BRITISH STANDARD

BS EN ISO 17078-2:2007

Incorporating corrigendum June 2009

Petroleum and natural gas industries — Drilling and production equipment —

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

ICS 75.180.10

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National foreword

This British Standard is the UK implementation of EN ISO 17078-2:2007. It is identical to ISO 17078-2:2007, incorporating corrigendum June 2009.

The UK participation in its preparation was entrusted by Technical Committee PSE/17, Materials and equipment for petroleum, petrochemical and natural gas industries, to Panel PSE/17/-/4, Drilling and production equipment for petroleum and natural gas industries.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2008

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English Version

Petroleum and natural gas industries - Drilling and production equipment - Part 2: Flow-control devices for side-pocket mandrels (ISO 17078-2:2007)

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 (ISO 17078-2:2007)

Erdöl- und Erdgasindustrie - Bohr- und Produktionsausrüstungen - Teil 2: Durchfluss-Regelvorrichtungen für Gaslift-Ventile (ISO 17078-2:2007)

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Foreword

This document (EN ISO 17078-2:2007) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2008, and conflicting national standards shall be withdrawn at the latest by June 2008.

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Endorsement notice

The text of ISO 17078-2:2007 has been approved by CEN as a EN ISO 17078-2:2007 without any modification.

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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.

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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.

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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.

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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.

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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

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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.

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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

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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

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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.

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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.

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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)

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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

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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 $\left[\mathrm{d}P/(P_1 + 14{,}7)\,\mathrm{psi}\right]$

$R_{p,crt}$ 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

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the pressure-retaining areas of the well (e.g. annulus-to-tubing flow of gas, tubing-to-annulus flow of injection fluid, etc.).

The user/purchaser shall specify, as applicable, the following functional characteristics.

a) Flow-control device functions, including the specific function for which the flow-control device is used, e.g. gas lift, chemical injection, water flood injection, etc.;

b) Functions, which the user/purchaser may define by specifying either a specific flow-control device or functional items such as the following:

   — flow-control device type: IPO, PPO, seat material, elastomers, packing type, TRO/PVC range and special coating;

   — nominal flow-control device size, e.g. 2,54 cm (1 in), 3,81 cm (1,5 in), etc.;

   — port size;

   — port type: square-edged, bevelled, tapered, venturi, cross-over;

   — maximum bellows pressure;

   — bellows protection;

   — maximum spring load rate;

   — minimum flow-control device stem travel;

   — minimum/maximum flow rate when fully open;

   — back-check flow-control device(s);

   — choke size and type, if applicable;

c) Latch, the size and/or type and/or model(s) of which may be used to install, secure and retrieve the flow-control device in a side-pocket mandrel;

d) Seal bore, either the nominal size and configuration with which to accommodate the flow-control or other device, or the model(s) of the side-pocket mandrel in which the flow-control or other device for installation;

e) Communication ports, either the location and configuration of both inlet and outlet ports on the flow-control device, and/or the model of the flow-control device for installation;

f) Conduit ports, the connection size and configuration for side-pocket mandrel external ports and outlets to which a side-string, control, or injection conduit is to connect. This is for reference to validate that the specified flow-control device communication and internal port sizes are compatible.

5.3 Well parameters

5.3.1 Well fluid parameters

The following well fluid parameters to which the flow-control device is exposed during its full life cycle shall be provided:

a) fluid composition, chemical composition, specific gravity, etc., of

   — produced fluids (liquid, hydrocarbon gas, CO_2, H_2S, etc.),

   — injection gas (e.g. hydrocarbon gas, CO_2, etc.),

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— injection fluids (e.g. water, steam, CO_2, chemicals, etc.),

— completion fluids,

— treatment/stimulation fluids/chemicals;

b) description of extraneous components (e.g. paraffin, sand, scale, corrosion products, etc.).

5.3.2 Allowable well operations

Expected well intervention(s) including its (their) parameters, such as the following, shall be stated:

a) acidizing, including acid composition, pressure, temperature and acidizing velocity, as well as exposure time and any other chemicals used during well stimulation;

b) fracturing, including proppant description, fracture fluid velocity, proppant/fluid ratio;

c) sand consolidation operations.

5.3.3 Corrosion information

If the user/purchaser has access to the corrosion property data of the operating environment based on historical data and/or research, this information shall be made available to the supplier/manufacturer. The user/purchaser may indicate to the supplier/manufacturer which material(s) has/have the ability to perform as required within the subject well's corrosion environment.

5.4 Operational parameters

The user/purchaser shall specify specific appropriate installation, testing and operational parameters to which the flow-control devices are subjected. These shall include, but are not limited to,

a) expected hydrostatic head at flow-control device depth,

b) expected minimum and maximum operating injection pressures,

c) expected minimum and maximum operating production pressures,

d) expected minimum and maximum operating temperatures,

e) expected minimum and maximum gas or liquid injection rates,

f) expected minimum and maximum fluid production rates,

g) expected maximum differential pressure across the back-check,

h) expected maximum internal-to-external differential pressure across the flow-control device,

i) expected pressure/differential at which a dump/kill or shear orifice opens,

j) expected installation, testing and operational procedures,

k) expected flow-control device deployment and retrieval method(s).

Exceptional operating conditions can require flow-control devices that are outside of the scope of this part of ISO 17078. In such cases, the user/purchaser and the supplier/manufacturer shall develop a mutually acceptable design and evaluation program that meets the intent and spirit of this part of ISO 17078.

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5.5 Compatibility with well-related equipment

The user/purchaser, where applicable, shall specify the interface connection designs and material requirements, free-passage requirements and external/internal dimensional limitations needed to ensure that the product conforms to their application.

An example list is as follows:

a) size, type, material, configuration and interface dimensions of the connection between the product and other well equipment.

b) internal/external receptacle profile(s)/securing mechanism(s), sealing dimensions and their respective locations.

