

Plunger Lift Lubricators and Related Equipment

API SPECIFICATION 11PL
FIRST EDITION, JUNE 2019

API MONOGRAM PROGRAM EFFECTIVE DATE: JUNE 1, 2020



AMERICAN PETROLEUM INSTITUTE

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Introduction

This specification has been developed by users/purchasers and suppliers/manufacturers of plunger lift lubricators intended for use in the petroleum and natural gas industry worldwide. This specification is intended to give requirements and information to both parties in the selection, manufacture, testing and use of plunger lift lubricators. Further, this specification addresses supplier/manufacturer requirements which set the minimum requirements with which suppliers/manufacturers shall conform.

This specification has been structured to allow for grades of increased requirements both in quality control and design validation. These variations allow the user/purchaser to select the grade required for a specific application for a chosen tool.

The quality grades and design validation grades provide the user/purchaser the choice of requirements to meet a specific preference or application. Additional quality and design validation requirements may be specified by the user/purchaser as supplemental requirements.

Plunger Lift Lubricators and Related Equipment

1 Scope

This specification provides requirements and guidelines for plunger lift lubricators, which includes plunger catchers as defined herein for use in the petroleum and natural gas industry. Threaded and flanged external connections are covered by the applicable API or proprietary connection design requirements. This specification provides requirements for the functional specification and technical specification, including design requirements (outlet locations, specified and optional), design extensions, design verification and validation, welding, materials, quality controls (QCs), marking, documentation and data control, shipment, and storage.

This specification does not include control system components, including electrical and electronic devices, installation requirements, field modifications of lubricators, and plunger lift downhole equipment. Additionally, the requirements for the inlet and outlet flange bolting and gaskets are not addressed herein. Equipment and technology that are covered by other API specifications and standards are exempted from this specification.

This specification includes five annexes: Annex A (informative), Annexes B through D (normative), and Annex E, which is informative and includes guidelines for plunger lift lubricator use and maintenance.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5B, *Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*, 15th Edition

API Recommended Practice 5B1, *Gauging and Inspection of Casing, Tubing, and Line Pipe Threads*

API Specification 5CRA, *Specification for Corrosion-resistant Alloy Seamless Tubes for Use as Casing, Tubing and Coupling Stock*

API Specification 5CT, *Specification for Casing and Tubing*, Ninth Edition

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*, 20th Edition

API Specification 20A, *Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Castings for Use in the Petroleum and Natural Gas Industry*

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

ANSI ¹/NACE ² MR0175/ISO ³ 15156 (all parts), *Petroleum and natural gas industries—Materials for use in H₂S-containing environments in oil and gas production*

ASME Boiler Pressure and Vessel Code (BPVC) ⁴, Section IX: *Welding, Brazing, and Fusing Qualifications*

¹ American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

² NACE International, 15835 Park Ten Place, Houston, Texas 77084, www.nace.org.

³ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

⁴ ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

ASNT Recommended Practice SNT-TC-1A ⁵, *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370 ⁶, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388/A388M, *Standard Practice for Ultrasonic Examination of Steel Forgings*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E92, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E140, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness*

ASTM E165, *Standard Practice for Liquid Penetrant Examination for General Industry*

ASTM E213, *Standard Practice for Ultrasonic Testing of Metal Pipe and Tubing*

ASTM E428, *Standard Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ISO 148 (all parts), *Metallic materials—Charpy pendulum impact test*

ISO 6506 (all parts), *Metallic materials—Brinell hardness test*

ISO 6507 (all parts), *Metallic materials—Vickers hardness test*

ISO 6508 (all parts), *Metallic materials—Rockwell hardness test*

ISO 9712, *Non-destructive testing—Qualification and certification of NDT personnel*

ISO 10893-5, *Non-destructive testing of steel tubes—Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

ISO 18265, *Metallic materials—Conversion of hardness values*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1

assembly

Product comprised of more than one component.

⁵ American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

⁶ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

3.1.2**auxiliary connections**

Access ports typically for chemical injection or pressure monitoring.

