FINAL DRAFT

INTERNATIONAL STANDARD

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Downhole equipment for petroleum and natural gas industries — Progressing cavity pump systems for artificial lift —

Part 1: Pumps

Équipement de forage et de production pour les industries du pétrole et du gaz naturel — Pompes de fond à cavité progressive pour activation des puits —

Partie 1: Pompes

Please see the administrative notes on page iii

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IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

Reference number
ISO/FDIS 15136-1:2001(E)

ISO/CEN PARALLEL PROCESSING

The CEN Director General has advised the ISO Secretary-General that this final draft International Standard covers a subject of interest to European standardization. Consultation on the ISO/DIS had the same effect for CEN members as a CEN enquiry on a draft European Standard. In accordance with subclause 5.1 of the Vienna Agreement, this final draft, established on the basis of comments received, is hereby submitted to a parallel two-month FDIS vote in ISO and formal vote in CEN.

Positive votes shall not be accompanied by comments.

Negative votes shall be accompanied by the relevant technical reasons.

In accordance with the provisions of Council Resolution 15/1993, this document is **circulated in the English language only.**

Contents

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 3.

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 part of ISO 15136 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15136-1 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC4, *Drilling and production equipment.*

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

— *Part 1: Pumps*

— *Part 2: Drive heads*

Annexes A and B form a normative part of this part of ISO 15136. Annexes C, D, E and F are for information only.

Introduction

This part of ISO 15136 has been developed by users/purchasers and suppliers/manufacturers of progressing cavity pumps (PCP) for artificial lift use in the petroleum and natural gas industries worldwide. This part of ISO 15136 is intended to give requirements and information to both parties in the selection, manufacture, testing and use of progressing cavity pumps. Further, this part of ISO 15136 addresses supplier/manufacturer requirements, which set the minimum parameters with which suppliers/manufacturers must comply to claim conformity with this part of ISO 15136.

A progressing cavity pump comprises two helical gears, one rotating inside the other. The stator and rotor axes are parallel and spaced between each other. The external helical gear (stator) has one more thread (or tooth) than the internal helical gear (rotor). Whatever the number of threads of the two elements, they must always differ by one. The fluid moves from suction to discharge. The discharge and the suction are always isolated from each other by a constant length seal line. Definitions of the accessories, engineering methodology and description of the PCP system, including illustrations, are provided in annexes D, E and F respectively.

Users of this part of ISO 15136 should be aware that further or differing requirements might 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 may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the supplier/manufacturer should identify any variations from this part of ISO 15136 and provide details.

Downhole equipment for petroleum and natural gas industries — Progressing cavity pump systems for artificial lift —

Part 1: Pumps

1 Scope

This part of ISO 15136 provides guidelines and requirements for subsurface progressing cavity pumps (PCP) used in the petroleum and natural gas industries for the production of single and multiphase fluids, based on the principle defined in [1].

This part of ISO 15136 is applicable to the subsurface progressing cavity pump. It refers to, but is not applicable to, intermediate components and accessories that are necessary to make a complete pumping unit. It does not include requirements for shipping, loading and transportation.

2 Terms and definitions

For the purposes of this part of ISO 15136, the following terms and definitions apply (for illustration, see annexes D, E and F).

2.1
cavity
lenticular, spiral, separate volume created between a pump stator and rotor when they are assembled

2.2
displacement
volume of fluid pumped in one revolution of the rotor in the stator

2.3
drive string
device transmitting power (usually sucker rods) between the drivehead and the PCP

2.4
dynamic level
fluid level under standard conditions of temperature and pressure when the PCP is in operation

NOTE Standard conditions, unless otherwise indicated, are 15 °C and 0,101 3 MPa.

2.5
flowrate
volume of fluid pumped per time unit

2.6
head rating
maximum allowable differential pressure of the PCP

2.7
helix
continuous spiral with a constant pitch

2.8
insert pump
pump whose stator is inserted into the tubing using the drive string

2.9
interference
radial fit between the pump rotor and stator

2.10
pitch length
distance between two crests belonging to the same seal line

NOTE The rotor and stator have different pitch lengths, p_r and p_s respectively (see Figures E.1, E.2 and F.1).

2.11
PCP
progressing cavity pump
pump consisting of a stator and a rotor whose geometry of assembly is such that it creates two or more series of lenticular, spiral, separate cavities

2.12
rotor
pump shaft, whose external surface is in the form of a single or multiple helix, provided with a connection to attach to the drive string

2.13
rotor stop
device which determines the rotor position during PCP installation

See Figure D.1.