ISO 17078-1:2004, Table 1, details the polished bore dimensions required for side-pocket mandrels built to ISO 17078-1 specifications. The flow-control devices shall be selected to match the dimensions in accordance with ISO 17078-1. If there are occasions when the design of the side-pocket mandrel requires polished bore dimensions other than those listed, agreement between user/purchaser and supplier/manufacturer shall be documented.

5.6 Environmental service classes

The user/purchaser shall specify one of the following environmental service classes. If no class is specified, class E4 is deemed acceptable. This part of ISO 17078 provides for the following four environmental service classes as stipulated in 6.3. See Annex B for definitions.

— E4: Standard service;

— E3: H_2S or sour service;

— E2: CO_2 service;

— E1: Unique service, the characteristics of which are specified by the user/purchaser.

5.7 Design validation grades

The user/purchaser shall specify one of the following design validation grades. If no design validation grade is specified, grade V3 shall be deemed acceptable. This part of ISO 17078 provides the following three design validation grades as stipulated in 6.5. See Annex C for definitions.

— V3: Basic level of design validation;

— V2: Intermediate level of design validation;

— V1: Highest level of design validation.

5.8 Product functional testing grades

The user/purchaser shall specify one of the following product functional testing grades. If no product functional testing grade is specified, grade F3 shall be deemed acceptable. This part of ISO 17078 provides the following three product functional testing grades as stipulated in 6.6. See Annex D for definitions.

— F3: Basic level of product functional testing;

— F2: Intermediate level of product functional testing;

— F1: Highest level of product functional testing.

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5.9 Quality control grades

The user/purchaser shall specify one of the following quality control grades. If no quality control grade is specified, grade Q2 shall be provided. This part of ISO 17078 provides two design quality control grades as stipulated in 7.4.

— Q2: Basic level of quality control;

— Q1: Highest level of quality control.

5.10 Additional required testing

The user/purchaser may specify additional design validation testing, product functional testing and/or quality control that is deemed necessary for a specific application. These requirements shall be in addition to those included herein.

6 Technical specification

6.1 General requirements

6.1.1 Purpose

The purpose of the technical specification is to guide the supplier/manufacturer to specify and define the technical requirements that shall be met by the flow-control device product(s) that are designed and manufactured to meet the functional specifications produced by the user/purchaser.

The supplier/manufacturer shall prepare the technical specification to meet the requirements defined in the user/purchaser's functional specification as defined in Clause 5. The supplier/manufacturer shall also provide the product data as defined in 7.2 to the user/purchaser.

6.1.2 Flow-control device groups

There are many possible types and permutations of flow-control devices. For purposes of simplification in flow-control device design validation testing and product functional testing, the various flow-control device types are classified into groups as shown in Table 1. See Clause 3 for definitions.

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Table 1 — Flow-control device descriptions

Flow-control device group	Flow-control device types	Flow-control device description
I	IPO	Injection-pressure-operated flow-control device
	Balanced IPO	Injection-pressure-operated flow-control device with no “spread”, that is the opening and closing pressures are the same
	IPO with choke	Injection-pressure-operated flow-control device, with a choke installed downstream of the port
II	PPO	Production-pressure-operated flow-control device
	PPO with choke	Production-pressure-operated flow-control device, with a choke installed upstream of the port
III	Pilot	Injection-pressure-operated flow-control device with a pilot section and a full-opening primary flow section
	Differential	Flow-control device that opens and closes depending on the difference between the injection and production pressures
IV	Orifice	Flow-control device that cannot be closed
	Nozzle venturi	Flow-control device that cannot be closed, having a port in the shape of a venturi nozzle
	Shear orifice	Flow-control device that is initially closed; once it is opened, it cannot then be reclosed
	Dump/kill	Flow-control device that is initially closed; once it is opened, it cannot then be reclosed. These valves have very large ports and no reverse-flow check to allow a high-injection rate to kill the well.
V	Dummy	Blank device that is installed in a side-pocket mandrel to prevent flow or pressure communication between the casing annulus and the tubing
VI	Chemical injection	Injection-pressure-operated flow-control device used for injection of chemical from a special injection line into the tubing
	Chemical injection – spring loaded	Spring-operated flow-control device used for injection of chemical from a special injection line into the tubing
VII	Surface controlled – hydraulic	Flow-control device that is opened or closed by use of hydraulic pressure actuated from the surface
	Surface controlled – electric	Flow-control device that is opened or closed by use of an electrical signal actuated from the surface
	“Smart”	Flow-control device that contains on-board logic that can be used to regulate its degree of open/close
VIII	Liquid injection	Flow-control device used to control the rate of liquid injection within desired ranges
IX	Other	Devices that are not intended to control flow but may be installed in side-pocket mandrels, such as devices for pressure measurement, temperature measurement, monitoring corrosion, measuring flow, connecting to other devices and providing control logic

6.2 Technical characteristics

6.2.1 General

The supplier/manufacturer shall design and manufacture the flow-control device product to meet the functional criteria in 6.2.2 through 6.2.6.

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6.2.2 Flow-control device installation

The flow-control device shall be positioned and seal at the specified location and remain so until human intervention defines otherwise.

6.2.3 Functional requirements

While located in the side-pocket mandrel, the flow-control device shall perform as in accordance with its specific technical specification.

6.2.4 Tool passage

The flow-control device, where applicable, shall not interfere with the safe passage through the side-pocket mandrel of tools, as specified in the functional specification.

6.2.5 Corrosion and chemical resistance requirements

Should the supplier/manufacturer determine that another material can equally or better meet the user/purchaser's specified corrosion-prevention requirements for the application (see 5.3.3), the user/purchaser shall be notified that this material has performance characteristics suitable for all parameters specified in the well and production/injection parameters (see 5.4). This applies to metallic and non-metallic components. Agreement shall be obtained before any change in materials from those indicated by the user/purchaser.

6.2.6 Operating parameters

The flow-control device shall perform in accordance with the operating parameters and characteristics as stated in the functional specification.

6.3 Design criteria

6.3.1 General

The supplier/manufacturer shall use the design criteria in 6.3.2 through 6.3.11 in designing the flow-control device(s).