3.1.3**body impact rating**

A rating based on the kinetic energy (KE) rating of the body of the lubricator design in the event that a KE absorption device is not functioning.

3.1.4**casing**

Conduit that is an integral lining of a drilled well, typically from the surface downward, which may also be used for a production conduit.

3.1.5**coatings and overlays**

Surface treatments to a component wherein material is applied to the external surface.

3.1.6**common hardware**

Nuts, cap screws, spacers, washers, and other hardware that does not have a material specification and does not require traceability.

3.1.7**component**

Individual part of an assembly or conduit.

3.1.8**conduit**

Pipe casing, tubing, or liner, either metallic or nonmetallic.

3.1.9**design validation**

Process of proving a design by testing to demonstrate conformity of the product to design requirements. [Source: API Q1]

3.1.10**design verification**

Process of examining the result of a given design or development activity to determine conformity with specified requirements. [Source: API Q1]

3.1.11**flow-wetted component**

Component that comes in direct contact with the dynamic movement of well fluids in the flow stream.

3.1.12**grade**

Category or rank given to different requirements for quality or design validation.

3.1.13**heat treat lot**

Material processed as a batch through a heat treat cycle.

3.1.14**inlet and outlet connections**

Thread or flange or other mechanism connecting the lubricator to the conduit/wellhead.

3.1.15**job lot**

Batch of material or components that have undergone the same process or series of processes.

3.1.16**kinetic energy****KE**

Energy that can be dissipated within the design function of the lubricator system.

3.1.17**kinetic energy absorption design****KE absorption design**

Subassembly of components designed to dissipate KE within the plunger lift lubricator, which may include spring housing, striker pad, and spring and cap assembly.

3.1.18**kinetic energy absorption device****KE absorption device**

Component of the KE absorption design that is designed to dissipate the KE from the plunger, e.g. a spring.

3.1.19**kinetic energy rating****KE rating**

Lowest of the body impact rating, KE absorption device capability, and connection impact ratings that are used to define the rating of the lubricator assembly.

3.1.20**lubricator body**

Tubular component where the plunger enters the inlet connection and ends at the wellbore access connection, and it may provide outlet connections.

3.1.21**manufacturing**

Process and actions performed by an equipment supplier/manufacture that are necessary to provide finished component(s), assembly(ies), and related documentation that fulfill the requests of the user/purchaser and meet the standards of the supplier/manufacture.

NOTE Manufacturing begins when the supplier/manufacture receives the order and is completed at the moment the component(s), assemblies, and related documentation are surrendered to a transportation provider.

3.1.22**nonconformance**

Nonfulfillment of a specified requirement.

3.1.23**plunger**

Traveling free piston designed to move wellbore fluid to the surface.

3.1.24**plunger lift catcher**

Catch device threaded or welded to the lubricator body that is used to catch and hold the plunger at surface, which can be manually operated or used with an actuator to check and help control plunger cycles.

3.1.25**plunger lift lubricator**

A pressure-retaining tubular device designed to mount to a Christmas tree with the means for inside diameter (ID) access, dynamic plunger acceptance, and redirection of fluids.

3.1.26**qualified person**

An individual with documented abilities gained through training or experience or both as measured against established requirements, which include standards or tests that enable the individual to perform a required function effectively.

3.1.27**quick union connection****QU connection**

Specific pin/box union with an internal O-ring (typically on pin) seal.

NOTE See Annex D for details.

3.1.28**rated working pressure****RWP**

Maximum pressure intended for continuous use as provided by the supplier/manufacture.

3.1.29**redress**

Replacement of components on a lubricator after original manufacture.

3.1.30**repair**

Rebuild and/or re-manufacture of the lubricator to restore it to the original functionality.

3.1.31**sealing device**

Device providing a barrier to the passage of liquid and/or gas across the interface between two components.

3.1.32**special feature**

Specific additional functional capability not validated by the defined validation testing.

3.1.33**spring housing**

Assembly that contains the KE absorption device.

