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Petroleum and natural gas industries — Drilling and production equipment —

Part 2: Flow-control devices for side-pocket mandrels

Industries du pétrole et du gaz naturel — Équipement de forage et de production —
Partie 2: Dispositifs de régulation de la vitesse d'écoulement pour raccords à poche latérale

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17078-2 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

ISO 17078 consists of the following parts, under the general title *Petroleum and natural gas industries — Drilling and production equipment*:

— *Part 1: Side-pocket mandrels*

— *Part 2: Flow-control devices for side-pocket mandrels*

— *Part 3: Running, pulling and kick-over tools, and latches for side-pocket mandrels*

A part 4 dealing with practices for side-pocket mandrels and related equipment is under development.

Introduction

This part of ISO 17078 has been developed by users/purchasers and suppliers/manufacturers of subsurface flow-control devices used in side-pocket mandrels (hereafter called flow-control devices) intended for use in the worldwide petroleum and natural gas industry. This part of ISO 17078 is intended to provide requirements and information to all parties who are involved in the specification, selection, manufacture, testing and use of flow-control devices. Further, this part of ISO 17078 addresses supplier/manufacturer requirements that set the minimum parameters with which suppliers/manufacturers shall comply to claim conformity with this part of ISO 17078.

This part of ISO 17078 has been structured to support varying requirements in environmental service classes, design validation, product functional testing and quality control grades. These variations allow the user/purchaser to select the grade for a specific application.

Well environmental service classes. There are four environmental service classes for flow-control devices that provide the user/purchaser with a range of choices from which to select products to meet varying environmental conditions.

Design validation grades. There are three design validation grades for flow-control devices that provide the user/purchaser with a range of technical and performance requirements. This ensures that the products supplied according to this part of ISO 17078 meet the requirements and that the user/purchaser is able to compare these requirements with its preference or application and determine whether additional requirements are placed on the supplier/manufacturer.

It is important that users of this part of ISO 17078 be aware that requirements in addition to those outlined herein can be needed for individual applications. This part of ISO 17078 is not intended to inhibit a supplier/manufacturer from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. This can be particularly applicable where there is innovative or developing technology. Where an alternative is offered, it is the responsibility of the supplier/manufacturer to identify any variations from this part of ISO 17078 and provide details.

Product functional testing grades. There are three product functional testing grades for flow-control devices that provide the user/purchaser with a range of choices for confirming that individual products manufactured under this part of ISO 17078 meet the design specifications.

Quality control grades. There are two quality control grades that provide the user/purchaser with the choice of requirements to meet specific preferences or applications. Additional quality upgrades can be specified by the user/purchaser as supplemental requirements.

In addition to this document, ISO 17078-1 provides requirements for side-pocket mandrels used in the petroleum and natural gas industry. ISO 17078-3, to be published, is intended to provide requirements for running, pulling and kick-over tools, and latches used in conjunction with side-pocket mandrel flow-control devices.

Petroleum and natural gas industries — Drilling and production equipment —

Part 2: Flow-control devices for side-pocket mandrels

1 Scope

This part of ISO 17078 provides requirements for subsurface flow-control devices used in side-pocket mandrels (hereafter called flow-control devices) intended for use in the worldwide petroleum and natural gas industry. This includes requirements for specifying, selecting, designing, manufacturing, quality-control, testing and preparation for shipping of flow-control devices. Additionally, it includes information regarding performance testing and calibration procedures.

The installation and retrieval of flow-control devices is outside the scope of this part of ISO 17078. Additionally, this part of ISO 17078 is not applicable to flow-control devices used in centre-set mandrels or with tubing-retrievable applications.

This part of ISO 17078 does not include requirements for side-pocket mandrels, running, pulling, and kick-over tools, and latches that might or might not be covered in other ISO specifications. Reconditioning of used flow-control devices is outside of the scope of this part of ISO 17078.

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.

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production*

ISO 17078-1:2004, *Petroleum and natural gas industries — Drilling and production equipment — Part 1: Side-pocket mandrels*

ANSI/NCSL Z540-1, *Calibration Laboratories and Measuring and Test Equipment General Requirements*[1)]

ASME Boiler and Pressure Vessel Code, Section IX, *Welding and Brazing Qualifications*[2)]

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*[3)]

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1) NCSL International, 2995 Wilderness Place, Suite 104, Boulder, Colorado 80301-5404, USA.

2) American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA.

3) ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959.

