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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 15136-1

Petroleum and natural gas industries — Progressing cavity pump systems for artificial lift —

Part 1: Pumps

*Industries du pétrole et du gaz naturel — Pompes de fond à
cavités progressantes pour activation des puits —*

Partie 1: Pompes

ICS: 75.180.10

ISO/TC 67/SC 4

Secretariat: **ANSI**

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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 15136-1 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.

This second edition cancels and replaces the first edition (ISO 15136-1:2001), which has been technically revised.

Added definitions of terms for equal-wall thickness stator and metal stator.

Added Technical specification for PCPs.

Added Supplier/manufacturer requirements for PCPs.

Revised the requirements for progressing cavity pump elastomers in [Appendix A](#).

Revised the Hydraulic validation in [Appendix B](#).

Revised the Pump bench test parameter requirements in [Appendix C](#).

ISO 15136 consists of the following parts, under the general title Petroleum and natural gas industries — Progressing cavity pump systems for artificial lift:

Part 1: Pumps

Part 2: Surface-drive systems

Introduction

This part of ISO 15136 has been developed by users/purchasers and suppliers/manufacturers of progressing cavity pumps and is intended for use in the petroleum and natural gas industry worldwide. This part of ISO 15136 provides requirements and information to both parties in the selection, manufacturing, testing, and using progressing cavity pumps as defined in the scope. Further, this part of ISO 15136 addresses supplier requirements, which set the minimum parameters with which it is necessary that suppliers comply to claim conformity with this part of ISO 15136.

This part of ISO 15136 provides grades of requirements for design validation, quality control and functional evaluations allowing the user/purchaser to select each for a specific application. There are three grades of design validation and quality control, and two grades of functional testing. Design validation grade V3 is restricted to legacy products, the basic grade is V2 and the highest grade is V1. Quality control grade 3 is the standard grade and grades 2 and 1 provide additional requirements. Functional evaluation grade F1 requires a hydraulic test of the PCP and grade F2 does not. The user/purchaser has the option of specifying requirements supplemental to these grades.

It is necessary that the users of this part of ISO 15136 be aware that requirements above those outlined in this part of ISO 15136 can be needed for individual applications. This part of ISO 15136 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 clearly and completely identify any variations from the requirements of this part of ISO 15136.

Petroleum and natural gas industries — Progressing cavity pump systems for artificial lift —

Part 1: Pumps

1 Scope

This part of ISO 15136 provides requirements for the design, design verification and validation, manufacturing and data control, performance ratings, functional evaluation, repair, handling and storage of progressing cavity pumps for use in artificial lift in the petroleum and natural gas industry. This part of ISO 15136 is applicable to those products meeting the definition of progressing cavity pumps (PCP) included herein. Connections to the drive string and tubulars are not covered by this part of ISO 15136.

This part of ISO 15136 includes normative annexes that establish requirements for characterization and testing of stator elastomer material, design validation and functional evaluation. Additionally, informative annexes provide information for PCP elastomer selection and testing, installation, start-up and operation guidelines, equipment selection and application guidelines, functional specification form, used pump evaluation, drive string selection and use, repair and reconditioning procedures and auxiliary equipment.

Equipment not covered by the requirements of this part of ISO 15136 includes bottom-drive systems except for the PCP components, drive-string components and auxiliary equipment such as tag bars, gas separators and torque anchors. These items might or might not be covered by other International Standards. Surface-drive systems are covered in ISO 15136-2.

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 34-1, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*

ISO 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 815-1:2008, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 1: At ambient or elevated temperatures*

ISO 2977, *Petroleum products and hydrocarbon solvents — Determination of aniline point and mixed aniline point*

ISO 4662, *Rubber, vulcanized or thermoplastic — Determination of rebound resilience*

ISO 4666 (all parts), *Rubber, vulcanized — Determination of temperature rise and resistance to fatigue in flexometer testing*

ISO 7619-1, *Rubber, vulcanized or thermoplastic — Determination of indentation hardness — Part 1: Durometer method (Shore hardness)*

ISO 7743, *Rubber, vulcanized or thermoplastic — Determination of compression stress-strain properties*

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

ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 15136-2, *Petroleum and natural gas industries — Progressing cavity pump systems for artificial lift — Part 2: Surface-drive systems*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

API Spec 11B, *Specification for Sucker Rods*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension*

ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*

ASTM D429-08, *Standard Test Methods for Rubber Property — Adhesion to Rigid Substrates*

ASTM D575, *Standard Test Methods for Rubber Properties in Compression*

ASTM D611-07, *Standard Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents*

ASTM D623, *Standard Test Methods for Rubber Property — Heat Generation and Flexing Fatigue in Compression*

ASTM D624, *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*

ASTM D2240-05, *Standard Test Method for Rubber Property — Durometer Hardness*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

actual capacity per rpm

volumetric capability determined through functional testing for a specific product

Note 1 to entry: “rpm” has been retained in this term on the basis that it is part of an established industry terminology. However, it is deprecated by ISO as a unit, in which case it is rendered as the accepted form “r/min.”

3.2

applied torque

torque that is applied to the rotor of the PCP by the drive system

3.3

artificial lift system

assembly of equipment used to transport fluid from a subsurface formation to surface, which may include pump, drive string, prime mover and production tubing

3.4

auxiliary equipment

equipment or components that are outside the scope of this part of ISO 15136 and that are typically selected and/or installed by the user/purchaser

EXAMPLE Tag bars, gas separators and torque anchors.

3.5

bottom-drive system

PCP drive system utilizing a downhole prime mover

3.6

casing

pipe extending from the surface and intended to line the walls of a drilled well

3.7

casing size

nominal casing OD as specified in ISO 11960

3.8

core deflection

radial offset of the stator cavity centre-line from the stator tube centre-line

3.9

corrosive environment

operating environment where the combination of temperature and chemical agents causes degradation of the equipment

3.10

design validation

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

3.11

design verification

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

3.12

dogleg severity

localized wellbore curvature

3.13

differential pressure

difference between pump intake and discharge pressures

3.14

downhole capacity per rpm

volumetric capability estimated through calculations and downhole conditions

Note 1 to entry: "rpm" has been retained in this term on the basis that it is part of an established industry terminology. However, it is deprecated by ISO as a unit, in which case it is rendered as the accepted form "r/min."