2.14
seal line
helix formed by the line of contact between rotor and stator

2.15
slippage
fluid leakage occurring across the dynamic seal lines between the cavities

2.16
static level
stabilized fluid level under standard conditions of temperature and pressure when the PCP is at a stopped position

NOTE Standard conditions, unless otherwise indicated, are 15 °C and 0,101 3 MPa.

2.17
stator
housing and a lining (typically elastomeric) in the form of a double or multiple internal helix, which always has one more helix than the rotor, with a connection to the production tubing

2.18
submergence
difference between the dynamic level and the PCP setting depth

2.19
tubing-conveyed pump
pump whose stator is threaded at the bottom of the tubing

3 Symbols

d_r rotor minor diameter, i.e. the diameter of the circle tangent to the inner rotor lobes

D_r rotor major diameter, i.e. the diameter of the circle tangent to the outer rotor lobes

d_s stator minor diameter, i.e. the diameter of the circle tangent to the inner stator lobes

D_s stator major diameter, i.e. the diameter of the circle tangent to the outer stator lobes

P_r rotor pitch length

P_s stator pitch length

n_r number of rotor lobes

N pump revolutions per minute

For illustration, see Figures E.1, E.2 and E.3.

4 Functional specification

4.1 General

The user/purchaser shall prepare a functional specification to order products which conform with this part of ISO 15136 in which he shall specify the requirements and operating conditions in 4.2 to 4.6, as appropriate, and/or identify the supplier's/manufacturer's specific product (see example of data form in annex C).

These requirements and operating conditions may be conveyed by means of a dimensional drawing, data sheet or other suitable documentation.

4.2 PCP type

— Tubing-conveyed;

— insert PCP.

4.3 Well parameters

— Sizes, grades, mass, thread of casing, liner, tubing;

— depth (true vertical and measured);

— perforation intervals (true vertical and measured);

— deviation survey;

— packer, anchor data, landing nipple or other restriction if any.

4.4 Operational parameters

- PCP setting depth;
- current production system and rate;
- planned production rate;
- static and dynamic fluid level; or
  - static level and productivity index; or
  - dynamic fluid level and bottomhole pressure;
- normal producing tubing and casing pressures;
- required wellhead pressure;
- chemical treatments;
- well monitoring and alarm points.

4.5 Environmental compatibility

- Specific gravity of oil and water;
- oil/emulsion viscosity;
- bubble point;
- production gas/oil ratio;
- water cut;
- mole fraction (as a percent) of aromatic solvents, (i.e. benzene, toluene and xylenes);
- gas specific gravity;
- mole fraction (as a percent) of H_2S and CO_2;
- solids content (i.e. type, size, shape and concentration);
- corrosive agents, (i.e. type and concentration);
- PCP inlet temperature or reservoir temperature and temperature gradient;
- wellhead temperature range;
- pH;
- completion fluid characteristics;
- rotor material, plating//coating material;
- elastomer material.

4.6 Compatibility with well equipment

— Tubing threads or insert size;

— wellhead connection;

— drive string (type, size, properties and connection);

— power source;

— electrical supply (voltage, frequency, zone classification);

— ambient temperature (minimum, maximum).

4.7 Quality control requirements

Quality control requirements may be specified by the user/purchaser.

4.8 Design validation documentation

User/purchaser may request performance curve and test report, as per annex A and annex B.

5 Technical specification

5.1 General

The aspects in 5.2 to 5.7 shall be considered in the design/application of a PCP system (see annex C).

5.2 PCP characteristics

Physical dimensions can limit the selection of a PCP.

The stator shall:

— be able to pass through the casing and all other devices which are part of the casing string;

— allow annular space for tools, i.e. over-shot or wash pipe;

— allow annular space for gas separation;

— allow annular space for fluid passage, if the PCP is landed below perforations.

The rotor shall be able to pass through the tubing and all other devices which are part of the tubing string.

A sufficiently large inside diameter shall be provided in the tubing to allow for the eccentric movement of the rotor. If the tubing inside diameter is not large enough, a transition length of tubing (or pup joint) having an acceptable inside diameter shall be placed immediately above the stator (see Figure D.2).

5.3 Design criteria

5.3.1 Head requirements

The differential pressure across the PCP should not exceed the head rating of the PCP, as efficiency will be affected and could result in premature wear on components.

The differential pressure is the sum of the following, taking into consideration gas and different liquid densities:

— the head of fluid in the tubing minus the head of fluid in the annulus at the PCP inlet;

— the frictional loss in the tubing between the PCP outlet and the wellhead, which is a function of:

  — inside diameter of the tubing;

  — outside diameter of the drive string;

  — pressure drop across restrictions such as couplings and centralizers;

  — viscosity and velocity of the fluid.

