significant decrease in the ohmmeter resistance reading.

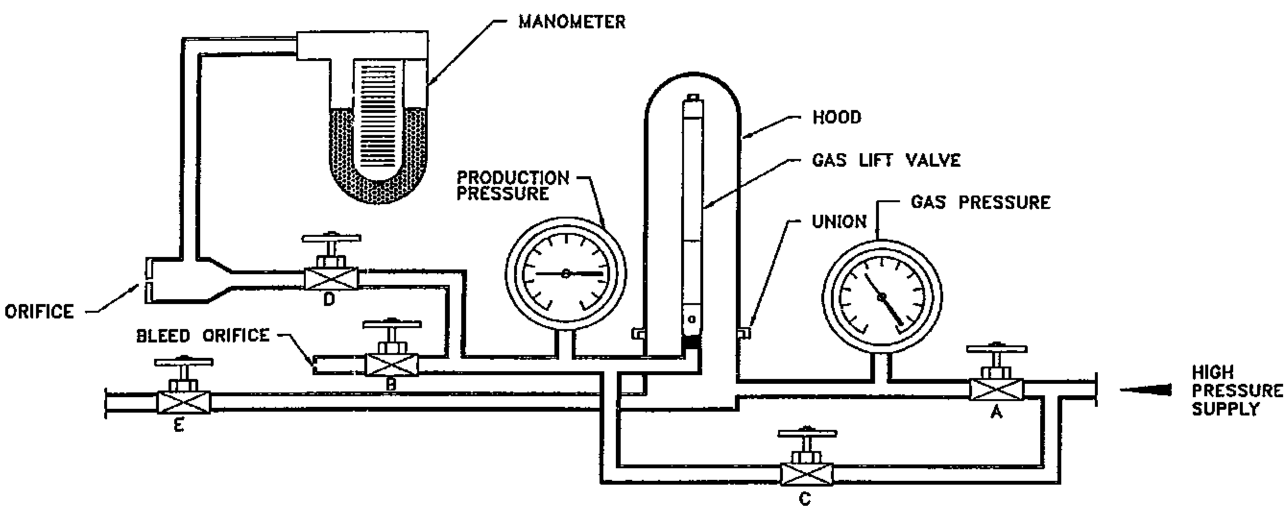

Figure 20—Typical Stem and Seat Leakage

B.5.3.4.8 Record the pressure, and the stem position using Form 1 of this Specification.

B.5.3.4.9 Repeat B.5.3.4.6 through B.5.3.4.8 using the same (± 5%) pressure increments until the valve stem is back on its seat (initial micrometer reading ±0.005 inch [0.127 mm] and at least 10 stem positions have been recorded. At least 5 of the recorded values must be in the straight line portion of the graph. Several preliminary tests may need to be conducted to establish a suitable pressure increment to use.

B.5.4 DETERMINING VALVE LOAD RATE

B.5.4.1 Plot the data on linear coordinate paper with the pressure readings on the vertical axis and the stem position readings on the horizontal axis as shown in Figure 21.

Note on Figure 21 there are two (2) distinct regions of the plot where the slopes are different. The region identified as Slope A is the effective usable travel range of the valve. The region identified as Slope B is the travel range where the bellows has met a substantial resistance to travel and represents travel that is not normally usable. This additional resistance to travel can be the result of many different factors, but is usually the result of "bellows stacking".

The region of Slope A should extend from zero stem travel to the point where the slope of the load rate data turns sharply upward. This point will be visually determined.

B.5.4.2 Draw the best-fit straight line to the data of the region corresponding to Slope A. Reference Figure 22.

B.5.4.3 Calculate the slope of this best-fit straight line as follows: Slope (psi/inch [kPa/mm]) = (P1-P2) / dx (ref Figure 22). The slope of this line is the Bellows Assembly Load Rate of the valve (B_{lr}).

B.5.4.4 The Bellows Assembly Load Rate (B_{lr}) documentation shall include a graph showing ALL the data points, the best-fit straight line, and the B_{lr} calculation.

B.5.5 DETERMINING MAXIMUM EFFECTIVE STEM TRAVEL

The maximum effective stem travel is the greatest travel obtainable within the region of Slope A as shown in Figure 22.