3.15

drive string

device transmitting power (usually sucker rods) between the surface drive system and the PCP

3.16

engaged cavities

number of full cavities created by the interaction between the rotor and stator

3.17

failed item

any item that has failed

3.18

failure

termination of the ability of an item to perform a required function

3.19

failure descriptor

apparent, observed effect of failure (of a failed item)

3.20

failure cause

circumstances during design, manufacture, or use which have led to a failure

3.21

flow rate

volume of fluid pumped per unit of time

3.22

friction torque

resistance to rotation of the drive string (inside the tubing) and the rotor (inside the stator) that is dependent upon factors including (but not exclusive to) well depth and trajectory, pump geometry and interference fit between rotor and stator, and stuffing box characteristics

3.23

function

operation of a product during service

3.24

functional specification

features, characteristics, process conditions, boundaries and exclusions defining the performance and use requirements of the equipment

3.25

functional test

test performed to confirm proper equipment operation

3.26

grade

category or rank given to different requirements for quality or design validation

3.27

head rating

pressure rating expressed in terms of equivalent water column

3.28

hydraulic torque

torque induced by the differential pressure across the pump

3.29

insertable pump

PCP where the stator is run into the well through the production tubing

3.30

item

any part, component, device, subsystem, functional unit, equipment or system that may be individually considered

3.31

manufacturing

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

Note 1 to entry: Manufacturing begins when the supplier/manufacture receives the order and is completed at the moment the component(s), assembly(ies) and related documentation are surrendered to a transportation provider.

3.32

maximum operating speed

maximum operating speed for the pump as specified by the supplier/manufacturer

3.33

maximum operating temperature

maximum operating temperature for the pump as specified by the supplier/manufacturer

3.34

model

equipment with unique components and operating characteristics which differentiate it from other equipment of the same type

3.35

no-turn tool

prevents the PCP stator and/or tubing from backing off due to rotational torque caused by the interference fit between the rotor and stator

3.36

nominal capacity per rpm

published volumetric capability based on theoretical calculations and adjusted for commercial purposes

Note 1 to entry: "rpm" has been retained in this term on the basis that it is part of an established industry terminology. However, it is deprecated by ISO as a unit, in which case it is rendered as the accepted form "r/min."

3.37

non-conformance

non-fulfilment of a specified requirement, such as the divergence of equipment, part, practice or procedure from an established standard

3.38

operator

user of the equipment

3.39

operator's manual

publication issued by the supplier/manufacturer that contains detailed data and instructions related to the design, installation, operation and maintenance of equipment

3.40

operating environment

set of conditions to which the product is exposed during its full life cycle

3.41

orbit tube

section of oversized production tubing installed immediately above the stator

3.42

PCP geometry

unique combination of pitch, eccentricity and diameter

3.43

performance ratings

ratings for the hydraulic performance of the pump

3.44

pressure rating

rated differential pressure capacity

3.45

primary failed item

failed item within the PCP responsible for initiating the failure of the PCP

3.46

prime mover

motor (typically hydraulic, electric or internal combustion) providing the torque to rotate the pump rotor

3.47

progressing cavity pump PCP

pump installed in a well consisting of a stator and rotor whose geometry of assembly is such that it creates two or more series of lenticular, spiral, separated cavities

3.48

Equal-wall thickness PCP

A PCP that has a uniform and equal cross-sectional thickness of the elastomer along the axial direction and is also referred to as an even-wall PCP.

3.49

metal PCP

A PCP with the inner surface^a processed from metallic materials

Note 1 to entry: a: see [Figure 4](#)

3.50

qualified part

part manufactured under an authorized quality assurance programme and in the case of replacement, produced to meet or exceed the performance of the original part

3.51

qualified person

individual with characteristics or abilities gained through training or experience or both as measured against established requirements, such as standards or tests that enable the individual to perform a required function

3.52

reason for pull

motive for the pump being pulled from the well

3.53

redress

any activity restricted to the replacement of qualified parts

3.54

repair

any activity beyond the scope of redress that includes disassembly, re-assembly and testing with or without the replacement of qualified parts and may include machining, welding, heat treating or other manufacturing operations that restore the equipment to its original performance

3.55

required function

function or a combination of functions of an item, which is considered necessary to provide a given service

3.56

rotor

helical, contoured shaft

3.57

rotor phasing alignment jig

short segment of material moulded to match the rotor profile

3.58

substantial design change

change to the design, identified by the supplier/manufacturer, that affects the performance of the product in the intended service condition

3.59

size

relevant dimensional characteristics of the equipment as defined by the supplier/manufacturer

3.60

slugging

well production characterized by non-homogeneous flow

3.61

stator

segment of tube with an internal helical contoured surface which meshes with a rotor to create a series of lenticular cavities along the length of the tube.

3.62

stator phasing alignment jig

short segment of material moulded to match the stator core profile

3.63

swelling process

volume increase of an elastomer when a fluid diffuses into the material due to physical interactions between fluid and the elastomer

3.64

tag bar

assembly attached to the bottom of the stator that limits the distance the rotor may extend past the end of the stator

Note 1 to entry: Also known as a “stop bushing.”

3.65

technical specification

requirements that shall be fulfilled by the equipment to comply with the functional specification

3.66

test pressure

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

3.67

test temperature

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

3.68

torque anchor

device that prevents the stator and/or tubing from backing off due to rotational torque generated by the interference fit between the rotor and the stator

3.69

tubing

pipe placed within a well to serve as a production or injection conduit

3.70

tubing deployed

PCP system for which the stator is run into the well on the bottom of the tubing string

3.71

type

equipment with unique characteristics that differentiate it from other functionally similar equipment

3.72

unique identifier

unique combination of alphanumeric characters to identify a specific component

3.73**validated capacity per rpm**

volumetric capability determined through design validation testing

Note 1 to entry: “rpm” has been retained in this term on the basis that it is part of an established industry terminology. However, it is deprecated by ISO as a unit, in which case it is rendered as the accepted form “r/min.”

3.74**wellhead**

composite of equipment used at the surface to maintain control of the well

Note 1 to entry: Included in the wellhead equipment are casing heads (lowermost and intermediate), tubing heads, Christmas tree equipment with valves and fittings, casing and tubing hangers, and associated equipment.