6.3.2 Material environmental service grades

The supplier/manufacturer shall meet the environmental service requirements as specified by the user/purchaser. The required design requirements associated with each environmental service grade are detailed in Annex B.

6.3.3 Performance rating

The supplier/manufacturer shall state the pressure, temperature and other operational characteristics of the flow-control device.

6.3.4 Polished bore dimensions

ISO 17078-1:2004, Table 1, details the polished bore dimensions required for side-pocket mandrels built to ISO 17078-1 specifications. The flow-control device shall be designed to be compatible with dimensions in accordance with ISO 17078-1. However, there may be occasions when the design of the flow-control devices requires polished bore dimensions other than those listed. In those cases, agreement between user/purchaser and supplier/manufacturer shall be documented.

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6.3.5 Interchangeability

Components and subassemblies of each type, model and size of flow-control device shall be designed, manufactured and identified to provide interchangeability within the product line of any one manufacturer. Stems and seats lapped to form matched sets are considered a single component for the purposes of this subclause.

6.3.6 Compatibility

The supplier/manufacturer shall provide documentation of specific side-pocket mandrels and latches that are compatible with the flow-control device. The level of documentation depends on the design validation grade and/or product functional test grade selected by the user/purchaser.

6.3.7 Dimensions

Dimensional tolerances of components or subassemblies shall be such that cumulative tolerances do not preclude proper operation as described in the design validation requirements. The assumptions, calculations and/or other design criteria shall be detailed in the design file for that product.

6.3.8 Packing, O-rings and seals

6.3.8.1 Allowable elastomeric materials

The supplier/manufacturer shall provide elastomeric materials that are compatible with the environmental service grade specified by the user/purchaser. Where applicable, consider the effects on elastomeric materials of the presence of aromatics and the proportion of hydrocarbons with a molecular weight of less than 120. The supplier/manufacturer shall document the process used for selecting compatible elastomeric materials.

6.3.8.2 Packing polished bore dimensions

The diameters of the external packing on all flow-control devices shall be designed using the polished bore dimensions as listed in ISO 17078-1 or upon special agreement between user/purchaser and supplier/manufacturer.

6.3.8.3 Design validation testing

Packing, O-rings and seal design validation testing shall be conducted as detailed in 7.4.8.2.

6.3.9 Good design practice

Good design practices, such as the following, shall be used.

— Locate the gas passage entry port of the flow-control device in the gas passage undercut of the side-pocket mandrel pocket.

— Provide rounded or bevelled exterior surfaces to prevent handing difficulties as the flow-control devices are lowered into or retrieved from the well.

— Design to prevent possible unseating of the flow-control device from the side-pocket mandrel as other devices are pulled through the side-pocket mandrel.

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6.3.10 Design methods

Flow-control devices shall be designed using all or some of the following:

— finite element analysis for strength of material issues;

— computational fluid dynamics for flow characteristics;

— proprietary equations;

— standard equations;

— experimental stress analyses;

— experimental flow analyses;

— proof test analysis.

This part of ISO 17078 does not dictate the methods, equations or procedures for design purposes. The design method(s) that are used shall be documented in written supplier/manufacturer procedures.

All pressure-containing parts shall be designed to satisfy the supplier/manufacturer's test pressures and to meet the conditions defined in the functional specification. The assumptions, calculations and/or other design criteria shall be detailed in the design file for that product.

All flow characteristics pertinent to the design that are calculated by computational fluid dynamics shall be validated through testing, the use of appropriate equations, flow analysis modelling or other means in accordance with this part of ISO 17078 and recognized industry practices in regard to flow validations.

6.3.11 Scaling of design

6.3.11.1 Qualified design families

For the purpose of design scaling, scaling is allowed to scale only between maximum and minimum port sizes on a specific flow-control device design family.

Products may be grouped into design families if they have interchangeable parts and if their configurations, sizes and applications are sufficiently similar to utilize a common methodology for establishing their design limits.

If requested by user/purchaser, the supplier/manufacturer shall provide the following documentation with products that have been verified by association:

— summary of all records of validated designs and/or products from the family;

— trend analyses or scatter diagrams, as appropriate, to demonstrate that the performance generated by the design methodology and analysis are sufficiently consistent to permit other designs to be validated by association;

— defined limits to the design variables within the validated family, outside of which similar designs cannot be considered to be validated by association and are, therefore, not part of the validated family.

6.3.11.2 New design variations

New designs may be added to existing design families if their configurations, materials and applications are documented and approved by the supplier/manufacturer's assigned approval agent, as sufficiently similar to utilize the common methodology for establishing the design performance for products in that family. These designs are considered to be variations within the scope of the existing product family. If the design family is a qualified design family, the new designs may be considered qualified by association.

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6.4 Allowable design changes

6.4.1 General

Under certain circumstances, design changes are allowed. Any changes in the design of a flow-control device shall be made following the procedures listed in 6.4.2 and 6.4.3.

6.4.2 Design changes

Design changes to existing products within a design family that meet the following requirements do not change their status as part of the design family and do not change their qualification by association within a qualified design family.

— The design changes do not require a change in the common methodology for establishing design performance envelopes within the design family.

— The operational parameters for the product(s) experiencing a design change are consistent with the operational parameters for the design family.

— A change in seat size is not considered a change in flow-control device design for the purposes of this subclause unless it also changes the calculated stem travel and bellows position from the initial starting position to the mechanical stop by more than 5 %.

A design that undergoes a substantive change becomes a new design requiring design validation. Justifications for design changes identified as non-substantive shall be documented.

For flow-control devices with unique or multiple features that do not constitute a substantive change of the design configuration of the product, the new feature(s) are tested in accordance with the supplier/manufacturer's documented requirements for design validation of that feature. Acceptance criteria and results shall be documented.

6.4.3 Supplemental features validation test

Flow-control devices with unique or multiple supplemental features that do not change the design of the product are to be tested in accordance with the supplier/manufacturer's documented requirements that validate proper operation of that feature. Acceptance criteria and results shall be documented.