B.5.6 DOCUMENTATION

The following documentation shall be available to demonstrate the execution of the probe test per this section. Form 1 of this Specification is a convenient method for recording the data.

a. Assembly drawing of the probe test equipment.
b. Type and accuracy of the pressure gauge.
c. API designation of tested valve, manufacturers part number and dated assembly drawing of valve.
d. Test data including:
   1. Valve set pressure
   2. Test pressures
   3. Stem positions
e. Graph showing:
   1. tested pressures and stem positions
   2. best fit straight line
f. Bellows assembly load rate (B_{lr})
g. Maximum effective stem travel

B.6 Valve Insertion Test

B.6.1 This test is run to assure that installation of the valve into a mandrel does not cause a change in the set pressure of the valve.

B.6.2 This test shall be conducted in an environment such that the test equipment and the valve are at the same temperature within ± 5°F [± 3°C].

B.6.3 All 5 test valves shall be equipped with manufacturer's recommended packing and latches for which the valve was designed. The valves shall be set for a test rack opening pressure of 800 psig ± 10 psi [5516 kPa ± 69 kPa] at the temperature defined in B.6.2 above. Record the set pressure for each valve and the ambient temperature at the test fixture. Form 2 is available as a convenient place to record the data.

B.6.4 The test shall be conducted using the following equipment:

B.6.4.1 Test stand as defined in Figure 18.

B.6.4.2 Rope socket.

B.6.4.3 Five feet ± 3 inches [150 cm ± 8 cm] of a nominal 1½ inch OD [38.1 mm] weight bar.

B.6.4.4 20-inch ± 2 inches [50 cm ± 5 cm] stroke using a nominal 1½ inch [38.1 cm] OD mechanical jar.

B.6.4.5 Manufacturer's specified running tool.

B.6.5 Each valve in turn is pinned to the manufacturer's specified running tool and then attached to the mechanical jars, weight stem, and rope socket on a test stand as defined in Figure 18. (The shear pins shall be the number, size, and shear stock specified by the latch manufacturer.) The valve is lowered until the nose goes into the pocket. Drive the valve into the pocket with 5 blows minimum using the full stroke of the jars and free fall of the weight stem each time. The latch should be fully engaged. If not, continue jarring until it is. Then jar upward to release the running tool. Measure and record the valve opening pressure with the valve in the pocket. Measure and record the ambient temperature at the test fixture. Form 2 is available as a convenient place to record the data. The difference between the original set pres-

1) Assembly drawing of probe test apparatus attached (Y/N). __________

2) Type of pressure measurement device ______________ Accuracy ______________

3) API designation for valve.________________________
Manufacturer's part number for valve. ______________________
Dated assembly drawing of valve attached. (Y/N) __________

4) Test data:
Unit system (check appropriate one): _______ inch/psi _________mm/kPa
Valve set pressure _________ Pvo or Pvc?_________

Test pressure	Stem position		Test pressure	Stem position	
Increasing pressure	Actual	Corrected	Decreasing pressure	Actual	Corrected
1)			1)		
2)			2)		
3)			3)		
4)			4)		
5)			5)		
6)			6)		
7)			7)		
8)			8)		
9)			9)		
10)			10)		
11)			11)		
12)			12)		
13)			13)		
14)			14)		
15)			15)		
16)			16)		
17)			17)		
18)			18)		
19)			19)		
20)			20)		

5) Graph attached showing test pressures and stem positions? (Y/N) _________
Graph attached showing best-fit straight line? (Y/N) _________

6) Bellows assembly load rate (Blr) ______________ psi/inch (kPa/mm)

7) Maximum effective travel_________ inch (mm)