4 Abbreviated terms and symbols

4.1 For the purposes of this part of ISO 15136, the following abbreviated terms apply.

BHT	bottomhole temperature
C30 ₊	hydrocarbon fractions with more than 30 carbon atoms per molecule
CP	failure in the cover cement-prime cement (interfacial failure) day (unit of time)
d	day (unit of time)
GOR	gas oil ratio
M	failure in the prime cement-metal interface (interfacial failure) measured depth
MD	measured depth
NDE	non-destructive examination
NPSH	net positive suction head
PCP	progressing cavity pump
PIP	pump intake pressure
R	failure of the rubber (substrate failure)
RC	failure in the rubber-cover cement (interfacial failure)
rpm	revolutions per minute
TVD	true vertical depth

4.2 For the purposes of this part of ISO 15136, the following symbols are used.

d_r	drive string diameter
Δp	differential pressure
D	minor diameter
e	eccentricity
F_r	drive string axial load

F_t	axial force on threads
F_s	axial force on torque shoulder
P	stator pitch; see Figure G.1
E_{all}	overall pump efficiency
Q	flow rate at a given differential pressure
Q_{eff}	volumetric efficiency
$Q_{\Delta p}$	volumetric flow rate at a differential pressure
Q_o	volumetric flow rate at $\Delta p < 350$ kPa
q_{TC}	theoretical capacity; see Equation (G.1)
T_r	drive string torque
T_s	torsion on torque shoulder
T_t	torsion on threads
W_{eff}	mechanical pump efficiency at specified pressure and flow rate
W_{fluid}	fluid power
W_{shaft}	input power at the pump shaft
δ	phase or loss angle
σ_e	effective stress
τ	shaft torque
ω	shaft speed

5 Functional specification

5.1 General

The user/purchaser shall prepare a functional specification to order products that conform to this part of ISO 15136 and specify the following requirements and operating conditions as appropriate and/or identify the supplier/manufacture's specific product. This information is used by the supplier/manufacture to recommend the PCP and/or components for the application. These requirements and operating conditions may be conveyed by means of a user/purchaser functional-specification form ([Annex H](#)) and operational guidelines ([Annex F](#)). The user/purchaser shall specify the units of measurement for the data provided.

PCPs are designed for specific applications; their use in new/different applications requires a detailed evaluation by the user/purchaser to ensure that the system can operate properly in all aspects in that new application. [Annexes E](#) and [F](#) contain installation and operational guidelines that can be relevant in this consideration. The process used to evaluate the new application shall be no less stringent than that required for the initial application.

5.2 PCP type description

The user/purchaser shall select a PCP on the basis of the following conditions:

- a) production requirements;

- b) fluid characteristics;
- c) surface and completion equipment configuration;
- d) stator conveyance method, such as drive string, tubing, wireline, coiled tubing.

5.3 Functional requirements

5.3.1 Application parameters

5.3.1.1 General

While installed, the PCP shall perform in accordance with its functional requirements, which are typically determined based on application parameters. These parameters include, but are not limited to, those listed in [5.3.1.2](#) to [5.3.3.4](#), as applicable.

5.3.1.2 Well information

The following well information shall be specified, as applicable:

- a) operating environment, such as thermal recovery, abrasive conditions, corrosive environments, heavy and conventional oil production, and coal bed methane production applications;
- b) well type, such as vertical, slant, deviated or horizontal;
- c) well directional survey, as applicable;
- d) wellhead location, such as onshore, platform or subsea;
- e) reservoir type, such as carbonate, consolidated sandstone, unconsolidated sandstone, coal, or shale;
- f) reservoir recovery mechanism or process, such as aquifer drive, solution-gas drive, water flood, thermal, coal dewatering, enhanced oil recovery, such as CO₂ flood, water-alternating-gas, or polymer flood;
- g) completion type, such as perforated casing, open hole, slotted liner, gravel pack, or sand screen;
- h) previous production history using PCPs and other operating practices, such as other artificial lift methods and flowing well;
- i) service-life expectation, such as total production volume, revolutions, days, years.

5.3.1.3 Completion information

The following completion information shall be specified, as applicable:

- a) pump setting depth in terms of MD and TVD of the pump intake;
- b) depth of producing interval in terms of MD and TVD;
- c) current well total depth, such as plug-back depth in terms of MD and TVD;
- d) in cases where no well deviation survey is provided:
 - inclination (hole angle) and wellbore curvature (if applicable) at pump seating depth,
 - maximum wellbore curvature (maximum dogleg severity) between wellhead and pump seating depth through which it is necessary for the PCP to pass through during installation;
- e) casing size, including outside diameter and mass (weight), connection type and grade of production casing;
- f) minimum drift diameter between wellhead and pump seating depth;

- g) minimum drift diameter at pump seating depth;
- h) production tubing size, including outside diameter, mass (weight), connection type and grade;
- i) production tubing inner coating type and thickness;
- j) pump intake type preference, such as slotted, selective, static gas separator, tail joint;
- k) torque anchor type;
- l) measured depth to the top of the torque anchor;
- m) other well dimensions that can restrict pump installation or operation.

5.3.1.4 Operating and production information

The following operating and production information shall be specified, as applicable:

- a) total liquid rate at standard conditions (15 °C, atmospheric pressure);
- b) water cut by percentage volume of produced liquids or producing oil and water rates;
- c) sand cut, expressed as percent by volume;
- d) maximum and minimum operational speed, expressed in revolution per minute;
- e) wellhead pressure;
- f) wellhead fluid temperature;
- g) casing-head pressure;
- h) static or shut-in pressure at the pump intake;
- i) static or shut-in reservoir pressure at a reference depth;
- j) static or shut-in temperature at the pump intake;
- k) static or shut-in reservoir temperature at a reference depth;
- l) producing gas-oil ratio or measured gas rate at standard conditions (15 °C, atmospheric pressure);
- m) ratio of casing-gas rate to tubing-gas rate at standard conditions (15 °C, atmospheric pressure) and/or downhole free-gas-separation efficiency;
- n) PIP, expressed as one of the following:
 - producing pressure at the pump intake,
 - producing fluid level (metres to fluid), annular gradient/density and casing-head pressure,
 - reservoir static pressure and productivity index,
 - static fluid level and productivity index;
- o) slugging tendency, such as gas, water, solids, steam.

5.3.2 Environmental compatibility

The user/purchaser shall specify the environmental compatibility requirements. The following parameters shall be supplied, as applicable:

- a) for oil:
 - density at standard temperature and pressure (15 °C, atmospheric pressure);

- compositional analysis, including, but not limited to
 - type and concentration of aromatic species,
 - aniline point;
- viscosity at test conditions and/or operating conditions;
- bubble-point pressure at reservoir temperature;
- b) for water:
 - pH;
 - density;
 - chloride concentration;
- c) for gas:
 - composition, such as
 - CO₂ concentration, expressed as a mole percentage,
 - H₂S concentration, expressed as a mole percentage,
 - steam temperature, pressure and quality;
 - specific gravity;
- d) for solids:
 - history of solids-related problems, such as erosion, plugging, wear;
 - morphology, such as size, structure, angularity, composition;
 - scale-deposition tendency;
 - asphaltene and/or paraffin deposition tendency;
- e) other:
 - emulsion properties, such as
 - inversion point (percentage water cut),
 - emulsion viscosity at downhole operating conditions over predicted pump life,
 - emulsion forming tendency;
 - foamy oil behaviour;
 - other fluid types and concentrations, such as diluent, corrosion/scale inhibitor, completion fluid, dispersants and injection points in the wellbore.