6.5 Design verification and validation requirements

6.5.1 General

The supplier/manufacturer shall use these design verification and validation procedures to ensure that each flow-control device design family fulfils the applicable functional requirements that it is intended to meet.

6.5.2 Design verification

Design verification shall be performed on each design family of flow-control device to ensure that the device meets the supplier/manufacturer's technical specifications. Design verification includes activities such as design reviews, design calculations and comparison with similar designs and historical records of defined operating conditions.

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6.5.3 Design validation

6.5.3.1 Testing

Design validation testing shall be performed on each design family of flow-control devices to ensure that the device meets the supplier/manufacturer's technical specifications. Design validation test requirements are specified in the normative Annexes A to M.

6.5.3.2 Design validation grade table

The design validation grade table specifies the design validation process(es), procedure(s) and test(s) that shall be followed for each design validation grade. See Table A.2.

6.5.4 Optional design validation testing

Some applications can require additional design validation testing. These additional design validation tests shall be specified by the user/purchaser in the functional specification.

6.6 Product functional testing requirements

6.6.1 General

The supplier/manufacturer shall use the following test(s) and/or process(es) to demonstrate that each flow-control device that is produced fully meets the design specifications.

6.6.2 Product functional testing grade table

The product functional testing grade table specifies the process(es) or procedure(s) that shall be followed for each product functional testing grade. See Table A.2.

6.6.3 Optional product functional testing

Some applications can require additional product functional testing. These shall be specified by the user/purchaser in the functional specification.

7 Supplier/manufacturer requirements

7.1 General

The supplier/manufacturer shall meet the following requirements in designing, manufacturing, testing, and delivering the flow-control device product(s) that are covered by this part of ISO 17078.

Clause 7 contains the detailed requirements to ensure that each product manufactured meets the requirements of the functional specifications in Clause 5 and the technical specifications in Clause 6. As a minimum, each of the topics discussed in 7.2 to 7.9 shall be addressed.

7.2 Documentation and data control

7.2.1 General

The supplier/manufacturer shall establish and maintain documented procedures to control all documents and data that relate to the requirements, including normative annexes of this part of ISO 17078. These documents and data shall be maintained to demonstrate conformance to specified requirements. All documents and data shall be legible and shall be sorted and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss. Documents and data

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may be in the form of any type of media, such as hard copy or electronic media. All documents and data shall be available and auditable by the user/purchaser.

7.2.2 Documentation requirements

The supplier/manufacturer shall have available a completed design file containing all the supplier/manufacturer's required design validation testing procedures and design validation grade testing records, with verified acceptance of each. The file shall further contain test results and/or calculations that validate the design. The design packet shall be properly reviewed and approved by a qualified person other than the originator.

7.2.3 Documentation requirements for specific product design validation testing

There are three sets of requirements for the documentation of product design validation tests, one for each product design validation grade: V3, V2 and V1. These are identified in Table A.2 and the test requirement annexes to which Table A.2 refers. In some cases, the requirements in 7.2 are sufficient. In other cases, special documentation is required and is specified in the appropriate annexes.

7.2.4 Devices tested prior to date of publication of this part of ISO 17078

The requirements for documentation may be met for flow-control device products that existed before the publication of this part of ISO 17078 if the supplier/manufacturer can document that they successfully performed the required tests on these devices to meet the equivalent validation testing requirements, and that these tests have been approved by a qualified person. If the procedures are not the same as defined in this part of ISO 17078, the supplier/manufacturer shall provide written evidence of the suitability of the previous test procedure(s) to ensure that they meet or exceed these requirements.

7.2.5 Design documentation

The design validation test results shall be clearly identified as grade V3, V2 or V1.

The product functional test results shall be clearly identified as grade F3, F2 or F1.

All design documents, data, design validation test results and initial product functional test results in the following list shall be maintained for five years after the date of last manufacture:

a) functional and technical specifications;

b) supplier/manufacturer's quality manual;

c) required grade of QC (quality control) documentation as specified in 5.8;

d) one complete set of drawings, written specifications and design calculations and standards;

e) instructions providing methods for the safe installation and use of the flow-control device. This document shall state the operations that are permitted and shall preclude those operations that can lead to failure and/or non-compliance with the functional and performance requirements;

f) material type, yield strength and connection identification for the actual end connection(s) provided with the flow-control device (where applicable);

g) welding procedure specification (WPS);

h) weld procedure qualification record (PQR);

i) welder/welding operator performance qualification (WPQ).

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7.2.6 Product functional testing documentation

7.2.6.1 Test file

The supplier/manufacturer shall have available a complete test file containing all the supplier/manufacturer's required product functional testing procedures and product functional test grade testing records, with verified acceptance of each. The file shall further contain test results and/or calculations that confirm the performance of the product(s) that have been tested.

7.2.6.2 Documentation requirements for specific product functional testing

There are three sets of requirements for documentation of product functional tests, one for each product functional testing grade: F3, F2 and F1. These are identified in Table A.2 and the test requirement annexes to which Table A.2 refers.

7.2.7 User/purchaser documentation

A product data sheet for each line item on each order shall be supplied upon delivery of the order to the user/purchaser, as required in the quality control grade.

NOTE The intent of this is to require a separate product data sheet for each unique product or set of products that is part of a specific design family.

The product sheet shall contain at least the following, as applicable:

a) name and address of supplier/manufacturer;

b) supplier/manufacturer assembly number;

c) supplier/manufacturer product name;

d) product type;

e) operational parameters as specified in 5.4;

f) metallic materials;

g) non-metallic materials;

h) overall length;

i) temperature range for rated pressure;

j) rated pressure;

k) top connection(s);

l) conveyance method;

m) maximum conveyance OD, inclusive of running equipment, as applicable;

n) retrieval method;

o) quality control grade;

p) design validation grade;

q) product functional testing grade;

r) technical/operations manual reference number.