— the flowline back-pressure.

5.3.2 Volume requirements

The PCP shall be capable of displacing the volume required per revolution at the anticipated head within the speed limitations mentioned in 5.3.3.6. Volume requirements should consider the presence of free gas, transport of solids and PCP cooling.

5.3.3 Materials

5.3.3.1 Thermal effect — Elastomers

Wellbore temperature and fluid characteristics shall be considered for each application.

The PCP operating temperature may cause thermal expansion of the elastomer. Elastomer expansion will result in reduction of the internal stator diameter. Therefore, the rotor shall be sized to accommodate for this reduction to ensure appropriate interference fit.

The maximum operating temperature of the PCP shall be below the maximum rated working temperature of the elastomer published by the manufacturer.

The PCP operating temperature is influenced by:

— fluid temperature around the PCP;

— friction effect due to interference, rotating speed and differential pressure;

— elastic deformation;

— gas compression;

— fluid lubricity;

— heat transfer effects.

5.3.3.2 Chemical effects — Elastomers

Detrimental effects on elastomers, such as swelling and hardening, can be caused by chemicals, aromatic solvents (i.e. benzene, toluene and xylenes), napthenes and water. Rotor/stator sizing shall be adjusted accordingly.

Where chemical treatments are anticipated, caution shall be exercised in the selection of materials.

5.3.3.3 Elastomer data

Elastomer designations are required for the purpose of differentiating the elastomers of an individual manufacturer's product line. Designations shall include a general description of elastomer type.

Manufacturers shall not change the formulation of a designated elastomer unless changes are within the original performance parameters Each new or revised formulation shall have a new designation. However, each manufacturer has the right to keep his formulations confidential.

General performance parameters are required for each of the elastomers:

— control of bonding process (resistance to shearing, traction);

— elastomer resistance to temperature;

— elastomer resistance to gas under pressure (H_2S, CO_2);

— elastomer resistance to aromatics;

— elastomer resistance to explosive decompression;

— elastomer resistance to abrasion;

— swelling test and/or calculation;

— calculation of rotor size versus temperature, swelling and elastomer type.

5.3.3.4 Abrasion

The effects of abrasion shall be considered in the selection of rotor and stator materials.

Abrasive wear is a function of:

— solids content (type, size, shape and concentration);

— particle velocity;

— pressure differential per cavity;

— rotating speed.

5.3.3.5 Inlet conditions

The PCP requires a positive inlet pressure to operate efficiently.

The manufacturer shall advise the minimum submergence/inlet pressure required by the pump.

5.3.3.6 Rotating speed

The following parameters shall be considered when establishing the rotational speed for normal operation:

— total volume to be pumped, considering slippage;

— abrasive solids content;

— fluid viscosity and PCP inlet pressure;

— PCP submergence;

— vibration of the rods and tubing, considering harmonic speeds, well deviation;

— wear on components;

— maximum speed rating of all system components.

The rotational speed of the PCP shall be adjusted to achieve optimum well production.

5.3.3.7 Dimensional data

The following dimensions shall be specified:

— outside diameter of the stator and the rotor;

— length of the rotor helix;

— length of the stator elastomer;

— length from the elastomer to the rotor stop;

— rotor and stator thread specifications;

— maximum speed of PCP;

— head rating;

— displacement.

5.3.3.8 Metallurgy and finishes

The following parameters shall be considered when selecting the materials for the pump:

— metallurgy of the PCP components;

— degree of rotor polishing (surface roughness);

— characteristics of rotor coating/plating (surface hardness, roughness, resistance to wear);

— minimal thickness of coating/plating on the major diameter of the rotor.

Where chemical treatments are anticipated, caution shall be exercised in the selection of materials.

5.4 Design verification

Design verification shall be performed to ensure that each PCP design meets the supplier/manufacturer technical specifications. Design verification includes activities such as design reviews, design calculations, physical tests, comparison with similar designs and historical records of defined operating conditions.

As a minimum:

— verify the flow capacity of the PCP considering the rotor and stator size;

— verify the head capacity of the PCP considering the number of stator cavities;

— verify the tightening between rotor and stator versus temperature.

5.5 Design validation

5.5.1 Validation parameters

To verify flow and head capacity of each PCP, the following test shall be conducted with water at a rotating speed of 500 r/min, except for high volume/high pressure pumps where speed can be reduced to limit power consumption as agreed between supplier/manufacturer and user/purchaser:

— at zero differential pressure and zero leakage;

— at maximum operating differential pressure at a target of 15 % leakage (minimum 10 %, maximum 20 %).