5.3.3 Compatibility with related well equipment and services

5.3.3.1 General

The user/purchaser shall specify, where applicable, the interface connection designs and material requirements, and external dimensional limitations, required to assure that the product shall conform to the intended application.

5.3.3.2 Drive system

The following topics shall be considered for the application:

- a) type: surface or bottom drive;

NOTE Surface-drive systems are covered in ISO 15136-2.

- b) torque, speed and axial load limitations;
- c) for bottom-drive systems:
 - type of drive, such as electric, hydraulic,
 - operational limitations, such as heat generation, flow restriction on intake or discharge,
 - maximum outside diameter, length and position, above or below PCP,
 - gearbox ratio.

5.3.3.3 Drive string

The following topics shall be considered for the application:

- a) type, such as standard, continuous, hollow;
- b) material grade;
- c) diameter of body;
- d) connection type and description;
- e) torque and axial load rating;
- f) rotating centralizer type, description and number installed;
- g) guide type, description and number installed.

5.3.3.4 Accessory equipment and well operation

The following topics shall be considered for the application:

- a) OD of injection tubing string and injection point, such as above pump, below pump, annulus, tubing string;
- b) subsurface instrumentation OD, length and location, such as above or below pump, as applicable;
- c) subsurface equipment OD, ID, length, location relative to the pump and attachment to the pump, such as interfaces with tag bars, no-turn tools, gas separators, tail pipes, backflow valves;
- d) well intervention limitations, such as minimum polished rod length, pump length, maximum coiled tubing diameter.

5.4 Design validation

The user/purchaser shall specify one of the following three design-validation grades defined by this part of ISO 15136:

- V1: highest level of design validation;
- V2: basic design validation;
- V3: legacy.

The principal requirements for each design validation grade are presented in [Annex B](#).

5.5 Product functional evaluation

The user/purchaser shall specify one of the following two product functional evaluation grades defined by this part of ISO 15136:

- F1: functional hydraulic test of the pump:

The user/purchaser may specify the volumetric efficiency range, test fluid, pump speed, fluid temperature and pressures for use in the functional test.

- F2: functional evaluation without bench testing:

The user/purchaser may specify the volumetric efficiency range, fluid, pump speed, fluid temperature and pressures as applicable for use in the functional evaluation.

The principal requirements for each product functional evaluation grade are presented in [Annex C](#).

5.6 Quality control grades

The user/purchaser shall specify one of the following three quality control grades defined in [Clause 7](#).

- Q1: highest level of quality control;
- Q2: intermediate level of quality control;
- Q3: basic level of quality control.

5.7 Additional documentation

Additional documentation, such as operator's manuals, certificate of compliance and/or product data sheet, above that required for a specific quality grade may be requested by the user/purchaser.

5.8 Additional requirements

The user/purchaser may specify additional design verification, design validation testing and/or product functional evaluation that is deemed necessary for a specific application. These requirements shall be in addition to those specified in [Annexes B](#) and [C](#).

Application-specific elastomer compatibility and bond testing, when requested, shall be performed in accordance with [Annex D](#). These requirements shall be in addition to those specified in [Annex A](#).

6 Technical specification

6.1 General

The supplier/manufacturer shall prepare the technical specification that responds to the requirements defined in the functional specification. The supplier/manufacturer shall also provide the user/purchaser with the product data defined in [Clause 7](#).

6.2 Technical characteristics

The following criteria shall be met.

- The PCP shall move fluid from downhole to the surface against a differential pressure and shall do so until intentional intervention defines otherwise. Exceptions to this are working life limitations related to normal equipment wear or aging, and any operation of the PCP outside the design conditions or against the recommendations in the operator's manual.
- While installed, the PCP shall perform in accordance with its functional specification.

- Where applicable, the PCP shall be compatible with related well equipment and services.

6.3 Design criteria

6.3.1 General

Metallic and non-metallic materials shall be specified by the supplier/manufacturer and shall be appropriate for the requirements in the functional specification. The supplier/manufacturer shall have written specifications for all materials and all materials used shall comply with these specifications.

Materials substitutions in validated equipment designs are allowed without validation testing provided that the supplier/manufacturer's materials-selection criteria are documented and approved by a qualified person and meet all other requirements of this part of ISO 15136.

6.3.2 Metals

6.3.2.1 General

In a PCP, the primary metal components are the tube of stator, metal stator, associated connecting assemblies and the rotor, which is normally coated or plated.

The supplier/manufacturer's specifications shall define the materials for the tube of stator, metal stator and rotor bar that are appropriate for the application, taking into account the following:

- a) chemical-composition limits;
- b) mechanical-property limits:
 - tensile strength,
 - yield strength,
 - elongation,
 - hardness.

The rotor bar shall be of sufficient strength that the profile and connection can withstand the combined torsional and axial loads within the specified operational range for the pump model. When bending loads and alternating combined loads are anticipated, the rotor-strength evaluation shall consider the effect of fatigue. High-temperature applications shall also de-rate material strength as appropriate for the application. The resulting design verification shall be approved by a qualified person.

Material test reports provided by the material supplier or the manufacturer may be used to verify compliance of the material to the specifications.

6.3.2.2 Welds

Welds in rotor and stator components shall be in accordance with the supplier/manufacturer's specifications as defined in [7.6.3](#). Weld identification and examination shall be in accordance with the specified quality grade.

6.3.3 Rotor coating or surface treatments

Rotor coating or surface-treatment type and thickness (if applicable) shall take into consideration the fluid characteristics of the operating environment specified in the functional requirements, in particular the abrasiveness, as well as any special chemical treatments that are anticipated. The supplier/manufacturer's specifications shall define the characteristics and acceptance criteria of the rotor coating or treatment, including

- a) the basic coating or surface treatment composition;
- b) the effective surface hardness;

- c) the minimum and maximum coating thickness on rotor peak and valley, if applicable;
- d) the surface roughness.

6.3.4 Stator elastomer and bond system

The stator elastomer and bond system shall comply with [Annex A](#), which contains detailed information on elastomer classifications, characteristics and test procedures.