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7.2.8 Technical/operations manual

A technical/operations manual shall be available for products supplied in accordance with this part of ISO 17078 and shall contain at least the following information:

a) manual reference number and revision level;

b) product data sheet;

NOTE An example product data sheet will be shown in ISO 17078-4, which is under development as of the date of publication of this part of ISO 17078.

c) operational procedures;

d) pre-installation inspection procedures;

e) storage recommendations;

f) representative drawing showing major dimensions (ODs, IDs, and lengths);

g) special precautions and handling;

h) list of all devices with which compatibility is claimed for the flow-control device.

7.3 Product identification requirements

7.3.1 General

The supplier/manufacturer shall clearly identify and mark each flow-control device according to the requirements of 7.3.

7.3.2 Product identification

Each product furnished to this part of ISO 17078 shall be permanently identified using low-stress marking devices, which include interrupted-dot or rounded cold die-stamp, vibratory method or laser etching. Supplier/manufacturer specifications shall define the method(s) and location of the markings. The following information, as a minimum, shall be marked on each flow-control device:

a) supplier/manufacturer's name or mark;

b) date (month and year) of manufacture;

c) supplier/manufacturer's part number and unique traceable serial number.

7.4 Quality control requirements

7.4.1 General

This part of ISO 17078 provides for two quality control grades. Requirements for each of these grades are specified in 7.4.6.

7.4.2 Quality control personnel qualifications

All personnel performing quality control activities directly affecting material and product quality shall be qualified in accordance with the supplier/manufacturer's documented requirements.

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7.4.3 Manufacturing non-conformance

The supplier/manufacturer shall establish and maintain documented procedures to ensure that an assembly or component that does not conform to specified requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when applicable) and disposition of non-conforming assemblies or components.

The responsibility for review and authority for the disposition of non-conforming assemblies or components shall be defined by the supplier/manufacturer. Non-conforming assemblies or components may be

— reworked to meet the specified requirements,

— accepted, with or without repair, by concession of the supplier/manufacturer's authorized personnel, if the assembly or component does not violate design validation requirements, or

— rejected or scrapped.

Repaired and/or reworked assemblies or components shall be inspected in accordance with the appropriate quality control grade.

7.4.4 Component dimensional examination

Components and assemblies shall be dimensionally inspected to ensure proper function and compliance with design criteria and technical specifications. The frequency of these examinations shall be performed as detailed in the supplier/manufacturer’s written requirements.

7.4.5 Traceability

The supplier/manufacturer is responsible for traceability, documentation and the product condition at time of shipment to the user/purchaser.

All components, weldments, subassemblies and assemblies of equipment supplied in accordance with this part of ISO 17078 shall be traceable to a job lot, for which components and weldments shall also identify the heat(s) or batch lot(s) included. All components and weldments in a multi-heat or batch job lot shall be rejected if any heat or batch does not comply with specified requirements. Individual component identification shall be maintained to facilitate traceability until the supplier/manufacturer’s final inspection is completed.

7.4.6 Quality control grade selection

7.4.6.1 General

This part of ISO 17078 provides two grades of quality control for flow-control devices. The user/purchaser shall specify, in the functional specification, the grade of quality control and/or additional requirements when desired. The documentation of quality control shall be presented to the user/purchaser on request.

7.4.6.2 Grade Q2 — Basic grade of flow-control device quality control

The documentation shall include a certificate of conformance for the flow-control devices in the flow-control device job lot, at the request of the user/purchaser.

7.4.6.3 Grade Q1 — Highest level of flow-control device quality control

The documentation shall include a certificate of conformance for the flow-control devices in the flow-control device job lot. It shall also contain mill certification for all components, except common hardware items, as specified in this subclause. In addition, it shall contain the results of all product functional tests run on this flow-control device job lot.

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The following are examples of common hardware items that may be excluded:

— roll pins;

— copper gaskets;

— snap rings;

— coating materials;

— valve cores.

Products shall be supplied to quality control grade Q2 unless the user/purchaser specifies grade Q1.

The user/purchaser may also specify an additional quality/certification system to apply to equipment supplied to this part of ISO 17078.

Each quality control grade requires appropriate documentation. This documentation shall be maintained in manufacturing or quality control files. It shall be presented to the user/purchaser if requested.

7.4.7 Measuring/testing equipment

7.4.7.1 General

Measuring and testing equipment shall meet or exceed the measurement accuracy required by the acceptance criteria for that evaluation or test.

7.4.7.2 Calibration

7.4.7.2.1 General

Measuring and testing equipment used for acceptance (including annex acceptance criteria) shall be identified, inspected, calibrated and adjusted at specific intervals in accordance with documented specifications, ANSI/NCSL Z540-1 and this part of ISO 17078.

7.4.7.2.2 Pressure-measuring devices

Pressure-measuring devices shall

a) be readable to at least ± 0,5 % of full-scale range, or better, as required to perform the specified measurement;

b) be calibrated to maintain ± 2 % accuracy of full-scale range, or better, as required to perform the specified measurement.

Pressure-measuring devices shall be used only within the calibrated range.

Pressure-measuring devices shall be calibrated with a master pressure-measuring device or a dead weight tester. Calibration intervals for pressure-measuring devices shall be a maximum of three months until a documented calibration history can be established. Calibration intervals shall then be established based on repeatability, degree of usage and documented calibration history.

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7.4.8 Elastomeric materials and seal design

7.4.8.1 Inspection requirements for packing, O-rings and seal materials

7.4.8.1.1 General

All flow-control device packing, O-rings and seal materials shall be inspected according to the requirements of 7.4.

7.4.8.1.2 Elastomeric materials

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

a) Tolerances

The tolerances of O-rings shall be in compliance with SAE AS 568A. Other packing elements shall meet the dimensional tolerances of the supplier/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-1916, General Inspection Level II, at a 2.5 AQL for O-rings and at a 1.5 AQL for other packing elements.

b) Hardness

The durometer hardness of O-rings shall be measured in accordance with ASTM D2240 or ASTM D1415. The preferred method is to conduct the hardness test on a test specimen from each batch and cure cycle rather than test individual seals. In the event that such tests are 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 7.4 for O-rings or other packing elements.

c) Visual inspection

O-rings shall be visually inspected in accordance with MIL-STD-413C. Other packing elements shall be visually inspected according to the manufacturer's written inspection procedures. The inspection shall include such items as lip damage, flashing, breaks, cracks or other visible damage.

d) Handling and storage

Materials used for sealing devices such as O-rings or other packing elements require special handling and storage procedures. The supplier/manufacturer shall have written specifications that include handling and storage requirements, including the shelf life appropriate for each specific material compound.