The resulting performance curve is the performance baseline for acceptance testing of the PCP. Consideration shall be given to a swelling test on an elastomer sample with the anticipated crude or equivalent.

5.5.2 Validation test

5.5.2.1 Test procedure

The PCP shall be installed and secured on a test bench. Rotation and power are provided to the rotor by means of a drive system. The test medium shall be water, which is pumped through a closed loop system, flows through the PCP and discharge lines. A choke shall be used to regulate a discharge pressure, which creates a differential pressure across the PCP. A pressure-measurement device measures the differential pressure and/or the intake/discharge pressures and an apparatus shall be used to measure the flowrate. This information shall be used to calculate volumetric efficiency η_v (annex B).

Record flowrate, the differential pressure and/or the intake/discharge pressures, pump absorbed power, pump torque and fluid temperature for the different set points until the maximum pressure and speed are reached.

The test report is illustrated in annex B and performance curve in annex A. The graph shall state the rotor code and the test temperature.

Test procedures may vary among suppliers/manufacturers but shall follow these guidelines:

— record pertinent test information, including:

  — location of test;

  — date of test;

  — person testing;

  — model of PCP (rotor code, stator serial number, rotor serial number and elastomer name);

  — minimum and maximum specified revolutions per minute or nominal fixed speed (revolutions per minute);

  — test fluid temperature;

  — PCP intake pressure;

— install and secure the PCP on a test bench;

— prepare stator lubrication (lube) mix (water + oil) for easier installation of rotor into the stator and to overcome friction;

— apply lube mix to the stator;

— record rotor measurements for length, diameter and coating/plating thickness;

— select appropriate test bench coupling to match rotor size;

— turn circulation pump on and bring test fluid up to the test temperature;

— conduct a no-load pretest to determine PCP efficiency at zero head;

— start load test;

— choke back on PCP until target pressure is reached;

— record flowrate, pressure, power, torque, fluid temperature for the different set points until the target pressure is reached; these values are required to calculate the PCP efficiency.

The PCP may be tested with a special rotor (designed for test purposes only) to consider the effects of temperature and swelling. The test temperature (usually 30 °C) may differ from the actual operating temperature. In this case, only the user/purchaser's stator is physically tested. The user/purchaser's rotor is only checked dimensionally and its thermal expansion is derived by calculation.

Due to chemical swelling and thermal expansion of the elastomer once the PCP is exposed to the well environment, the functional tests may produce different results (see 6.5).

5.5.2.2 Calibration

Measurement devices shall be capable of measuring the recorded values within the following measurement tolerances:

pressure, Δp	± 2,5 %
speed, N	± 1 %
flowrate, q	± 2,5 %
pump absorbed power	± 1 %

Equipment used for final acceptance shall be identified, controlled, calibrated and adjusted in accordance with an internationally or nationally recognized standard.

5.5.2.3 Acceptance criteria

At 500 r/min, the flowrate and torque shall be within ± 10 % of published values as per manufacturer's pump curve at zero and maximum differential pressures.

5.6 Design change

All design changes shall be documented and reviewed against the design validation test to determine if the changes are substantive changes. A substantive design change is defined as a change to the design by the supplier/manufacturer that affects the performance of the product in the intended service condition. A design that undergoes a substantive change becomes a new design, which requires design validation.

5.7 Functional test parameters

Each PCP shall be functionally tested prior to shipment to the user/purchaser in accordance with 6.5. Data accuracy and acceptance criteria shall be identical to 5.5.2.2 and 5.5.2.3 respectively.

6 Supplier/manufacturer requirements

6.1 Document and data control

The supplier/manufacturer shall establish and maintain documented procedures to control all documents and data that relate to 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 stored and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and prevent loss. Documents and data may be in the form of any type of media, such as hard copy or electronic media. All documents and data shall be available for audit by the user/purchaser.

All design verification and validation documents and data shall be maintained for a minimum of two years after the date of last manufacture.

6.2 User/purchaser documentation

6.2.1 Installation, operation and maintenance manual

The PCP shall be compatible with oilfield equipment of standard design. Its installation is achieved by using standard oilfield practices. Typical installation of a PCP is shown in annex D, Figures D.1 and D.2. The supplier/manufacturer shall have available a manual describing the following items in detail:

— rotor installation;

— stator installation;

— pre-start checks;

— start-up/shut-down;

— troubleshooting guide.

6.2.2 Product data sheet

A product data sheet shall be available at delivery to the user/purchaser and shall contain at least the following information:

— name and address of supplier/manufacturer;

— manufacturer's assembly number;

— manufacturer's product name;

— product type;

— product characteristics.