3.1.34**strike pad**

Component that accepts the direct impact of the plunger and transfers that energy to the KE absorption device.

3.1.35**substantive design change**

Change to the design, identified by the supplier/manufacture, that may affect the performance of the product in the validation testing.

3.1.36**surface treatment**

Designated processes applied to component surfaces to achieve a defined property(s).

3.1.37**temperature range**

Specified range of temperature at which the product is designed to operate.

3.1.38**top-cap (cap)**

The uppermost component of a lubricator that provides sealing, impact, and pressure retention, while allowing access to the plunger for its removal or installation.

3.1.39**traceable**

The ability to identify individual components as originating from a specified source material and processing.

3.1.40**tubing**

Pipe placed within a well to serve as a production or injection conduit.

3.1.41**tubing size**

Nominal tubing outside diameter (OD) as typically specified in API 5CT or in API 5CRA.

3.1.42**Type 1 component**

Traceable component that contains pressure and/or may retain wellbore fluids and/or accepts impact loading.

3.1.43**Type 2 component**

Component that does not meet the criteria of a Type 1 component.

3.1.44**wellbore access connection**

Connection that allows access to the wellbore and mates the lubricator body to the spring housing.

3.2 Acronyms and Abbreviations

COC	certificate of conformance
EUE	external upset end
ID	inside diameter
KE	kinetic energy
LP	liquid penetrant
MP	magnetic particle
MTR	material test report
NDE	nondestructive examination
NUE	non-upset end
OD	outside diameter
QC	quality control
QMS	quality management system
QU	quick union (connection)
RWP	rated working pressure
TP	test pressure

TPI	threads per inch
UNS	unified numbering system
UT	ultrasonic testing
WPS	welding procedure specification

4 Functional Specification

4.1 General

The user/purchaser shall prepare a functional specification to order products that conform with this specification and specify the following requirements and operating conditions, as applicable, and/or identify the supplier/manufacture's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, datasheet, or other suitable documentation.

4.2 Lubricator Type Selection

The user/purchaser shall specify the following functional type(s) based on the product's primary function. Secondary functions and their interactions with the primary functions shall also be identified in detail as required by the operational needs. See Figure 1, Figure 2, Figure 3, and Figure 4, which illustrate the main types of plunger lift lubricator designs.