7.4.8.1.3 Other materials

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

7.4.8.1.4 Traceability

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

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7.4.8.2 Sealing device design validation testing

7.4.8.2.1 General

The supplier/manufacturer shall perform and document design validation testing for each size, design and material of sealing device used in each flow-control device. Once a sealing device has successfully passed design validation testing, it is qualified for use on multiple products of similar dimensional requirements within the temperature and pressure differentials tested. All sealing devices shall be tested by pressurization in the direction(s) of the seal's intended use and design requirements. Sealing devices that qualified to ISO 10432 or ANSI/API Spec 14A, prior to the publication of this part of ISO 17078, may be considered as meeting the design validation test requirements of this part of ISO 17078, providing that the documentation of these tests confirms conformance to test requirements of this part of ISO 17078.

7.4.8.2.2 Required characteristics for the apparatus

The apparatus shall meet the following requirements.

a) The tested sealing device and the gland, mandrel and sealing bore surfaces shall be of the identical configuration, dimension and tolerances as used for the production products.

b) When a test fixture is used, it shall be designed to apply the pressures, temperatures and loads in a manner comparable to that of the production products.

c) Testing components/fluids shall be designed to perform the test procedure within the required parameters.

d) The sealing device design, materials, test results and all test pressures, test temperatures and fluid descriptions shall be documented.

7.4.8.2.3 Test procedure

The test shall be carried out as outlined below.

a) Install the sealing device in the test apparatus following the supplier/manufacturer's procedures. Verify that all equipment and fluids can safely meet the required pressures, temperatures and accuracy.

b) Adjust and stabilize the assembled test apparatus to within $^{+10}_{0}$ % of the sealing device's maximum rated temperature. Adjust and stabilize the differential pressure on the sealing device to (25 ± 2) % of the maximum rated pressure. Hold and continuously record the temperature and pressure for a minimum of 15 min. The pressure and temperature measurement shall remain within the tolerances for a successful test. If there are concerns with low-temperature service, this shall be addressed with a special separate written test procedure.

c) Repeat step (b) at (100 ± 2) % of the maximum rated pressure with all other parameters unchanged.

d) Release the pressure.

e) Repeat step (b) at the maximum rated temperature $^{+10}_{0}$ % with all other parameters unchanged.

f) Repeat step (e) at (100 ± 2) % of the maximum rated pressure.

g) Release the pressure.

7.4.8.2.4 Acceptance criteria

Acceptance criteria are listed below.

a) The sealing device shall successfully meet the test requirements and remain within the required limits.

b) A visual inspection of the sealing device following this testing shall confirm that it meets the supplier/manufacturer's written acceptance criteria.

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7.4.9 Material certifications

7.4.9.1 Test certificates

A supplier/manufacturer's mill test certificate of the original heat of the material or a supplier/manufacturer's certification of test results are acceptable if the certifications include test results for mechanical properties and chemical composition for that heat of material. If the material is altered by subsequent processes that change its properties, then acceptance is based on either hardness or mechanical properties as specified in ASTM A370 from the heat of the material in question. These tests are completed using the heat treat cycle for which the material is being qualified. If the initial test specimen fails, two new, additional tests shall be successfully performed 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 the supplier/manufacturer shall document the hardness-strength correlations.

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

Raw material used in the manufacture of components shall meet the following requirements:

a) certificate of conformance stating that the raw material meets the supplier/manufacturer’s documented specifications;

b) material test report showing that the supplier/manufacturer can verify that the raw material meets the supplier/manufacturer’s documented specifications.

7.4.9.2 Mechanical properties

Material mechanical properties shall be as follows.

a) Mechanical property test procedures and practices for metallic materials shall be in accordance with ASTM A370 for the metallic materials used for traceable components.

b) Mechanical property test procedures for elastomeric and non-metallic compound types shall be in accordance with 7.4 of this part of ISO 17078.

7.4.9.3 Inspection requirements

Inspection requirements for packing, O-ring and seal materials shall be conducted as detailed in 7.4, as applicable.

7.5 Heat-treating-equipment qualification

Heat-treating-equipment shall meet the following qualifications.

a) Heat treating of production parts shall be performed with heat-treating equipment that has been calibrated and surveyed.

b) Each furnace shall be surveyed within one year prior to heat-treating operations. When a furnace is repaired or rebuilt, a new survey shall be required before heat treating.

c) Batch-type and continuous-type heat-treating furnaces shall be calibrated in accordance with one of the following procedures:

   1) procedures specified in SAE AMS-H-6875;

   2) procedures specified in BS 2M 54;

   3) supplier/manufacturer's written specifications, including acceptance criteria that are not less stringent than the procedures identified above.

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7.6 Welding requirements

7.6.1 General

The supplier/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. Instruments utilized to verify temperature, voltage and amperage shall be serviced and calibrated in accordance with the flow-control device supplier/manufacturer's written procedures.

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

7.6.2 Welding consumables

Welding consumables shall conform to AWS or supplier/manufacturer's written specifications. The supplier/manufacturer shall have a written procedure for selection, 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.

7.6.3 Welding procedures/qualification records

Welding shall be performed in accordance with welding procedure specifications written and qualified in accordance with Article II of ASME Boiler and Pressure Vessel Code Section IX. The WPS shall describe all the essential and nonessential variables as defined in ASME Boiler and Pressure Vessel Code Section IX. The procedure qualification record shall record all essential variables as defined in ASME Boiler and Pressure Vessel Code Section IX of the weld procedure used for the qualification test(s).