The supplier/manufacturer shall have documented procedures and evaluations, the results of which shall verify that the stator elastomer material and bond system used are suitable for use in the specific PCP configuration, environment and application as defined in the functional specification. These evaluations shall be performed and the results approved by a qualified person and shall consider test data and the historical performance of the elastomer and bond system in combinations of pressure, temperature and fluids similar to those in the functional specification.

6.3.5 Inner surface treatment of metal stator

When determining the form and thickness of the inner surface treatment of metal stator, it is necessary to consider the stator processing method, the fluid characteristics in the working environment (the environment specified in the performance requirements), especially the wear, and the unique chemical treatment in advance. The supplier/manufacturer's specifications shall define the metal stator processing method, and determine the nature and acceptance criteria of the inner surface coating or treatment of the stator, including:

- a) the basic coating or surface treatment composition;
- b) the effective surface hardness;
- c) the minimum and maximum coating thickness on rotor peak and valley, if applicable;
- d) the surface roughness.

6.4 Dimensional information

6.4.1 Rotor-stator fit

The supplier/manufacturer shall have documented procedures performed by qualified personnel to select the appropriate rotor-stator fit to meet the requirements of the functional specification. [Annex G](#) provides information on considerations for selecting rotor-stator fit.

6.4.2 Dimensional limits

PCP components shall be dimensioned such that they can be run through and, where required, operated in the specified well curvatures. For tubing-deployed configurations, the stator shall provide adequate annular space for gas separation and, in instances where the PCP is landed below the perforations, provide for fluid passage without excessive pressure drops. In the event that the functional specification includes equipment such as secondary tubing strings for injection/flushing or instrumentation cables, the stator assembly shall allow the required annular space.

The supplier/manufacturer shall specify the following:

- a) stator OD and maximum OD of the stator assembly; the stator assembly shall pass through the casing for a tubing-deployed pump and through the tubing for insertable pumps and all other devices that are part of these strings;
- b) major diameter of the rotor and maximum diameter of the rotor assembly; the rotor assembly shall pass through the production tubing and all other devices that are part of the tubing string;

- c) orbit diameter of the rotor profile and rotor connection; the eccentric motion of the rotor and the rotor connection shall be less than the inside diameter of the production tubing or orbit tube immediately above the stator;
- d) total assembly lengths and masses (weights) of the rotor and stator.

6.5 Performance ratings

6.5.1 Volume capability

The supplier/manufacturer shall provide the nominal capacity per rpm and validated capacity per rpm for each basic pump geometry. These parameters shall be expressed in terms of a fluid rate at a given speed as $(\text{m}^3/\text{d})/(100 \text{ r/min})$.

The validated capacity per rpm shall be determined through validation testing as outlined in [6.7](#) and detailed in [Annex B](#). Additional discussion on volume capability is provided in [Annex G](#).

6.5.2 Pressure and head rating

The supplier/manufacturer shall provide the PCP pressure rating, head rating, pressure per cavity and number of engaged cavities.

Pressure ratings shall be confirmed through validation testing as outlined in [6.7](#) and detailed in [Annex B](#). Additional discussion on pressure rating is provided in [G.5](#).

6.5.3 Design performance curves

The supplier/manufacturer shall prepare the design performance curves for each model that displays fluid rates as a function of differential pressure and pump speed. At a minimum, these curves shall present calculated data from zero pressure to the pump pressure rating, at speeds of 100 r/min, 200 r/min and 300 r/min with a nominal rotor and stator fit.

6.5.4 Volumetric efficiency

The supplier/manufacturer shall prepare design performance curves representing predicted performance under conditions specified in the functional specification.

NOTE Actual volumetric efficiencies can vary significantly over the wide range of potential downhole and operating conditions. Volumetric efficiency represents a combination of the pump volumetric efficiency and the inefficiency implied by the differences between the multiphase fluid rate at the pump intake and the surface liquid rate. See [Annex G](#) for more information.

6.5.5 Design pump speed, torque and power

The supplier/manufacturer shall prepare the design hydraulic and total torque and power values for the PCP design as a function of differential pressure and speed. Where appropriate, the supplier/manufacturer shall specify maximum torque and minimum and maximum rotational speed values.

NOTE Additional discussion on pump speed, torque and speed is provided in [Annex G](#). It is necessary that the design hydraulic and total torque and power values be used cautiously since they might not be representative of downhole conditions. Experience is used to translate these values to expected performance under downhole conditions.

6.5.6 Maximum pump intake gas volume fraction

The supplier/manufacturer shall provide the maximum pump intake gas volume fraction that can be handled by the pump. The supplier/manufacturer shall have a documented process that supports the reported maximum pump-intake gas-volume fraction.

NOTE While PCPs are capable of pumping gas, it results in non-uniform pressure loading within the pump and a reduced ability to remove internal frictional heat. The resulting mechanical loads and temperatures within the pump can have a detrimental impact on pump service life.

6.6 Design verification

Design verification shall be performed by the supplier/manufacturer to verify that the product design meets the technical specifications. Design verification includes documented activities such as review of design calculations, product testing and comparison with similar designs and historical records of defined operating conditions. Empirical methods and/or physical testing used in design verification shall be fully documented and supported with drawings and material specifications.

The results of design verification shall be documented and include a review of the fundamental geometry and its ability to meet the volume and pressure capacity requirements, dimensional limits, strength characteristics and tolerances to ensure that it meets the technical specifications. All design verification documentation shall be included in the product design file and be approved by a qualified person other than the design's originator.

6.7 Design validation

Design validation testing shall be performed on each PCP basic design of rotor/stator and elastomer combination to ensure that its design meets the supplier/manufacturer's technical specifications. The design validation grade specifies the design validation process(es), procedure(s) and test(s) required for each validation grade. [Annex B](#) provides a detailed description of the three validation grades (V1, V2 and V3) in this part of ISO 15136. Supplemental design validation may be required by the user/purchaser.

NOTE Some applications can require supplemental design validation testing. Examples include pump performance or durability testing with alternative test media and multiphase fluids; minimum pump intake pressure; maximum gas fraction; or advanced elastomer evaluation, such as explosive decompression resistance, compression set, heat resistance, dynamic characterization or H₂S resistance.

6.8 Functional evaluation requirements

Functional evaluation shall be performed in accordance with [Annex C](#) and approved by a qualified person to verify that each PCP manufactured meets the supplier/manufacturer's documented requirements, technical specification and the functional specification. The results of these evaluations shall be recorded and become a portion of the quality documentation for that product.