ASTM D1415, *Standard Test Method for Rubber Property — International Hardness*

ASTM D2240, *Standard Test Method for Rubber Property — Durometer Hardness*

BS 2M 54, *Specification for temperature control in the heat treatment of metals*[4)]

MIL-STD-1916, *DOD Preferred Methods for Acceptance of Product*[5)]

MIL-STD-413C, *Visual Inspection Guide for Elastomeric O-rings*[5)]

SAE AMS-H-6875, *Heat Treatment of Steel Raw Materials*[6)]

SAE AS568B, *Aerospace Size Standard for O-Rings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9000 (for quality-system-related terms not given below) and the following apply.

3.1
acceptance
flow-control device component(s) and/or assembly(s) accepted for use without restriction

3.2
ager
pressure device used to apply an external pressure to a flow-control device for a specified period of time and/or number of cycles

3.3
balanced injection-pressure-operated
injected gas pressure-operated flow-control device with no spread, that is, for which the opening and closing pressures are the same

3.4
certificate of conformance
documentation declaring that a specific flow-control device meets the requirements of this part of ISO 17078 and the requirements of the functional specification

3.5
coating
application of a thin film of one material on the surface of another material for different purposes

3.6
date of manufacture
date of manufacturer's final acceptance of finished products

NOTE The date is day-month-year in the format DD-MM-YYYY.

3.7
design family
group of products whose configurations, sizes, materials and applications are sufficiently similar that identical design methodologies can be used to establish the design parameters for each product within the family

4) British Standards Institute, Customer Services, 389 Chiswick High Road, London W4 4AL, UK.

5) US military/Department of Defense standard.

6) SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

3.8
design method
method, procedure or equations used by the supplier/manufacturer to design a flow-control device product

3.9
design validation
process of proving a design by testing to demonstrate conformity of the product to design requirements

3.10
design verification
process of examining the premise of a given design by calculation, comparison or investigation to substantiate conformity with specified requirements

3.11
differential flow-control device
flow-control device that opens and closes on differential pressure between the injected gas and production pressures

3.12
dome
chamber that contains an internal pressure that is applied to the responsive element that may be a bellows or piston

3.13
dome charge maximum
supplier/manufacturer's maximum recommended pressure charge in the dome at recommended operating temperature

3.14
dummy flow-control device
blank device that is installed in a side-pocket mandrel to prevent flow or pressure communication between the casing annulus and the tubing

3.15
dump/kill flow-control device
flow-control device that is initially closed; once it is open, it cannot be closed again

NOTE These valves have very large ports and no reverse-flow check to allow a high injection rate to kill the well.

3.16
dynamic flow testing
flow testing of an operable flow-control device to determine the flow characteristics as a function of changes in either upstream or downstream pressures

3.17
end connections
thread or other mechanism providing a connection between the flow-control device and other equipment

3.18
flow coefficient testing
testing that is performed on a modified flow-control device to determine the flow capacity as a function of fixed stem travel

3.19
full life cycle
expected period of time over which the product shall function according to the manufacturer's specifications

3.20
functional test
test performed to confirm proper operation of equipment

3.21
functionality
definition or description of the performance with associated properties, characteristics and limits of a flow-control device

3.22
gas passage undercut
clearance between the flow-control device and the pocket of the side-pocket mandrel through which injected media flows

3.23
heat
⟨cast lot⟩ material originating from a final melt or cast lot

NOTE For re-melted alloys, a heat is defined as the raw material originating from a single re-melted ingot.

3.24
informative
information that is meant to inform the user/purchaser or supplier/manufacturer without containing requirements

3.25
injection-pressure-operated
injected gas pressure-operated flow-control device

3.26
injection-pressure-operated with choke
injected gas pressure-operated flow-control device with a choke installed downstream of the port

3.27
job lot
group or quantity of piece parts, subassemblies or assemblies that are grouped or processed together during the manufacturing process

3.28
latch
retention mechanism for a flow-control device that is landed in a side-pocket mandrel

3.29
manufacturing
process(es) and action(s) performed by an equipment supplier/manufacturer that are necessary to provide finished component(s), assemblies and related documentation that fulfil the requests of the user/purchaser, and to meet the standards of the supplier/manufacturer

NOTE Manufacturing begins when the supplier/manufacturer receives the order and is completed at the moment the component(s), assembly(ies) and related documentation are transferred to a transportation provider.

3.30
model
side-pocket mandrel flow-control device that has unique components and functional characteristics that differentiate it from other products of the same type

3.31
normative
information or procedures that shall be used by the user/purchaser or supplier/manufacturer as they comply with this part of ISO 17078

3.32
nozzle venturi flow-control device
flow-control device that cannot be closed, but is intended to restrict flow to a desired rate

NOTE The port is in the shape of a venturi nozzle.