The test weldment for hardness testing shall have the same type of post-weld heat treatment as the final product. For flow-control device environmental service class E3, hardness tests across the weld, base material and heat-affected zone (HAZ) cross-section shall be performed in accordance with ASTM E18 and recorded as part of the PQR. Maximum hardness values for environmental grade E3 service shall not exceed the requirements of ISO 15156 (all parts).

NOTE For the purposes of this provision, NACE MR0175 is equivalent to ISO 15156 (all parts).

7.6.4 Welder/welding operator performance qualification

Welders and welding operators shall be qualified in accordance with Article III of ASME Boiler and Pressure Vessel Code Section IX. Records of WPQ test shall include all welding parameters as detailed in ASME Boiler and Pressure Vessel Code Section IX.

7.7 Non-destructive examination requirements

Non-destructive examinations (NDE) are not required as part of this part of ISO 17078, except as indicated in this subclause. If NDE examinations are conducted for supplier/manufacturer's internal procedures or because of user/purchaser written requests, the NDE procedures defined in ISO 17078-1 shall be followed.

Where NDE is used on flow-control devices, the supplier/manufacturer shall prepare written specifications for allowable relevant indications.

7.8 Storage and shipping preparation

7.8.1.1 General

The supplier/manufacturer shall comply with the requirements specified in 7.8.1.2 to 7.8.1.5 for storage and shipping of flow-control device products.

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7.8.1.2 Draining, cleaning and/or drying

The processes for draining, cleaning and/or drying of flow-control device products after they have been tested shall be specified in the supplier/manufacturer's written procedures. The minimum standard shall be that the products be free of any foreign liquids and/or matter.

7.8.1.3 Threaded connections and packing

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

7.8.1.4 Permanent marking prior to coating

Prior to coating, all permanent marking that is required by this part of ISO 17078 shall be completed. No marking may affect the operation of any component of a flow-control device. All markings shall be made and located according to supplier/manufacturer’s written procedures. No coating is allowed on or in active threads or on the sealing surface other than coating, plating or other surface treatments that are specified by the supplier/manufacturer for these surfaces.

7.8.1.5 Shipping of pressurized flow-control devices

Shipping of pressurized flow-control devices shall conform with applicable transportation regulations.

7.9 Allowable changes after manufacturing

Any reconfiguration of, or change to, a previously validated and tested product, over and above settings and adjustments, shall require full design validation and product functional testing to qualify it to this part of ISO 17078.

7.10 Reconditioning of flow-control devices

Reconditioning of used flow-control device products is outside of the scope of this part of ISO 17078. However, this process is used in industry. See ISO 17078-4, which is under preparation as of the date of publication of this part of ISO 17078, for a discussion of this topic.

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Annex A
(normative)

Design validation and product functional testing requirements

A.1 General

Table A.1 is an index of the annexes and their purpose.

Table A.1 — Purpose of normative and informative annexes

Annex	Annex title	Purpose of annex[a]
A	Design validation and product functional testing requirements	List purpose of each annex List all required design validation and product functional test requirements
B	Environmental service classes	Tests required for four environmental service grades: E4, E3, E2 and E1
C	Design validation grades	Tests required for three design validation grades: V3, V2 and V1
D	Product functional testing grades	Tests required for three product functional testing grades: F3, F2 and F1
E	Interface testing requirements	Design validation testing of all interfaces between flow-control devices and other related devices such as side-pocket mandrels
F	Insertion testing requirements	Design validation testing of insertion and retrieval of flow-control devices into and from side-pocket mandrels
G	Probe and travel testing and load rate determination	Design validation testing of maximum travel and load rate Product functional testing of maximum travel and load rate
H	Dynamic flow testing and flow coefficient, C_v, calculation	Design validation testing of flow and flow coefficient, C_v Product functional testing of flow and flow coefficient, C_v
I	Back-check testing	Design validation testing of back-check devices Product functional testing of back-check devices
J	Opening and closing pressure testing	Design validation testing of opening and closing Product functional testing of opening and closing
K	Bellows actuation life cycle testing	Design validation testing of bellows life cycles
L	Erosion testing requirements	Design validation testing of effects of erosion
M	Shelf (bellows integrity) testing requirements for nitrogen-pressure-charged flow-control devices	Design validation shelf (bellows integrity) testing Product functional shelf (bellows integrity) testing
N	Conducting port/seat leakage rate testing	Design validation testing of port/seat leakage rates Product functional testing of port/seat leakage rates
O	Performance testing — Recommendations for a flow-control device performance test facility	Recommended practices for facilities for performance testing of flow-control devices
P	Performance testing — Prediction correlations using a simplified flow-control device performance model	Tests to develop performance correlations Recommended practices for performance testing of flow-control devices

[a] The purpose of the normative Annexes A to M is to define design validation and product functional test requirements for flow-control devices.

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A.2 Design validation and product functional testing requirements

The following table summarizes the design validation and product functional testing requirements that shall be performed for each flow-control device group and type (see 6.1.2 and Table 1 for a definition of each flow-control device and type). There are several categories of tests, for example interface testing, insertion testing, probe or travel testing, etc. However, the open and close test is only pertinent for design validation testing and the separate open and close tests are only pertinent for product functional testing.

The specific requirements for each category of test are defined in one of the normative Annexes E through M. For each group and type of flow-control device there are three design validation grades (V3, V2 and V1) and three product functional test grades (F3, F2 and F1). There can be a separate test required for each grade or a single test can be used for more than one grade.

If a cell in the following table contains a dash, no test is required. If a specific test is not listed for a specific flow-control device group and type, it is not required.

In Table A.2, the specific test for each grade is identified. For example, the interface testing requirements for flow-control device type IPO are defined in Annex E. The design validation test specified in E.2.1 is required for grades V3 and V2. The design validation test specified in E.2.2 is required for grade V1. No product functional tests are required for interface testing for this flow-control device type.

As another example, the back-check testing requirements for flow-control device type IPO are defined in Annex I. The design validation test specified in I.2.1 is required for grade V3. The design validation test specified in I.2.2 is required for grade V2. The design validation test specified in I.2.3 is required for grade V1. The product functional test specified in I.3.1 is required for grade F3. The product functional test specified in I.3.2 is required for grade F2. The product functional test specified in I.3.3 is required for grade F1.