6.3 Product identification

6.3.1 Stator code

Each stator shall have the following code permanently impressed on the exterior :

vvv/hh/eee

where

vvv is the flowrate, expressed in cubic metres per day at 500 r/min and zero discharge pressure;

hh is the maximum head rating of the PCP, expressed in megapascals;

eee is the manufacturer's code for the elastomer.

This code shall be located no more than 0,8 m from the top of the stator, thus differentiating the top from the rotor stop.

6.3.2 Rotor code

Each rotor head shall be permanently impressed with the following code:

vvv/hh

where

vvv is the flowrate, expressed in cubic metres per day at 500 r/min and zero discharge pressure;

hh is the maximum head rating of the PCP, expressed in megapascals.

6.3.3 Additional identification

The manufacturer's name and part number shall be clearly labelled on rotor and stator. Other information, such as month/year of manufacture and identification of individual or assembled elements, may be included if requested.

6.4 Quality control

The supplier/manufacturer shall have documented quality control procedures, which include acceptance criteria.

6.5 Functional tests

Testing shall be identical to 5.5.2. Data accuracy and acceptance criteria shall be identical to 5.5.2.2 and 5.5.2.3 respectively.

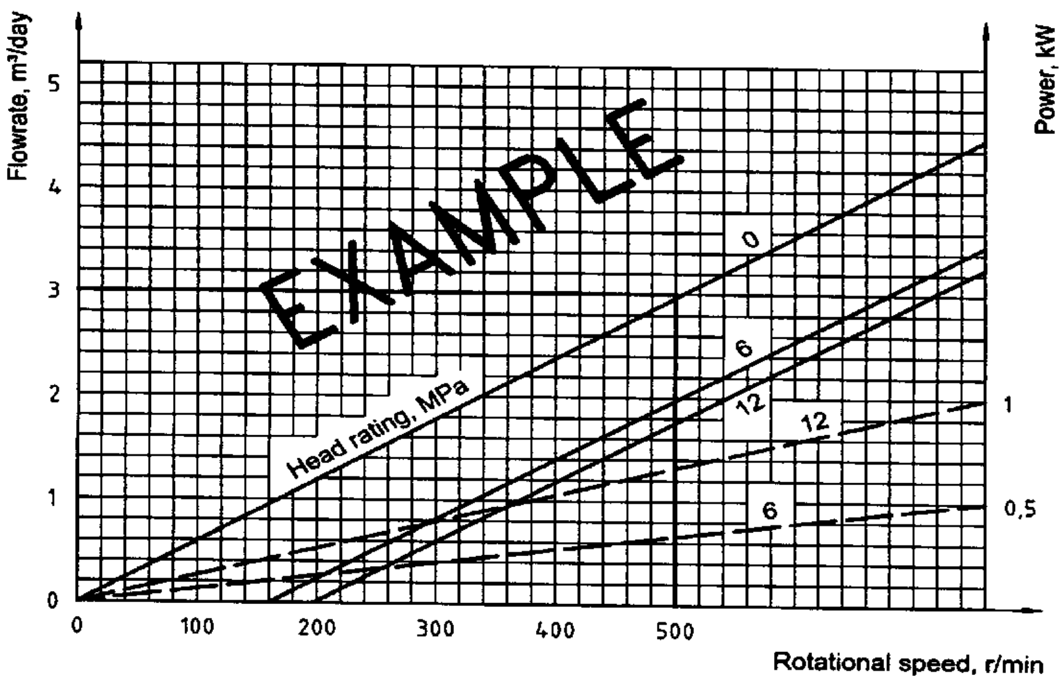
Due to chemical swelling and thermal expansion of the elastomer once the PCP is exposed to the well environment, the results of functional tests may not duplicate the manufacturer's published performance curves. Allowance should be made for interpolation of results, especially interference fit. To take these parameters into consideration, the supplier/manufacturer shall be able to prove the validity of the extrapolation based upon field experience or calculation.

Annex A
(normative)

Example of performance curves for pump selection

EXAMPLE

Rotor code	3 /12
Temperature	50 °C
Outside diameter of stator	85 mm
Outside diameter of rotor	60 mm
Minimum tubing ID above pump	70 mm
Length of rotor helix	1,2 m
Length of stator elastomer	1,0 m
Length between elastomer and rotor stop	16 mm
Stator thread specification	2 3/8 in
Rotor thread specification	1 1/16 in, API 3/4 in rod
Maximum speed of PCP	500 r/min
Head rating	12 MPa



Annex B
(normative)