Test conducted by: ______________
Date of test: ______________

Form 1

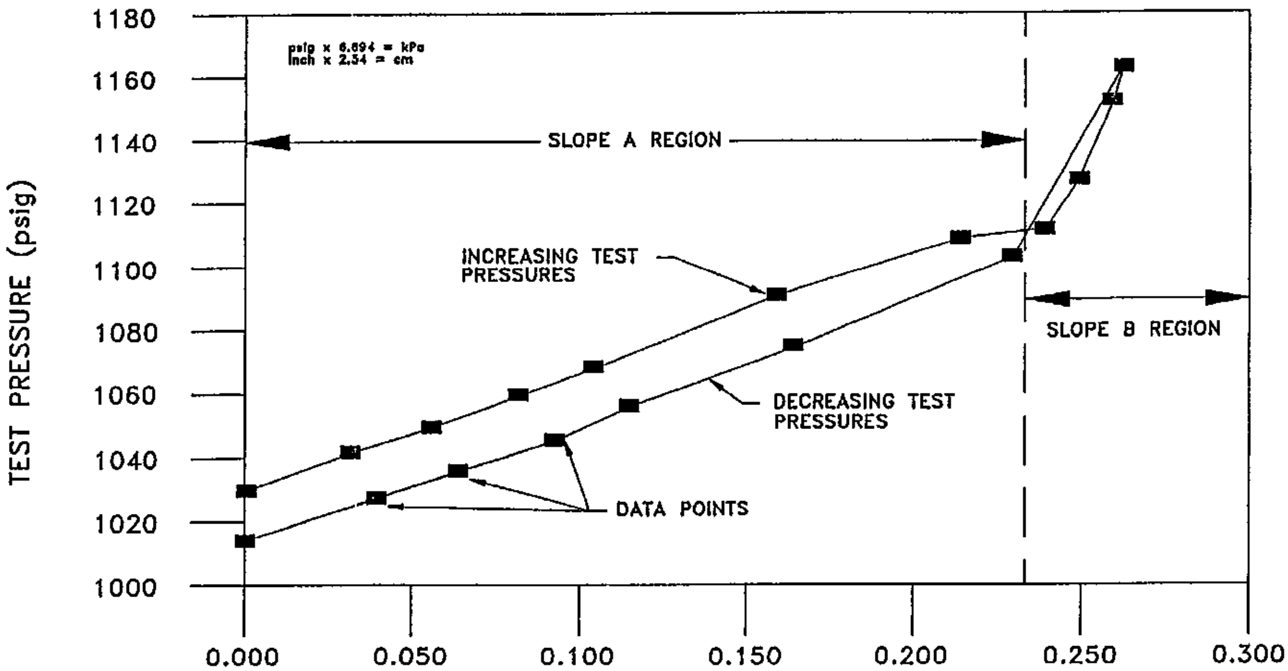

Figure 21—Stem Travel (Inch) Typical Data from Probe Test

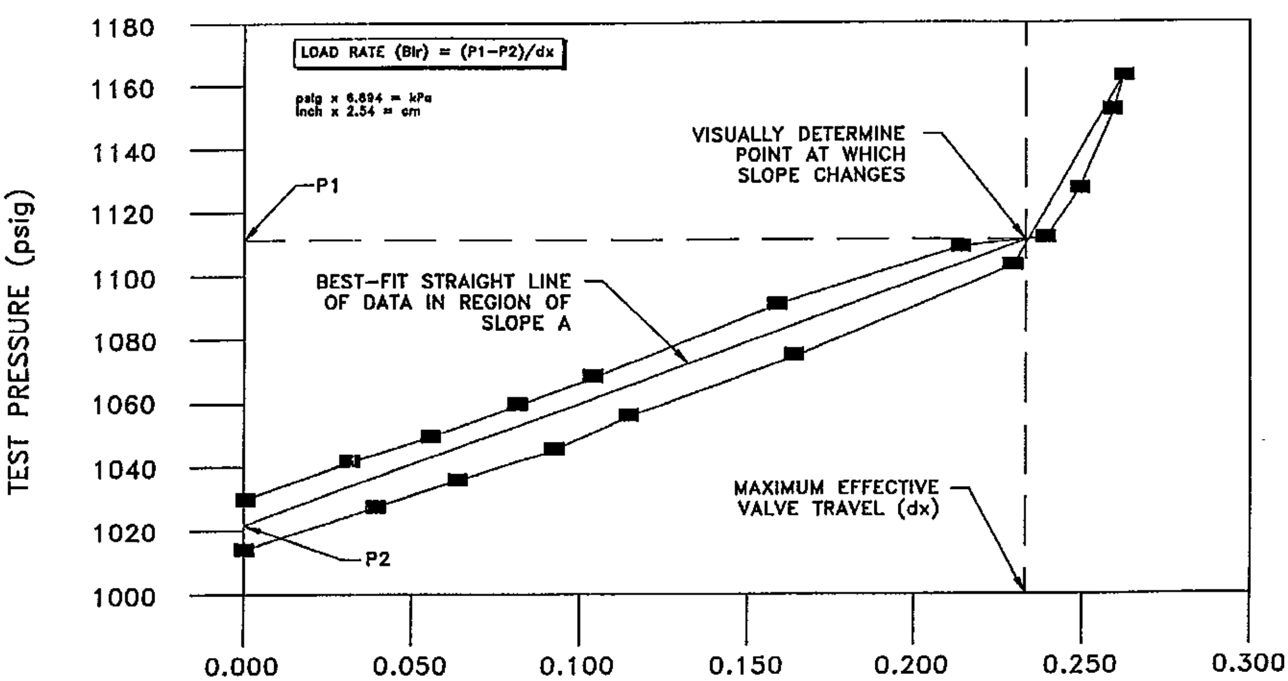

Figure 22—Stem Travel (Inch) Determining Valve Load Rate (psig/inch)