Open and close testing are conducted together for design validation. Separate open and close tests are required for production functional testing. Therefore, these tests are listed separately in Table A.2.

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Table A.2 — Testing requirements

Flow-control device group and type (See 6.1.2)		Design validation test and/or product functional test	Annex	Design validation and product functional test requirements for each flow-control device grade					
				V3 Basic grade	V2 Intermediate grade	V1 Highest grade	F3 Basic grade	F2 Intermediate grade	F1 Highest grade
I	IPO Balanced IPO IPO w/ choke	Interface	E	E.2.1	E.2.1	E.2.2	-	-	-
		Insertion	F	F.2	F.2	F.2	-	-	-
		Probe or travel	G	G.2	G.2	G.2	-	G.4.2	G.4.3
		Load rate	G	G.3	G.3	G.3	-	G.5.2	G.5.3
		Flow	H	-	H.2.2	H.2.3	-	-	H.3.4
		Back-check	I	I.2.1	I.2.2	I.2.3	I.3.1	I.3.2	I.3.3
		Open and close	J	J.1.2	J.1.2	J.1.2	-	-	-
		Open	J	-	-	-	J.2	J.2	J.2
		Close	J	-	-	-	-	J.3.2	J.3.3
		Actuation life cycle	K	-	-	K.2.2	-	-	-
		Erosion	L	-	L.2.2	L.2.2	-	-	-
		Shelf	M	M.2.1	M.2.1	M.2.1	M.3.2	M.3.2	M.3.2
		Port/seat leakage rate	N	N.2.1	N.2.1	N.2.1	N.3.1	N.3.1	N.3.1
II	PPO PPO w/choke	Interface	E	E.2.1	E.2.1	E.2.2	-	-	-
		Insertion	F	F.2	F.2	F.2	-	-	-
		Probe or travel	G	G.2	G.2	G.2	-	G.4.2	G.4.3
		Load rate	G	G.3	G.3	G.3	-	G.5.2	G.5.3
		Flow	H	-	H.2.2	H.2.3	-	-	H.3.4
		Back-check	I	I.2.1	I.2.2	I.2.3	I.3.1	I.3.2	I.3.3
		Open and close	J	J.1.2	J.1.2	J.1.2	-	-	-
		Open	J	-	-	-	J.2	J.2	J.2
		Close	J	-	-	-	-	J.3.2	J.3.3
		Actuation life cycle	K	-	-	K.2.2	-	-	-
		Erosion	L	-	L.2.2	L.2.2	-	-	-
		Shelf	M	M.2.1	M.2.1	M.2.1	M.3.2	M.3.2	M.3.2
		Port/seat leakage rate	N	N.2.1	N.2.1	N.2.1	N.3.1	N.3.1	N.3.1

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Table A.2 (*continued*)

Flow-control device group and type (See 6.1.2)		Design validation test and/or product functional test	Annex	Design validation and product functional test requirements for each flow-control device grade					
				V3 Basic grade	V2 Intermediate grade	V1 Highest grade	F3 Basic grade	F2 Intermediate grade	F1 Highest grade
III	Pilot Differential	Interface	E	E.2.1	E.2.1	E.2.2	-	-	-
		Insertion	F	F.2	F.2	F.2	-	-	-
		Flow	H	-	H.2.2	H.2.3	-	-	H.3.4
		Back-check	I	I.2.1	I.2.2	I.2.3	I.3.1	I.3.2	I.3.3
		Open and close	J	J.1.2	J.1.2	J.1.2	-	-	-
		Open	J	-	-	-	J.2	J.2	J.2
		Close	j	-	-	-	-	J.3.2	J.3.3
		Actuation life cycle	K	-	-	K.2.2	-	-	-
		Erosion	L	-	L.2.2	L.2.2	-	-	-
		Shelf	M	M.2.1	M.2.1	M.2.1	M.3.2	M.3.2	M.3.2
		Port/seat leakage rate	N	N.2.1	N.2.1	N.2.1	N.3.1	N.3.1	N.3.1
IV	Orifice Nozzle venturi Shear orifice Dump/kill	Interface	E	E.2.1	E.2.1	E.2.2	-	-	-
		Insertion	F	F.2	F.2	F.2	-	-	-
		Flow	H	-	H.2.2	H.2.3	-	-	H.3.4
		Back-check	I	I.2.1	I.2.2	I.2.3	I.3.1	I.3.2	I.3.3
		Open and close	J	J.1.2	J.1.2	J.1.2	-	-	-
		Erosion	L	-	L.2.2	L.2.2	-	-	-
		Shelf	M	M.2.1	M.2.1	M.2.1	-	-	-
		Port/seat leakage rate	N	-	-	-	N.3.1	N.3.1	N.3.1
V	Dummy	Interface	E	E.2.1	E.2.1	E.2.2	-	-	-
VI	Chemical injection Chemical injection, spring-loaded	Interface	E	E.2.1	E.2.1	E.2.2	-	-	-
		Insertion	F	F.2	F.2	F.2	-	-	-
		Probe or travel	G	-	-	-	-	G.4.2	G.4.3
		Load rate	G	-	-	-	-	G.5.2	G.5.3
		Flow	H	-	H.2.2	H.2.3	-	-	-
		Back-check	I	I.2.1	I.2.2	I.2.3	I.3.1	I.3.2	I.3.3
		Open and close	J	J.1.2	J.1.2	J.1.2	-	-	-
		Open	J	-	-	-	J.2	J.2	J.2
		Close	J	-	-	-	-	J.3.2	J.3.3
		Actuation life cycle	K	-	-	K.2.2			-
		Erosion	L	-	L.2.2	L.2.2			-
		Shelf	M	M.2.1	M.2.1	M.2.1	M.3.2	M.3.2	M.3.2
		Port/seat leakage rate	N	N.2.1	N.2.1	N.2.1	N.3.1	N.3.1	N.3.1

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