PCP test report data sheet

Test characteristics		Order reference
Pump intake pressure:	kPa	Purchase order No.:
Fluid test temperature:	°C	Customer:
		Rotor code:
Date of test:		Stator, serial No.:
Location of test:		Rotor, serial No.:
		Elastomer name:
Tested by:		Rotor coating:

	N = r/min			q_c = m³/d				
Measured points	q_m m³/d	η_V %	Δp kPa	P_h kW	Γ N·m	P_{req} kW	η %	T °C
P1								
P2								
P3								
P4								

q_c actual pump displacement (m³/d), at zero discharge pressure, for a considered rotational speed, N (r/min);

q_m measured flowrate (m³/d), at a specific rotational speed (r/min) and differential pressure (kPa);

η_V volumetric efficiency, %: $(q_m/q_c) \times 100$;

Δp differential pump pressure, kPa: discharge pressure minus intake pressure;

P_h hydraulic pump power, kW;

Γ pump torque, N·m;

P_{req} power required to drive the pump, kW;

η pump overall efficiency, %: $(P_h/P_{req}) \times 100$;

T actual fluid test temperature, °C.

If the temperature of test is different from field temperature, the manufacturer shall explain and adjust the results; the same applies if the elastomer will swell when immersed in the oil.

NOTE 1 At a speed, N, at different points P1, P2, ... the values of pressure are measured; then the same operation can be repeated for another speed.

NOTE 2 Refer to ISO 31 for units.

Annex C
(informative)

Application design specification data sheet

DATE: __________ COMPANY NAME: __________________ CONTACT:__________
TELEPHONE No.: ____________ FAX/e-MAIL No.: ____________ WELL NAME: ______________
FIELD:_________________ WELL TYPE VERTICAL: ______ DIRECTIONAL: ______ SLANT: _

PERFORATION DEPTH: TVD _____________m, measured________________________ m
PUMP SETTING DEPTH: TVD______________m, measured________________________ m
TOTAL TUBING LENGTH: TVD __________m, measured________________________ m
FLUID LEVEL FROM SURFACE (TVD): STATIC: ________ m DYNAMIC: __________ m
PRODUCTIVITY INDEX: ___________m³/d/kPa BOTTOMHOLE PRESSURE:________kPa
FLOWLINE PRESSURE: ______________ kPa CASING PRESSURE: _____________ kPa
CASING ID: _________________ mm TUBING ID: _________________ mm
TUBING THREAD TYPE AND SIZE: ______ WELLHEAD CONNECTION TYPE AND SIZE:______
DRIVE STRING: TYPE: ___ OD: _____ mm COUPLING OD: ____ mm THREAD: ____

DAILY FLUID PRODUCTION: ________ m³/d PROJECTED DAILY FLUID PRODUCTION: _______m³/d
CURRENT MODE OF PRODUCTION: ______________________________
WATER CUT: ____ %
SOLIDS CONTENT: _______ % ______________________________
GAS/OIL RATIO: _ m³/m³ GAS BUBBLE POINT: _______ kPa GAS SPECIFIC GRAVITY:______ S.G.
VISCOSITY: __________________ cP at __________________ °C
API OIL GRAVITY: ________ MOLE PERCENT LIGHT MONOAROMATIC: ______________ %
TOTAL FLUID SPECIFIC GRAVITY: ______ OIL: ____ WATER:_____
H_2S: ___________ % pH: _____
CO_2: ___________ % CHLORIDES: ____ %
PUMP INLET TEMPERATURE: ______ °C WELLHEAD TEMPERATURE: ______ °C
AMBIENT TEMPERATURE: _____ °C ELECTRICAL ZONE CLASSIFICATION: _______

PRIME MOVER TYPE: _______________ GAS _________________ ELECTRIC
VOLTAGE ______________ V FREQUENCY: _______________ Hz
POWER TRANSMISSION MODE: _______________ DIRECT DRIVE ___________ HYDRAULIC

CHEMICAL TREATMENT PROGRAMME: YES _____ NO _______ IF YES THEN DESCRIBE: _____
____

COMMENTS: ____
____

Annex D
(informative)

Accessories

NOTE See Figure D.1 and Figure D.2.

D.1 Torque anchor

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

D.2 Drive string centralizers

When string-tubing wear is expected, the use of wear-reducing mechanisms such as centralizers is recommended.

It is not recommended to fit the rotor-to-lower-string connection with a centralizer.

The use of centralizers introduces restrictions which must be considered in the calculation of the total head and power required by the system.

D.3 Tubing rotators

Tubing rotors decrease the problems associated with tubing wear by allowing the tubing to be rotated periodically while the PCP is operating.

D.4 Torque limiter

A torque limiter may be required to prevent damage to any of the system components. Typically, it limits the stress in the drive string below the minimum yield.