6.9 Allowable design changes

All design changes shall be documented and reviewed by the supplier/manufacturer against the design verification and design validation documents to determine if the change is a substantial change. A substantial design change is a change to the design identified by the supplier/manufacturer that affects the performance of the product in the intended service condition. A design that undergoes a substantial change becomes a new design, requiring design verification in accordance with [6.6](#) and design validation in accordance with [6.7](#).

All design changes and modifications shall be identified, documented, reviewed and approved before their implementation and meet the applicable validation test requirements of this part of ISO 15136. Justifications for design changes that are identified as non-substantial shall be documented. The supplier/manufacturer shall, at a minimum, consider the following for each design change:

- a) stress levels in the modified or changed components;
- b) material changes;

- c) functional changes.

6.10 Scaling of design validation

Scaling may be used to validate new designs and design variations based on previously validated designs with the following limitations.

- a) Scaling applies only to designs validated to V1 or V2.
- b) Elastomer and bond validation in accordance with [Annex A](#) shall apply only to the specific elastomer compound tested. Scaling of this validation is not allowed for other elastomer compounds. Scaling of this validation is allowed for any designs that utilize the tested elastomer compound.
- c) Durability validation in accordance with [Annex B](#) can be scaled to design variations, including elastomer compounds that utilize the same stator geometry as the tested product, as long as the elastomer compound used in the design variation has been previously validated in a durability test on any stator geometry.
- d) Hydraulic validation in accordance with [Annex B](#) shall apply only to the specific elastomer compound and stator geometry combination tested. Hydraulic validation may be scaled to any design variations that utilize the same elastomer compound and stator geometry as the tested product.

7 Supplier/manufacturer requirements

7.1 General

The detailed requirements to verify that each product manufactured meets the requirements of the functional and technical specifications for each specific product are contained in [Clause 7](#).

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 of this part of ISO 15136. 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 suitable environments to prevent damage or deterioration and to prevent loss.

Documents and data may be in any type of media, such as hard copy or electronic media. All documents and data shall be available and auditable by the user/purchaser. Design documents and data shall be maintained for five years after date of last manufacture of that product.

7.2.2 Design documentation

Documentation of the design process for each type, size and model of pump shall include the following as a minimum:

- a) design criteria;
- b) functional and technical specifications;
- c) engineering drawings and bill of materials;
- d) applicable specifications and standards;
- e) validation testing procedures, acceptance criteria and approved results;
- f) functional evaluation procedures and acceptance criteria;

- g) design changes and design change justifications, if applicable.

7.2.3 Delivery documentation

Documentation supplied at the time of delivery of a product to the user/purchaser shall include the following as a minimum:

- a) name and address of supplier/manufacturer;
- b) supplier/manufacturer product identification;
- c) functional evaluation documentation according to specified functional grade;
- d) quality documentation according to specified quality grade.

7.2.4 Operator's manual

When required by the quality grade or the user/purchaser, an operator's manual shall be supplied and shall contain the following information as a minimum:

- a) name and address of supplier/manufacturer;
- b) supplier/manufacturer product identification;
- c) representative illustration(s) identifying major components, significant dimensions and configurations and details of the interface connections;
- d) handling and storage guidelines;
- e) pre-installation inspection and pre-service procedures;
- f) installation guidelines, including make-up procedures for all pump components and rotor space-out (see [Annex E](#));
- g) operating and troubleshooting guidelines, including precautions for safe and environmentally acceptable operation.

7.2.5 Certificate of compliance

When required by the quality grade or the user/purchaser the CoC should be provided. In addition to reflecting traceable original information, the CoC should also include the following requirements:

- a) quality grade;
- b) functional grade;
- c) validation grade.

The statement shall include the product identification and shall be approved by the supplier/manufacturer's designated qualified person.

7.2.6 Product data sheet

When required by the quality grade or the user/purchaser, a product data sheet shall be supplied and shall contain the following, as a minimum:

- a) product identification;
- b) name and address of supplier/manufacturer;
- c) conveyance method;
- d) nominal capacity per rpm;

- e) validated capacity per rpm;
- f) pressure rating;
- g) pressure per cavity;
- h) number of engaged cavities;
- i) design performance curves;
- j) torque and power curves;
- k) maximum pump-intake free-gas volume fraction;
- l) minimum and maximum speed;
- m) rotor length and mass (weight);
- n) stator assembly length and mass (weight);
- o) rotor major, minor and orbit diameter;
- p) stator outside diameter and maximum outside diameter of stator assembly;
- q) end connections for rotor and stator;
- r) rotor coating type and thickness;
- s) operator's manual identification.

7.2.7 Elastomer data sheet

When required by the quality grade or the user/purchaser, an elastomer data sheet shall be provided and shall contain, as a minimum, the following items as defined in [Annex A](#):

- a) stator elastomer classification;
- b) fluid resistance;
- c) mechanical properties;
- d) maximum operating temperature;
- e) unaged bond properties.

7.3 Product identification

Each furnished rotor and stator shall be permanently identified according to the supplier/manufacturer's specifications, which shall include the type and method of application. The following information is the minimum that shall be marked on each product:

- a) supplier/manufacturer's identifier;
- b) unique identifier;
- c) each stator shall be identified with month and year of manufacturer stated as mm-yyyy;
- d) each stator shall be identified with "ISO-vvv-hhhh-eee" no more than 1 m from the end of the stator where
 - vvv is the nominal capacity per rpm, expressed in units of m³/(100 r/min),
 - hhhh is the nominal head rating, expressed in units of metres of water,
 - eee is the elastomer code;

- e) each rotor shall be identified with a minimum of ISO-vvv-hhhh-rrr on the rotor head where
 - vvv is the nominal capacity per rpm, expressed in units of m³/(100 r/min),
 - hhhh is the nominal head rating, expressed in units of metres of water,
 - rrr is the rotor size code;
- f) repaired equipment shall be identified following the supplier/manufacturer unique identifier to identify each major repair where
 - T indicates rethreading,
 - R indicates recoating,
 - S indicates straightening.

7.4 Quality

7.4.1 General

The supplier/manufacturer shall have a quality management program in conformance with ISO-9001, and this program shall be implemented by qualified personnel to ensure that each product meets applicable specifications and drawings standards.

The quality control grades apply to the final product unless otherwise specified.

[Table 1](#) specifies the percentage of products that shall be inspected per purchase order with a minimum of 1. Where the percentage of products inspected is less than 100 %, the supplier/manufacturer and user/purchaser shall agree on the process for selecting representative specimens. If the manufacturer/user reach a consensus, for small lot sizes (under a lot size of 100), the sampling process specified in ISO 2859 (using a general inspection level II with AQL of 2,5 and c=0) can be adopted.