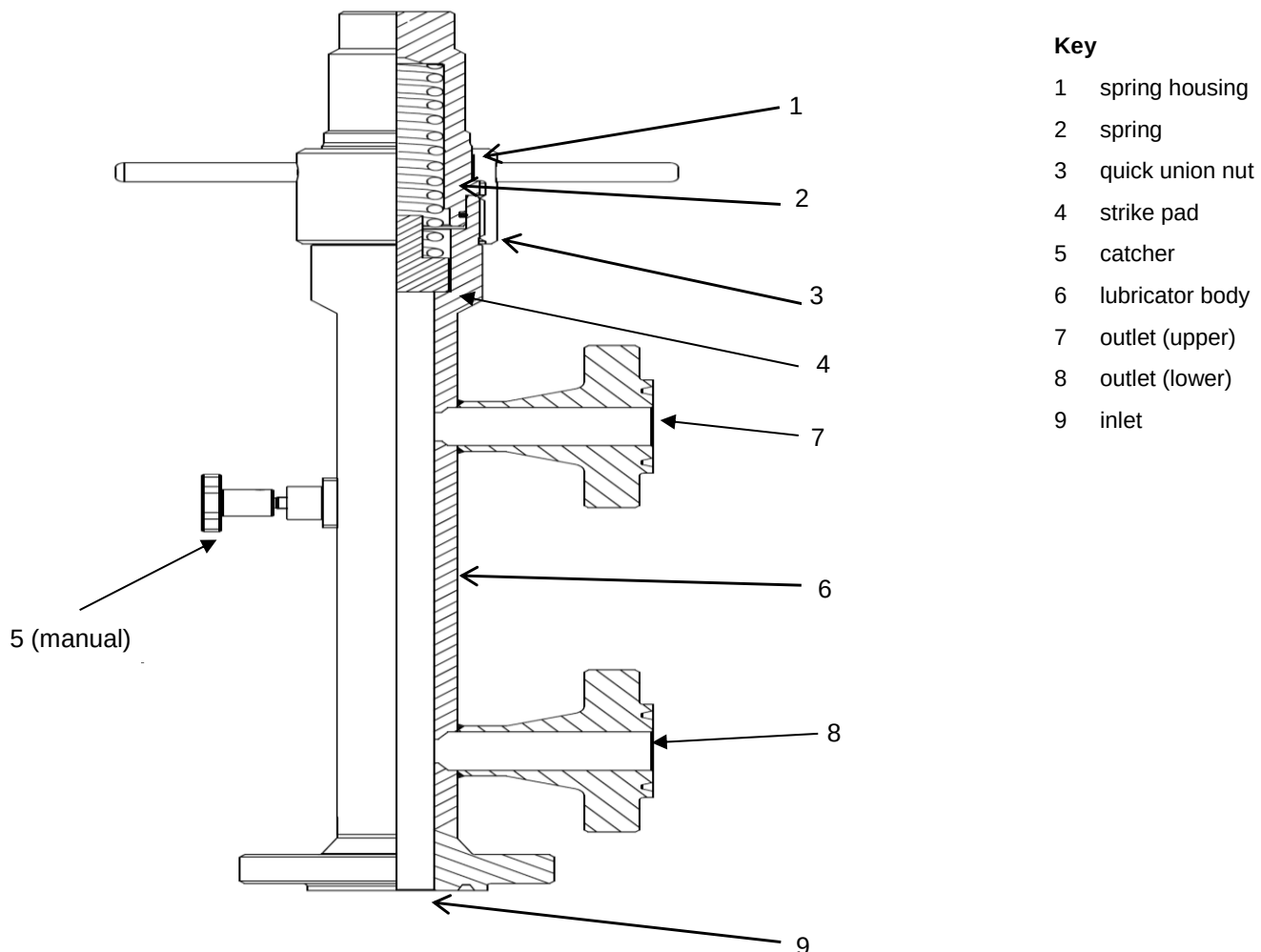


Figure 1—Example Quick-union-type Lubricator with Manual Catcher Illustration

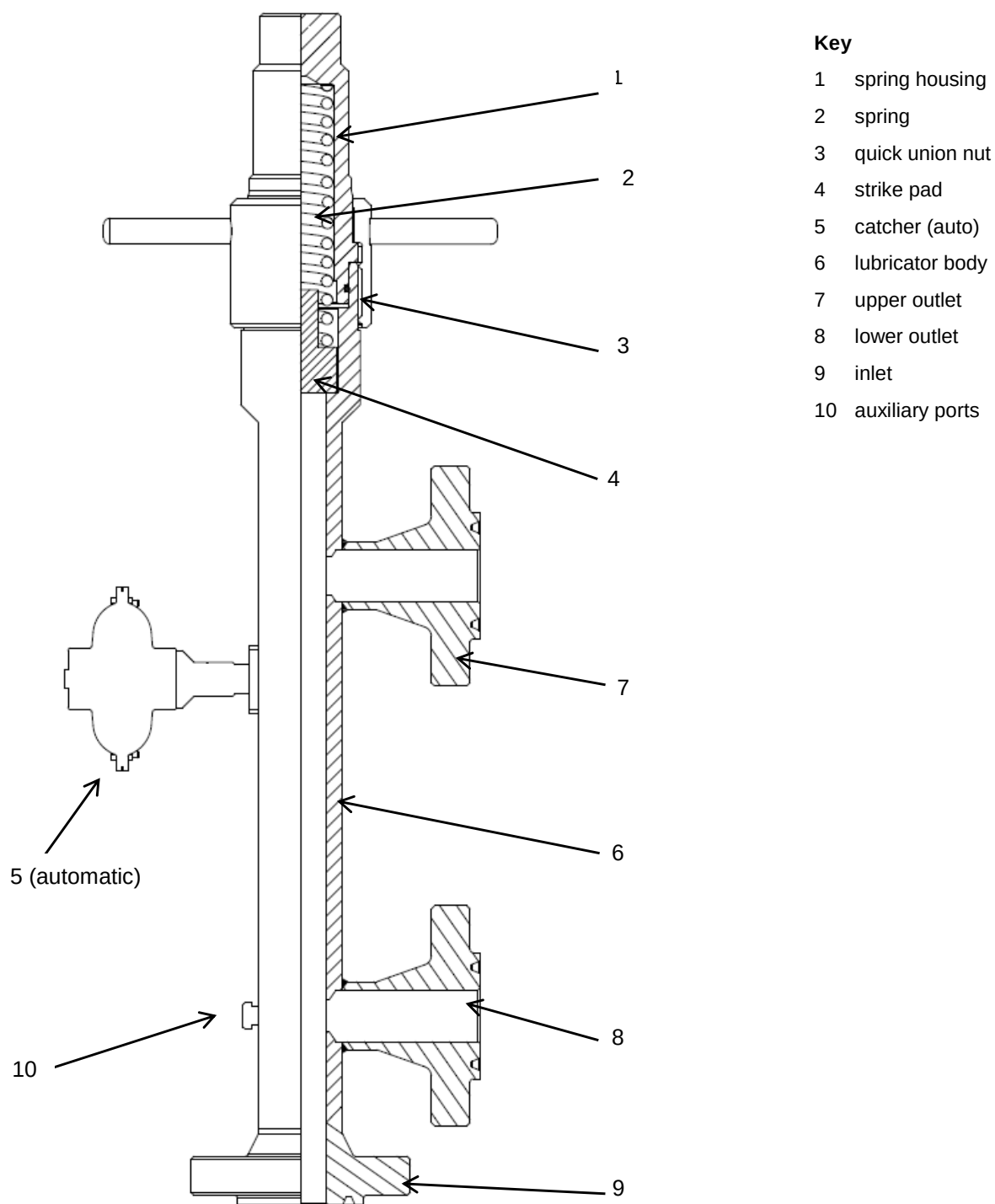


Figure 2—Example Quick-union-type Lubricator with Auto Catcher Illustration