API designation for valve: ______________________ Date: ____________

Manufacturer's part number for valve: ______________________

Unit selection: ______ psig/fahrenheit
(check one) ______ kPa(ga)/celsius

	Valve serial no.	Initial		After test		Change in TRO	Change in Temperature
		TRO	Temperature	TRO	Temperature		
1)							
2)							
3)							
4)							
5)							

Test data verfied by: ______________________ Date: ____________

Form 2

sure and the pressure after insertion in the test fixture must not exceed one percent of the original set pressure in 4.4.2.3 after correcting for temperature.

Note: The following equation should be used for nitrogen charged valves. If other gases are used for the bellows charge, then an appropriate correction should be made.

English Units version:

$$C_{t(nitrogen)} = 0.5[-B + (B^2 - 4A*C)^{0.5}]/(A*P_{bt})$$

Where:

P_{bt} = bellows pressure at elevated (well) temperature, psig

T_v = elevated (well) temperature, °F

and

if $(P_{bt}*520)/(460 + T_v)$ is > 1238 psig,

then

$A = 1.84E\text{-}07*(T_v - 60)$

$B = 1 + 2.298E\text{-}03*(T_v - 60)$

$C = -0.267*(T_v - 60) - P_{bt}$

otherwise

$A = 3.054E\text{-}07*(T_v - 60)$

$B = 1 + 1.934E\text{-}03*(T_v - 60)$

$C = -2.226E\text{-}03*(T_v - 60) - P_{bt}$

SI Units version:

$$C_{t(nitrogen)} = (0.5*(-B + (B^2 - 4A*C)^{0.5}))/(A*(P_{bt}/6.895))$$

Where:

P_{bt} = bellows pressure at elevated (well) temperature, kPa (ga)

T_V = elevated (well) temperature, °C

and

if $(P_{bt}*(288.5/(273 + T_v)))$ is > 8536 kPa (ga),

then

$A = 1.84E\text{-}07*(1.8T_v - 28)$

$B = 1 + 2.298E\text{-}03*(1.8T_v - 28)$

$C = -0.267*((1.8T_v - 28) - (P_{bt}/6.895))$

otherwise

$A = 3.054E\text{-}07*(1.8T_v - 28)$

$B = 1 + 1.934E\text{-}03*(1.8T_v - 28)$

$C = -2.226E\text{-}03*((1.8T_v - 28) - (P_{bt}/6.895))$

To calculate the correct bellows pressure at 60°F (15.5°C), multiply $C_t * P_{bt}$.

Form 3

1) Reverse flow valve type: ______________________

2) Type of flow measurement device: ______________________

Accuracy: ______________

3) API designation for valve: ______________________

Manufacturer's part number for valve: ______________

Dated assembly drawing of valve attached (Y/N): ________

4) Test data:

Indicate flow measurements units: ______________

FLOW RATE TO INITIATE CLOSING

1)	
2)	
3)	
4)	
5)	

Test conducted by: ______________________

Date of test: ______________

APPENDIX C—BELLOWS ATTACHMENT METHODS

C.1 General

C.1.1 The purpose of this appendix is to give some examples of various bellows attachment methods.

C.1.2 This appendix is non-mandatory as applied to API Specification 11V1 Specifications for Gas Lift Equipment.

C.1.3 Some of the bellows attachment methods are:

Silver brazing using electric induction heating.
Electron beam welding.
Plasma welding.

APPENDIX D—HEAT TREATING EQUIPMENT QUALIFICATION

D.1 General

All heat treating shall be performed with equipment meeting the requirements of this section. This appendix is mandatory as applied to API 11V1 Specifications for Gas Lift Equipment.

D.1.1 TEMPERATURE TOLERANCE

The temperature at any point in the furnace working zone shall not vary by more than ± 25°F [± 14°C] from the furnace set point temperature after the furnace working zone has been brought up to temperature. Furnaces which are used for tempering, aging, and/or stress relieving shall not vary by more than ± 15°F [± 8.3°C] from the furnace set point temperature after the furnace working zone has been brought up to temperature.