3.33
operating environment
set of environmental conditions to which the product is exposed during its service life

NOTE This includes such environmental variables as temperature, pressure, liquid composition and properties, gas composition and properties, solids, etc.

3.34
orifice flow-control device
flow-control device that cannot be closed but is intended to restrict flow to a desired rate

3.35
perceptible leak
any leak during a test that can be detected

3.36
pilot flow-control device
injected gas pressure-operated flow-control device with a primary opening section that activates the full-opening flow section

3.37
production-pressure-operated
production-well fluid pressure-operated flow-control device

3.38
production-pressure-operated with choke
production well fluid pressure-operated flow-control device with a choke installed upstream of the port

3.39
qualified design family
design family whereby the validation of one or more representative design(s) and product(s) permits the entire family to be treated as validated by association in accordance with 6.4

3.40
quality control
process and/or method(s) used by the supplier/manufacturer to ensure the quality of the materials and manufacturing process(es)

3.41
rated pressure
maximum pressure at the rated temperature for which the flow-control device is designed in normal operation

3.42
rated temperature
maximum temperature at the rated pressure for which the flow-control device is designed in normal operation

3.43
shear orifice flow-control device
flow-control device that is initially closed; once it is opened, it cannot then be reclosed

NOTE It is equipped with a back-check valve.

3.44
side-pocket mandrel
tubing-mounted device that accepts a flow-control or other device in a bore that is offset from, and essentially parallel with, the through-bore of the tubing product

NOTE This bore includes sealing surfaces and latching profiles.

3.45
supplier/manufacturer
company, organization or entity that designs, manufactures and/or markets flow-control device products

3.46
technical specifications
requirements of the equipment necessary for compliance with the functional specification

3.47
test pressure
pressure, based upon all relevant design criteria, at which the equipment is tested

NOTE Each test pressure has a related test temperature, as specified by the pertinent test procedure.

3.48
test temperature
temperature, based upon all relevant design criteria, at which the equipment is tested

3.49
traceability
⟨job lot⟩ ability for individual components to be designated as originating from a job lot that identifies the included heat(s)

3.50
type
flow-control device equipment with unique characteristics that differentiate it from other functionally similar flow-control device equipment

3.51
user/purchaser
company, organization or entity that purchases, installs and uses flow-control device products

3.52
welding
method for joining two metallic substances through a process of melting and re-solidification

NOTE The term “welding” covers welding, brazing, or soldering operations.

3.53
well environmental service grade
well environmental service grade refers to the service in which the flow-control device is used

3.54
wireline
equipment and associated technique(s) used to install and retrieve flow-control devices in a well using a continuous length of solid line (slick line) or stranded wire, appropriate spooling equipment at the surface and weight and specialized tools attached to the well (downhole) end of the wire

3.55
yield strength
stress level measured at test temperature, beyond which material plastically deforms and does not return to its original dimensions

NOTE The yield strength is expressed in units of force per unit of area.

4 Symbols and abbreviated terms

4.1 Abbreviations

ANSI	American National Standards Institute
AQL	acceptable quality level
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing Materials
AWS	American Welding Society
CIPT	constant injection pressure test
CPPT	constant production pressure test
ECV	equalizing control flow-control device
FCD	flow-control device
GST	geometric stem travel for fully opened condition
ID	internal diameter
IPO	injection-pressure-operated
ISA	Instrument Society of America
LST	maximum effective stem travel from the probe test
MSCFD	thousands of standard cubic feet per day
MSCMD	thousands of standard cubic metres per day
NDE	non-destructive testing method
OD	external diameter
PPO	production-pressure-operated
PQR	procedure qualification record
RP	recommended practice
SC	standard conditions, assumed to be 101 kPa (14,73 psia) and 15,5 °C (60 °F)
SCFD	standard cubic feet per day
SCMD	standard cubic meters per day
VST	flow-control device stem travel
WPQ	welder/welding operator performance qualification
WPS	welding procedure specification

4.2 Symbols and engineering terms

A_b	effective bellows area, expressed in square centimetres (square inches)
A_p	area based on the nominal port diameter, expressed in square centimetres (square inches)
A_s	area based on the diameter where the stem contacts the seat, expressed in square centimetres (square inches)
B_{lr}	bellows assembly load rate, expressed in kilopascals per centimetre (pounds per square inch per inch)
C_v	flow coefficient
dP	differential pressure, expressed in kilopascals (pounds per square inch)

d_{st} distance stem has moved from seat, expressed in centimetres (inches)

d_{LST} distance of maximum effective stem travel from probe test

d_{VST} distance of flow-control device stem travel

F_x specific heat factor, equal to k/1,40

H factor determined by the manufacturer to calculate the upstream test procedure for the constant injection pressure test

k ratio of specific heats of lift gas

m_{bf} slope of the best-fit straight line

P_1 upstream gauge pressure of test section, expressed in gauge kilopascals (pounds per square inch)