Testing methods specified in [Table 1](#) are considered as the minimum requirements to meet the quality grade. Conformance to the requirements of a higher quality grade automatically qualifies the final product for lower grades. These procedures include acceptance criteria for all manufactured products furnished to this part of ISO 15136.

The requirements defined in [Table 1](#) shall be implemented in accordance with the referenced subclauses.

Table 1 — Inspections required for each quality grade

Inspection	Reference	Inspection requirements for quality grades		
		Q3	Q2	Q1
Material certificate (metals and non-metals)	7.5.	as per supplier/ manufacturer specification	100 % rotors 100 % stators	100 % rotors 100 % stators
Tube of stator	7.9.2	as per supplier/ manufacturer specification	as per supplier/ manufacturer specification	100 %
Stator elastomer hardness testing	7.9.3.1	as per supplier/ manufacturer specification	20 %	100 %
Stator elastomer bond testing	7.9.3.2	as per supplier/ manufacturer specification	20 %	100 %
Stator phasing alignment	7.9.4	as per supplier/ manufacturer specification	as per supplier/ manufacturer specification	100 %
Rotor coating testing	7.9.5 and 7.9.6	as per supplier/ manufacturer specification	thickness, 20 %	thickness, 100 % surface finish, 100 % coupon hardness, 100 %

Table 1 (continued)

Inspection	Reference	Inspection requirements for quality grades		
		Q3	Q2	Q1
Rotor phasing alignment	7.9.7	as per supplier/ manufacturer specification	as per supplier/ manufacturer specification	100 %
Stator visual surface defect inspection	7.9.8	as per supplier/ manufacturer specification	basic, 100 %	detailed, 100 %
Rotor visual surface defect inspection	7.9.8	as per supplier/ manufacturer specification	100 %	100 %
Core deflection inspection	7.9.10	as per supplier/ manufacturer specification	pass/fail, 100 %	pass/fail, 100 %
Stator non-destructive weld examination	Q3: 7.9.9.2 Q2: 7.9.9.5 or 7.9.9.6 Q1: 7.9.9.3 or 7.9.9.4	visual	magnetic particle or liquid penetrant, 100 %	radiographic or ultrasonic, 100 %
Rotor non-destructive weld examination	Q3: 7.9.9.2 Q2: 7.9.9.5 or 7.9.9.6 Q1: 7.9.9.3 or 7.9.9.4	visual	magnetic particle or liquid penetrant, 100 %	radiographic or ultrasonic, 100 %
Component dimensional inspection	7.9.11	as per supplier/ manufacturer specification	general dimensions rotor and stator, 100 % rotor profile dimensions, 50 %	general dimensions rotor and stator, 100 % rotor profile dimension, 100 % stator profile dimensions, 100 %
Documentation	7.2.4 to 7.2.7	as per supplier/ manufacturer specification	certificate of compliance product data sheet elastomer data sheet	certificate of compliance operator's manual product data sheet elastomer data sheet

7.5 Raw materials certification

When required by the quality grade or requested by the user/purchaser, raw material used in the manufacture of components shall have a material test report to verify conformance to the properties defined in the supplier/manufacturer's documented material specifications.

7.6 Additional processes applied to components

7.6.1 Documentation

Documentation of the processes described in [7.6.2](#), [7.6.3](#) and [7.6.4](#) shall conform to at least one of the following requirements when approved by a qualified person:

- certificate of conformance stating that the material and processes applied comply with the supplier/manufacturer's documented specifications and acceptance criteria; and
- material test report verifying that the materials and processes conform to the supplier/manufacturer's documented specifications and acceptance criteria.

7.6.2 Coatings

The application of coatings and overlays shall be performed according to documented procedures that provide a product that meets the supplier/manufacturer's acceptance criteria.

When required by the quality grade, the rotor surface hardness shall be measured using coupons based on the supplier/manufacturer's sampling programme or in accordance with ISO 2859 (Use of General Inspection Level II with an AQL of 2,5 and $c=0$). Hardness testing and hardness conversion to other measurement units shall be in accordance with a national standard or International Standard, such as ISO 6506-1, ISO 6507-1, ISO 6508-1 or ISO 18265, with the exceptions noted in ISO 15156 for materials that are intended for use in wells where corrosive agents can induce stress corrosion cracking.

7.6.3 Welding

Welding and brazing procedures and personnel qualifications shall be in accordance with a national standard such as ASME BPVC, Section IX, or ANSI/AWS D1.1/D1.1M or an International Standard. Material and practices not listed in the ASME BPVC, Section IX, or ANSI/AWS D1.1/D1.1M shall be applied using weld procedures qualified in accordance with a national standard such as the methods of ASME BPVC, Section IX, or ANSI/AWS B2.1/B2.1M, or an International Standard.

The supplier/manufacturer shall ensure that welding and brazing procedures are appropriate for the specific well application, considering issues such as corrosion susceptibility and hydrogen embrittlement.

The supplier/manufacturer shall have documented acceptance criteria.

7.6.4 Heat treating

Heat treating shall be performed according to documented procedures that provide a product that meets the supplier/manufacturer's acceptance criteria.

7.7 Traceability

Traceability shall be in accordance with the supplier/manufacturer's documented procedures. All components shall be traceable to their raw material heat(s) or batch lot(s) and material test report using a unique identifier. Traceability of equipment is considered sufficient if the equipment meets the requirements of this part of ISO 15136 when it leaves the supplier/manufacturer's inventory.

7.8 Calibration systems

Inspection, measuring and testing equipment used for acceptance shall be identified, inspected, calibrated and adjusted at specific intervals in accordance with documented specifications, such as ISO/IEC 17025 and this part of ISO 15136 and traceable to the applicable national standards agency or International Standard that is no less stringent than the requirements included herein. Inspection, measuring and testing equipment shall be used only within the calibrated range.

Technologies for inspection, measuring and testing with verifiable accuracies equal to or better than those listed in this part of ISO 15136 may be applied with appropriate documentation and when approved by qualified personnel.

Calibration intervals shall be established based on repeatability and degree of usage. Calibration intervals shall be a maximum of three months until a recorded calibration history can be established. Intervals may be lengthened or shortened based on documented repeatability, amount of usage and calibration history. The calibration interval may not be increased by more than twice the previous interval, which shall not exceed one year.

Calibration standards used to calibrate measuring equipment shall be checked and approved by an independent outside agency in accordance with the applicable national or international standards.