D.1.2 FURNACE CALIBRATION

D.1.2.1 General

Heat treating of production parts shall be performed with heat treating equipment that has been calibrated and surveyed. Each furnace shall be surveyed within one year prior to heat treating.

D.1.2.2 Records

Records of furnace calibration and surveys shall be maintained for a period not less than two years.

D.1.2.3 Batch Type Furnace Methods

D.1.2.3.1 Temperature Survey

A temperature survey within the furnace working zone(s) shall be performed on each furnace at the maximum and minimum temperatures for which each furnace is to be used.

D.1.2.3.2 Minimum Test Locations

A minimum of nine thermocouple test locations shall be used for all furnaces having a working zone greater than 10 ft^3 [283 dm^3].

D.1.2.3.3 Maximum Number of Thermocouples

For each 125 ft^3 [3.54 m^3] of furnace working zone surveyed, at least one thermocouple test location shall be used up to a maximum of 60 thermocouple. See Figure 3 for thermocouple locations.

D.1.2.3.4 Minimum Number of Thermocouples

For furnaces having a working zone less than 10 ft^3 [283 dm^3], the temperature survey may be made with a minimum of three thermocouple located at the front, center and rear or the top, center and bottom of the furnace working zone.

D.1.2.3.5 Frequency of Readings When Heating

After insertion of the temperature sensing devices, readings shall be taken at least once every 3 minutes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

D.1.2.3.6 Frequency of Readings at Operating Temperature

Once the furnace temperature has reached the set point temperature, the temperature of all test locations shall be recorded at 2 minute intervals maximum for at least 10 minutes. Readings shall then be taken at 5 minute intervals maximum for sufficient time to determine the recurrent temperature pattern of the furnace working zone for at least 30 minutes.

D.1.2.3.7 Maximum Variation When Heating

Before the furnace set point temperature is reached, none of the temperature readings shall exceed the set point temperature by + 25°F [+ 14°C].

D.1.2.3.8 Maximum Variation at Operating Temperature

After the furnace control set point temperature is reached, no temperature readings shall exceed the limits specified.

D.1.2.3.9 Recalibration

When a furnace is repaired or rebuilt, a new survey shall be required before heat treating.

D.1.2.4 Continuous Type Furnace Method

Continuous heat treating furnaces shall be calibrated in accordance with procedures specified in MIL-H-6875, Heat Treatment of Steels—Aircraft Practice Process.

D.1.3 INSTRUMENTS

D.1.3.1 General

Automatic controlling and recording instruments shall be used. Thermocouple shall be located in the furnace working zone(s) and protected from furnace atmospheres by means of suitable protecting devices.

D.1.3.2 Accuracy

The controlling and recording instruments used for the heat treatment processes shall possess an accuracy of ± 1% of their full scale range.

D.1.3.3 Calibration

D.1.3.3.1 Frequency

Temperature controlling and recording instruments shall be calibrated at least once every three (3) months.

D.1.3.3.2 Accuracy

Equipment used to calibrate the production equipment shall possess an accuracy of ± 0.25% of full scale range.