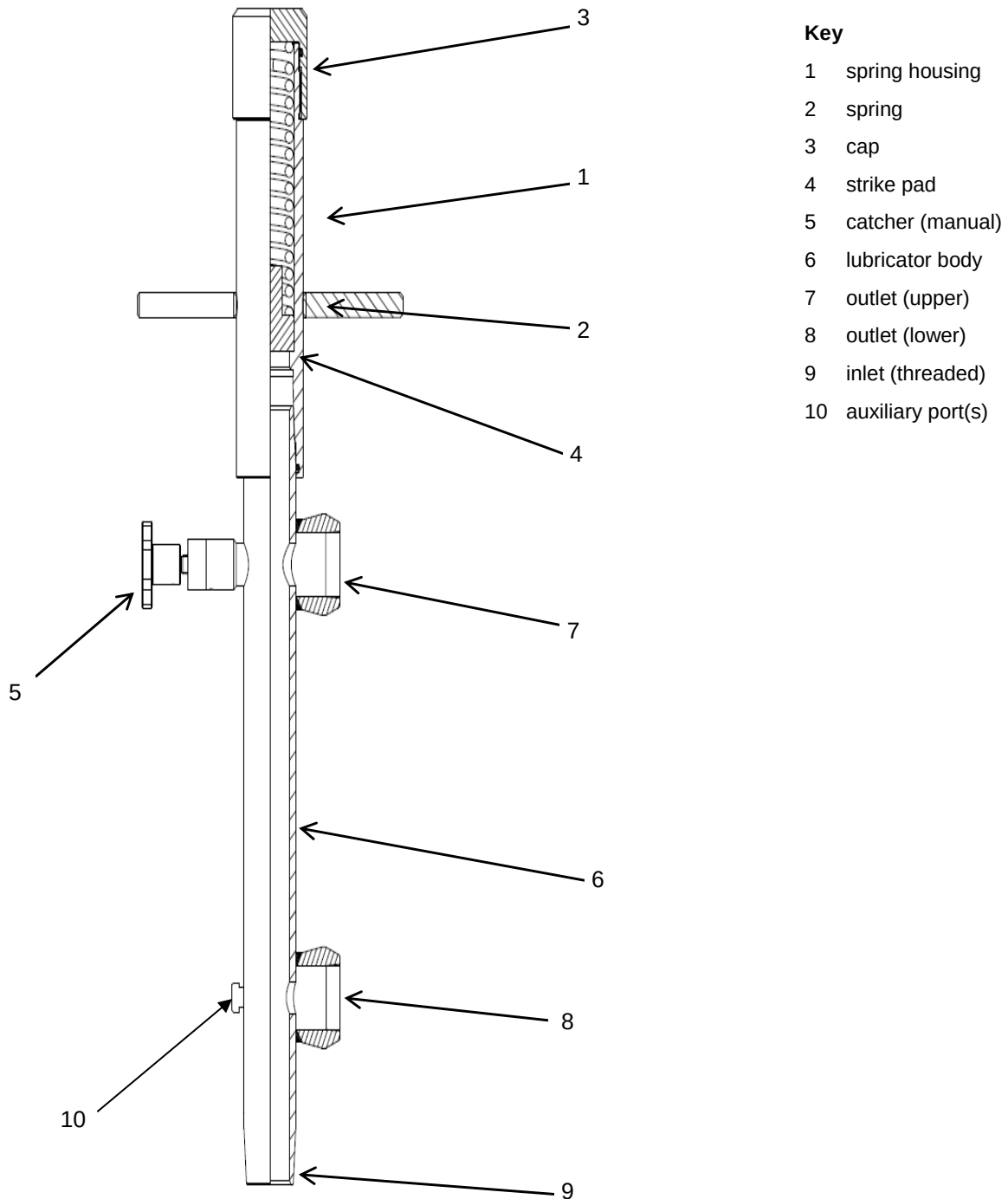


Figure 3—Example Threaded Lubricator with Manual Catcher Illustration

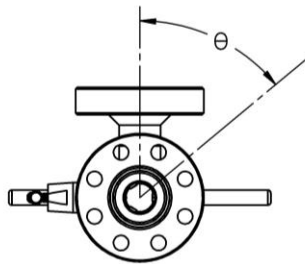
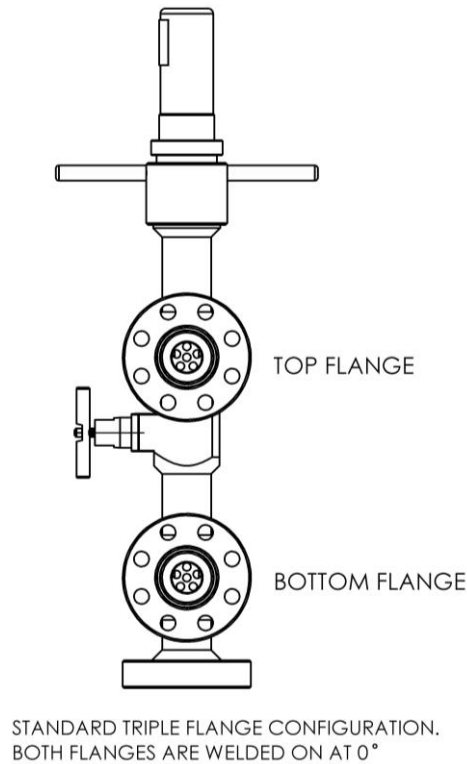


Figure 4—Example Lubricator Identifying the Outlet Angles Illustration

4.3 Well Parameters

The user/purchaser shall specify, as applicable, the following well parameters:

NOTE Where the specification covers multiple well applications, the user/purchaser shall address the applications in sufficient detail to assure effective performance.