7.9 Examination and inspection

7.9.1 General

When specified by the supplier/manufacture or user/purchaser, NDEs and inspections shall be performed and accepted according to the supplier/manufacture's documented specifications, which shall include the requirements defined in [7.9](#) and acceptance criteria.

NDE instructions shall be detailed in the supplier/manufacture's documented procedures and comply with this part of ISO 15136. All NDE instructions shall be approved by a qualified ISO 9712 level III examiner and performed by a qualified person. Personnel performing and accepting NDEs shall be qualified in accordance with the supplier/manufacture's procedures as a minimum for evaluation and interpretation. Personnel performing visual examinations shall have an annual eye examination in accordance with ISO 9712, as applicable to the discipline being performed. As an alternative, the quality manager shall be authorized to qualify inspector's reading/observation capabilities based on pre-specified criteria (e.g. eye examination chart readings from a specified distance).

NOTE For the purposes of this requirement, ASNT SNT-TC-1A is equivalent to ISO 9712.

7.9.2 The tube of stator

7.9.2.1 General

According to the quality level inspection requirements, the tube of stator is detected to ensure it to accord with suppliers/manufactures' design standards and specifications. And the inspection items include:

- a) Chemical composition;
- b) Tensile strength;
- c) Yield strength;
- d) Elongation;
- e) Hardness.

The verification items of the tube of stator with equal-wall thickness shall include :

- f) Thickness of tube of stator with equal-wall thickness
- g) Dimensional accuracy of the tube of stator with equal-wall thickness
 - coaxiality;
 - cross-sectional dimension error;
 - full-length straightness of the stator spiral tube;
 - cumulative lead error in the effective length of the spiral segment;
 - lead error of single stator

7.9.3 Stator elastomer

7.9.3.1 Stator elastomer hardness

The stator elastomer hardness shall be measured in accordance with [Annex A](#) using at least one representative elastomer specimen cut from the stator or selected from a stator specimen with consistent process parameter requirements and tested in accordance with [Annex A](#), and shall be within the range of elastomer hardness in the elastomer material specifications.

7.9.3.2 Stator elastomer bond

The stator-elastomer bond shall be tested in accordance with [A.4.5.1](#) using at least one representative elastomer specimen cut from the stator or selected from a specimen with consistent process parameter requirements and tested in accordance with [A.4.5.1](#) and shall exhibit rubber failure or no failure based upon a visual inspection by a qualified person.

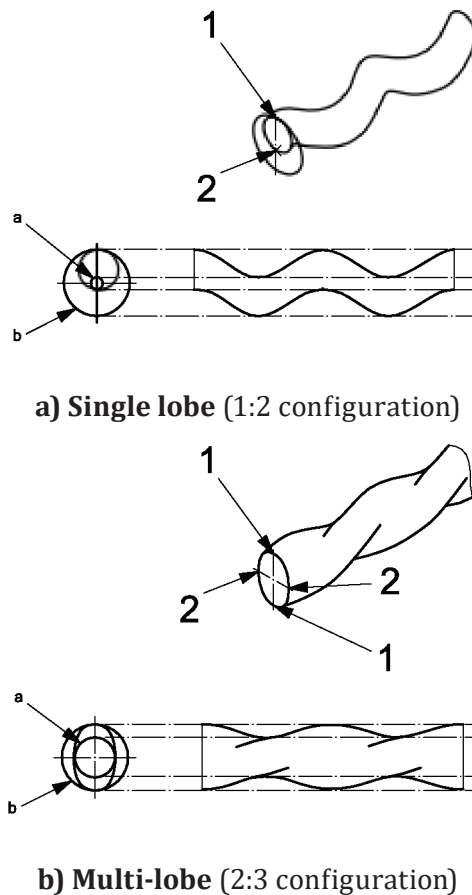
7.9.4 Stator phasing alignment

As a minimum, the phase alignment of stator sections shall be verified by inserting a stator phasing-alignment jig into the phased area of the assembled stator. The stator shall be rejected if the jig does not pass through the phased area unimpeded.

7.9.5 Rotor coating thickness

The rotor coating thickness shall be measured by direct measurement or by calculation using measurements made before and after the coating process. These measurements shall include, as a minimum, measurements approximately 1 m from each end of the rotor and at the middle. At each measurement location, at least two measurements shall be made at the rotor peak and rotor valley, as shown in [Figure 1](#).

All measurements shall be within the range of peak and valley thicknesses in the product technical specifications.



Key

- 1 peak
- 2 valley
- a Projected path of the valley on a plane normal to the rotor centre-line.
- b Projected path of the peak on a plane normal to the rotor centre-line.

Figure 1 — Definition of valley and peak for rotor-coating measurement specification

7.9.6 Rotor surface finish

The rotor surface finish shall be visually inspected using a visual-comparator method or other methods with proven history of accurate evaluation.

NOTE For these inspections, ISO 1302 is an example of an International Standard and ANSI B46.1 is an example of a national standard.

7.9.7 Phasing alignment of welded rotor

As a minimum, the phase alignment of rotor sections shall be verified by placing the assembled rotor in a rotor phasing-alignment jig. The welded rotor shall pass through the phasing jig using a force no greater than is required for passing non-welded sections.

7.9.8 Visual inspection

7.9.8.1 Rotor

Visual inspections of rotors shall include a comparison of the following features with the supplier/manufacturer's documented specifications:

- a) coating cracks (except for heat checking near weld zones) and blisters;
- b) pin holes in the rotor coating;
- c) mechanical damage to the surface finish;
- d) bends.

7.9.8.2 Stator

Two types of stator visual inspection shall be specified in accordance with the product quality grade.

- a) The basic visual inspection of the stator is limited to viewing the exterior of the stator and the internal surface from the stator ends.
- b) The detailed visual inspection includes the basic visual inspection plus a boroscope or other technique for viewing the full length of the internal surface of the stator.

In the visual inspection of a stator, there should be no liquid accumulation within the cavity of the stator, and the following shall be considered unacceptable:

- Burrs, cracks, rust, and other defects on the spiral surface in the stator;
- elastomer cracks, blisters and other surface irregularities;
- elastomer separation from the stator tube;
- mechanical damage to stator housing or plug screws, if applicable;
- bending.

7.9.9 Weld

7.9.9.1 General

Weld inspections shall be performed in accordance with the quality grade and according to the requirements of 7.9.9. Base-metal welds (such as in rotor stock material) are not included in the weld inspections in this part of ISO 15136. All other welds performed on the rotor or stator are included.