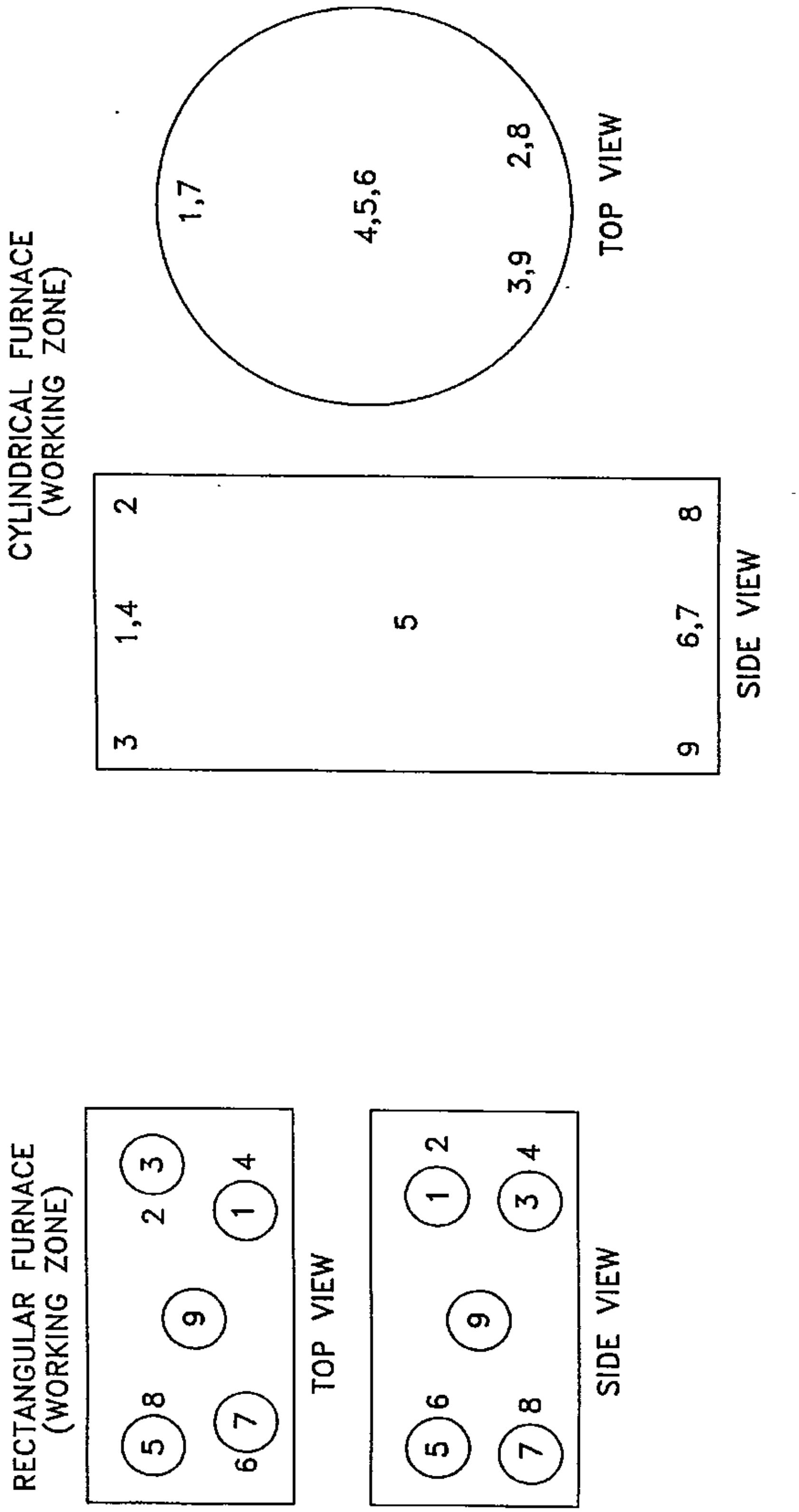

Figure 23—Thermocouple Locations

APPENDIX E—MARKING REQUIREMENTS FOR API MONOGRAM LICENSEES

E.1

This appendix is a requirement only for those manufacturers licensed to use the API monogram. The marking requirements of this section supersede the marking requirements of 4.5 and 5.1.6 of API Specification 11V1 Specification for Gas Lift Equipment.

E.2

The API monogram shall be applied only by licensed manufacturers. See API Bulletin S1, Bulletin on Policy and Procedures for Standardization of Oilfield Equipment and Materials for regulations governing the use of the API monogram.

E.3 Marking Requirements for Monogrammed Assemblies

All complete Gas lift valve, Orifice valves, Check valves and Dummy assemblies furnished under Specification 11V1 by licensed manufacturers shall be marked in accordance with NACE STD MR-01-75, latest revision as follows:

- Manufacturer's name or trademark.
- The API Monogram.
- API License number.
- Date of manufacture.

E.3.1 PARTS

There is no requirement for marking individual parts.

E.4 Marking Requirements for Monogrammed Mandrels

The metallic markings shall be made using low stress marking devices which include interrupted dot or rounded vee cold die stamp or vibratory method. The following information shall be marked on each mandrel:

- Manufacturer's Name or Mark
- API Monogram
- API License Number
- Date (month and year) of final acceptance by the Manufacturer.
- API Part Number as detailed in Table 5.
- Manufacturer's Mandrel Type Identification and Part Number.

Note: If manufacturer's part number does not include thread type, size and weight then it should be added as additional information.

E.4.1 PAINTED MARKING REQUIREMENTS

Painted marking requirements shall include an arrow pointing up and word "UP" adjacent to the arrow in capital letters on the flat of oval mandrels and the round of round mandrels toward the upper swage.

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