D.5 Pump-off control

The pump-off control senses a pump-off condition and controls the prime mover to prevent damage to the PCP.

D.6 High-pressure shut-down switches

Flowline pressure is monitored using a pressure gauge or pressure transducer which protects the system against excessive flowline pressure.

D.7 Downhole check valve

The downhole check valve provides a means of controlling back-flow through the PCP. It is installed below the rotor stop.

D.8 Variable-speed controllers

Variable-speed controllers allow the PCP speed to be easily adjusted in order to accommodate changing well conditions.

D.9 Tubing drain

A tubing drain can be used to drain the tubing for workover purposes. It is used when the PCP inlet is equipped with a downhole check valve or if there is a risk of blockage.

D.10 Drive string shear

A drive string shear, installed near the rotor, is used to release the drive strings in the event the rotor cannot be removed from the stator.

D.11 Gas separator

A gas separator is a device installed at the PCP inlet, used to divert free gas away from the PCP.

D.12 Drive strings

A drive string is typically a sucker rod string used to drive a PCP. Torque and axial load capacities of the drive string should be considered. The stress on the drive string is due to the combination of axial load and torque. When estimating operating life, consider rates of corrosion, drive-string wear due to erosion effects, and cyclical stresses.

D.13 Prime mover

The type of prime mover and its location should conform to standards or specifications agreed between user/purchaser and supplier/manufacturer, local government codes and regulations. Prime movers are available as follows:

— electric motors;

— hydraulic motors;

— internal combustion engines.

D.14 Drivehead

The drivehead is the surface equipment that connects the prime mover to the drive string via a solid or hollow shaft.

D.15 Drive-string clamp

The drive-string clamp is a device located on top of the drivehead that suspends the drive string and/or transmits torque to the drive string.

D.16 Lock-out clamps

Lock-out clamps are safety devices which are attached to the drivehead for the purpose of preventing accidental rotation of the drivehead.

D.17 Solid-shaft drivehead

A solid-shaft drivehead transmits power to the drive string by a fixed attachment.

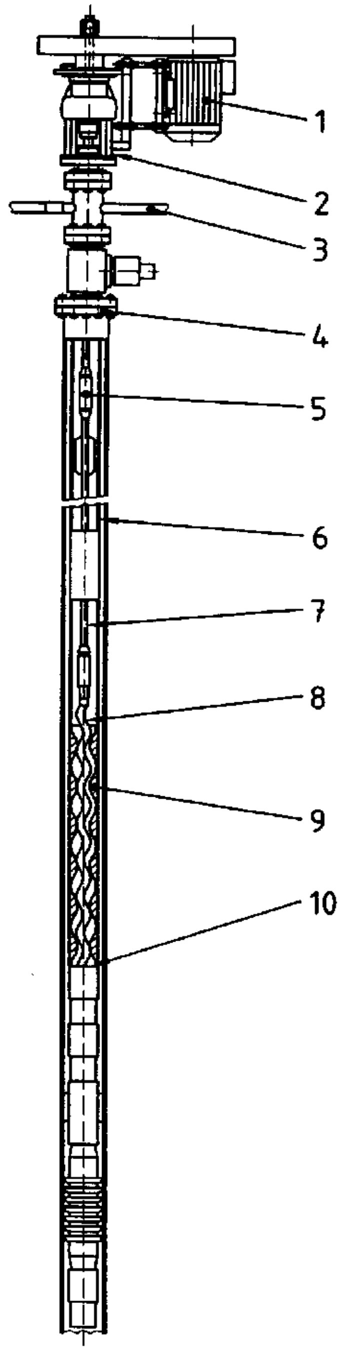
D.18 Hollow-shaft drivehead

A hollow-shaft drivehead uses a drive-string clamp rather than a fixed attachment to transmit power to the drive string. This provides a means to extend the drive string through the drivehead, which allows vertical movement of the drive string without dismantling the drivehead.