P_2 downstream gauge pressure of test section, expressed in gauge kilopascals (pounds per square inch)

P_{iod} operating injection gauge pressure at flow-control device depth, expressed in gauge kilopascals (pounds per square inch)

P_o upstream gauge pressure for a constant downstream pressure

P_{pd} flowing production gauge pressure at flow-control device depth, expressed in gauge kilopascals (pounds per square inch)

P_{ox} measured or calculated pressure applied over the area (A_b minus A_s), required to initiate flow through a flow-control device with zero gauge pressure downstream at the supplier/manufacturer's reference temperature

NOTE Referred to as flow-control device opening pressure at the supplier/manufacturer's reference temperature, expressed in gauge kilopascals (pounds per square inch).

P_{tro} measured or calculated gauge pressure applied over the area (A_b minus A_s), required to initiate flow through a flow-control device with zero gauge pressure downstream at 15,5 °C (60 °F)

NOTE Referred to as flow-control device opening pressure at standard temperature, expressed in gauge kilopascals (pounds per square inch).

P_{vc} measured or calculated upstream gauge pressure when the downstream pressure is equal to the upstream pressure and near zero gas flow rate at 15,5 °C (60 °F)

NOTE Referred to as flow-control device closing pressure at standard temperature, expressed in gauge kilopascals (pounds per square inch).

P_{vcT} measured or calculated upstream gauge pressure when the downstream pressure is equal to the upstream pressure and near zero gas flow rate at a known temperature

NOTE Referred to as flow-control device closing pressure at a known temperature, expressed in gauge kilopascals (pounds per square inch).

P_{vo} valve opening pressure

P_{voT} measured or calculated gauge pressure applied over the area (A_b minus A_s), required to initiate flow through a flow-control device with zero gauge pressure downstream at a known temperature

NOTE Referred to as flow-control device opening pressure at a known temperature, expressed in gauge kilopascals (pounds per square inch).

P_{vst} pressure at maximum stem travel

q measured flow rate at standard conditions, expressed in cubic metres per hour or standard cubic feet per hour

q_{gi} measured flow rate at standard conditions, expressed in thousands of standard cubic metres per day or thousands of cubic feet per day

R_{tef} ratio that expresses the "tubing effect factor" of flow-control devices, as given by Equation (1) or the alternative form given in Equation (2):

$$R_{tef} = \left(\frac{A_s}{A_b}\right) \Big/ \left(1 - \frac{A_s}{A_b}\right) \quad (1)$$

$$R_{tef} = \left(P_{voT} - P_{vcT}\right) / P_{vcT} \quad (2)$$

Ra roughness, expressed in micrometres (micro-inches)

S_g specific gravity of gas (the value for air equals 1,0)

t time, expressed in seconds

T_1 upstream gas temperature, expressed in either degrees Celsius (degrees Fahrenheit) or kelvin (degrees Rankine)

T_v temperature of flow-control device at depth, expressed in either degrees Celsius (degrees Fahrenheit) or kelvin (degrees Rankine)

R_p pressure ratio; the measured differential pressure across the test section divided by the absolute upstream pressure, expressed as $\mathrm{d}P/(P_1 + 100)$ kPa $\left[\mathrm{d}P/(P_1 + 14{,}7)\text{psi}\right]$

$R_{p,crt}$ critical pressure ratio factor; the pressure ratio factor at which the velocity of fluid exceeds the local speed of sound

NOTE Critical flow occurs when $F_k \times R_{p,crt}$ equals or exceeds the pressure ratio. The value is determined as specified in Clause 5.

F_Y expansion factor

Z_1 upstream compressibility factor

5 Functional specification

5.1 General

The purpose of the functional specification is to allow the user/purchaser to specify and define the functional requirements for flow-control device(s).

The user/purchaser shall prepare a functional specification for products that conform to this part of ISO 17078. The specification shall specify the following requirements and operating conditions, as appropriate, and/or identify the supplier/manufacturer's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, a data sheet, a functional specification form or other suitable documentation.

5.2 Functional characteristics

A flow-control device is a device that is landed by wireline or other means and secured in a side-pocket mandrel bore. The flow-control device acts to control the flow or communication of gas and/or liquid between