- dimensions (nominal and drift ID), material, nominal weight, and grade of the well conduit;
- mating inlet and outlet connections detail;
- configuration of tubing (single or multiple strings) and other lines (electrical/hydraulic);
- relationship of the lubricator with other well devices/tubing/casing by means of a well schematic drawing;
- expected minimum and maximum values of production/injection pressures, pressure differentials, temperatures, changes in temperatures, and flow rates;
- other relevant well parameter(s).

4.4 Operational Parameters

The user/purchaser shall specify, as applicable, the following operational parameters:

- a) servicing intervals;
- b) anticipated plunger specifications and speed;
- c) anticipated loading conditions;
- d) anticipated operational temperature range and the parallel environmental temperature range;
- e) size, type, and configuration of devices to be run through the lubricator;
- f) the required KE rating (see 5.10 and B.6.3);
- g) other relevant operational parameter(s).

4.5 Environmental Compatibility

The user/purchaser shall provide the service environment of the plunger lift lubricator to the supplier/manufacturer. The user/purchaser is responsible for the selection the materials used and ensuring that any material specified for use is satisfactory in the service environment. Materials may be proposed by the supplier/manufacturer based upon the user/purchaser-provided environmental conditions.

If the user/purchaser has access to the corrosion property data of the operating environment based on historical data and/or research, they shall state to the supplier/manufacturer which material(s) can perform as required within the corrosion environment.

The user/purchaser shall identify the density, chemical/physical composition, and the condition of the fluids and/or components, which includes solids (sand production, scale, etc.), liquid, and/or gaseous, to which the lubricator is exposed during its expected life cycle.

Environments where CO₂ corrosion may be present require intensive consideration to define the corrosion-related issues. These issues may be combined with other detrimental environmental factors, including temperature, sand, water, pH, and chloride ion concentrations.

The user/purchaser may define the requirement for the products using ANSI/NACE MR0175/ISO 15156 as a guide. This is the service in fluids that have an H₂S partial pressure greater than those listed for sulfide stress cracking in ANSI/NACE MR0175/ISO 15156 (all parts). The supplier/manufacturer shall provide component materials conforming to NACE requirements, and welding processes for this service shall also meet NACE requirements.

4.6 Compatibility with Related Well Equipment

The user/purchaser shall identify the following as applicable:

- the mating inlet and outlet connection design, size, orientation, location, and material, and include any supplemental and/or annex requirements;
- size, type, configuration, and location of other devices or conduits to be used in connection with this product.

4.7 Validation Grade Selection

The user/purchaser shall specify the required design validation grade as shown in Table 1. This specification provides three validation grades (V1, V2, and V3), as detailed in 5.12 and 6.5. The selected design validation grade applies to the validation testing per Annex B.

Table 1—Design Validation Grade Summary

Grade	Synopsis
V1	Gas testing per V1 as in Annex B after V2 testing
V2	Perform testing as defined in Annex B
V3	Supplier/manufacturer-defined validation criteria and testing procedure results that when compiled into a comprehensive report and approved by a qualified person support the product's design ratings

4.8 Quality Grade Selection

The user/purchaser shall specify the required quality grade as shown in Table 2. This specification provides three grades (QL1, QL2, and QL3) of QC, as detailed in Table 9.

Table 2—Quality Grade Summary

Grade	Synopsis
QL1	Most stringent level of requirements
QL2	Intermediate level of requirements
QL3	Supplier/manufacturer-defined criteria

4.9 Functional Testing

Lubricator functional testing has one set of requirements; therefore, no grade selection is required. See Annex C.

4.10 Temperature Range Selection

The user/purchaser shall specify the required temperature classification as shown in Table 3. This specification provides three classifications—"L," "P," and "U"—as detailed in 5.8.3. Typical temperature classifications are shown in Table 3; however, others may be specified.

Table 3—Typical Temperature Ranges

Temperature Classifications Correlating to API 6A, 20th Edition	Operating Temperature Ranges			
	°C Minimum	°C Maximum	°F Minimum	°F Maximum
L	−46°	82°	−50°	180°
P	−29°	82°	−20°	180°
U	−18°	121°	0°	250°

5 Technical Specification

5.1 General

5.1.1 General

The supplier/manufacturer shall prepare a technical specification that conforms to the requirements defined in the functional specification. If the technical specification does not fully meet the functional requirements, the supplier/manufacturer shall identify the differences to the user/purchaser. The supplier/manufacturer shall also provide to the user/purchaser the product datasheet defined in 6.2.5 and have available an operator's manual and design documentation as defined in 5.1.2 and 6.2.

Threaded and flanged external connections shall conform with the applicable API or proprietary connection design requirements.

Measuring and monitoring equipment used during the testing shall be calibrated as defined in 6.8. All measurements for acceptance shall be within the calibrated range(s) of the testing equipment. All pressures are defined as gauge unless otherwise specified and shall be recorded on time based equipment.

5.1.2 Design Documentation

Design of products manufactured to this specification shall include documentation of those designs. This documentation shall include, as applicable, design requirements, assumptions, analysis methods, comparison with previous designs or operating history of similar products, calculations, manufacturing drawings and specifications, design reviews, and/or physical testing results (which may include design validation/design verification testing). The supplier/manufacturer shall identify each component as either Type 1 or Type 2.

5.2 Technical Characteristics

The lubricator shall perform in accordance with the functional specification during installation and operation.

5.3 Design Requirements

5.3.1 General

Products conforming to this specification shall be manufactured to drawings and specifications that are substantially the same as those of the same size, type, and model of product that was validated. Lubricator designs shall have operational functionality as required in the functional requirements.

Components identified as Type 1 shall include all welded components, which are traceable, and components that contain pressure and/or may retain wellbore fluids and/or accept impact loading.

Components identified as Type 2 do not conform to the definition of Type 1 components.

The design verification of the KE rating of the assembled design shall be performed by the supplier/manufacturer. Verification shall use a documented procedure that contains documented limits and is performed by a qualified person. The results shall be approved by a second qualified person to establish a defined limit.

The anticipated combined loading conditions applied to the lubricator by the attached piping and the flowing loads therein shall be considered in the design.

5.3.2 Design Assumptions

The supplier/manufacturer shall apply a design margin to each component and/or assembly using a documented methodology and practice. Each design margin shall be established by a qualified person and be approved by a second qualified person who did not participate in the original design. The documented design margins shall be applied in the creation of component or assembly capabilities and/or ratings.

Lubricator designs are prepared and rated with the expectation of using one plunger at a time. Other applications require special considerations to be defined in the contract. Typical plunger operations are reviewed in informative Annex E.

The lubricator design(s) shall be analyzed to determine the supplier/manufacturer's stated performance limits. The minimum material condition, including a defined corrosion/wear allowance (where applicable) and minimum material yield strength, shall be used in the calculations.

5.3.3 Interface Connections

5.3.3.1 Flanged Designs

The interface connections of the lubricator are required to mount and seal on the API design flanges of the wellhead or wellhead valves; therefore, the API 6A specification tables are referenced for convenience in Table 4 and Table 5.

Nominal flange sizes and pressure ratings shall conform to the dimensional and material requirements of the following tables that are within API 6A, 20th Edition.

Table 4—API Specification 6A, 20th Edition (SI Units) Applicable Table

General Description	Table #
Type 6B flanges for 13.8 MPa rated working pressure (RWP)	49
Type 6B flanges for 20.7 MPa RWP	50
Type 6B flanges for 34.5 MPa RWP	51
Type 6BX integral flanges for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa RWPs	53
Type 6BX integral flanges for 103.5 MPa and 138.0 MPa RWPs	54
Type RX Segmented flanges for 34.5 MPa RWP	60
Type R ring gaskets	63
Type RX pressure-energized ring gaskets	64
Type BX pressure-energized ring gaskets	65