D.19 Drivehead brake

The drivehead brake is a device to dissipate stored energy to limit and/or stop rotation of the drive string during shutdown events. Brakes may be of the following type:

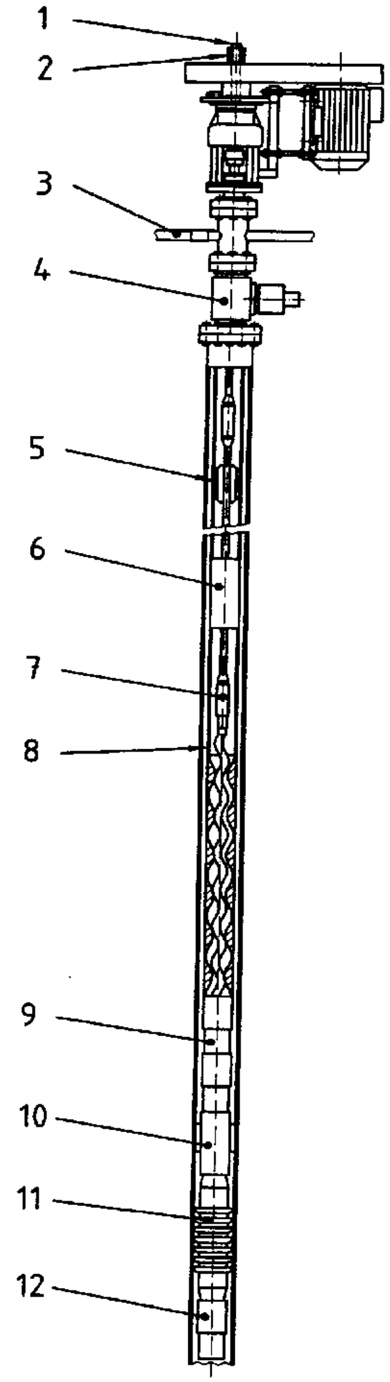
- friction brake;
- hydraulic brake;
- electrical motor brake;
- manual brake.



Key

1 Prime mover
2 Drive head
3 Storage flowline
4 Well head
5 Coupling
6 Tubing
7 Drive string
8 Rotor
9 Stator
10 Rotor stop

Figure D.1 — Standard equipment



Key

1 Hollow shaft
2 Clamp
3 Casing relief line
4 Tubing rotator
5 Drive-string centralizer
6 Tubing drain
7 Drive-string shear
8 Pup joint
9 Downhole check valve
10 Torque anchor
11 Gas separator
12 Tailpipe

Figure D.2 — Optional equipment

Annex E
(informative)

Engineering methodology

E.1 Geometry (see Figures E.1, E.2 and E.3)

E.1.1 General

The general geometry of PCPs is defined by two numbers, the first being the number of lobes of the rotor, and the second being the number of lobes of the stator.

For example, the geometry of a PCP with a single-helical rotor and a double-helical stator is described as a 1-2 pump.

The rotor is not concentric with the stator. Therefore, the motion of the rotor inside the stator is actually a combination of two motions:

— a rotation around its own centreline in one direction, and

— a rotation in the opposite direction of its own centreline around the centreline of the stator.

The orbit of the rotor head is defined as the minimum diameter inside which the rotor head rotates.

E.1.2 Diameters and eccentricity

E.1.2.1 Pump (single-lobe rotor — see Figure E.2)

Nominal diameters and eccentricity (assuming no interference) are defined as follows:

— the thickness of a single-helical rotor is the minor diameter, d_r;

— the eccentricity, E, is the distance between the centreline of the rotor and the centreline of the stator;

— the diameter of the helix of a single-helical rotor is the major diameter, D_r ($D_r = d_r + 2E$);

— the width of the double-threaded helix in the stator is d_s (where $d_s = d_r$); the breadth is D_s (where $D_s = d_r + 4E$).

E.1.2.2 Pump with multi-lobe rotor (see Figure E.3)

Diameters and eccentricity are extrapolated from the 1-2 pump as follows:

— n_r is the number of lobes of the rotor;

— $n_r + 1$ is the number of lobes of the stator;

— d_r is the rotor minor diameter; it is the diameter of the circle tangent to the inner rotor lobes;

— D_r is the rotor major diameter; it is the diameter of the circle tangent to the outer rotor lobes;

— d_s is the stator minor diameter; it is the diameter of the circle tangent to the inner stator lobes;

— D_s is the stator major diameter; it is the diameter of the circle tangent to the outer stator lobes.

NOTE For multi-lobe PCPs, rotor and stator minor diameters are different, and $d_r \neq d_s$.

E.1.3 Pitch length

This term may refer to the pitch length of the rotor or the stator. Therefore:

— P_r is the pitch length of the rotor, and

— P_s is the pitch length of the stator.

For a 1-2 pump:

$$P_s = 2\,P_r$$

For any pump, where n is the number of lobes of the rotor:

$$P_s = [(n+1)/n]\,P_r$$

E.1.4 Cavity

The length of a cavity is always the pitch length of the stator.

The number of cavities, C, is calculated in the following manner:

$$C = n_r\,[(H_s/P_r) - 1]$$

where

n_r is the number of rotor lobes;

H_s is the total length of the stator helix;

P_r is the rotor pitch.

E.2 Interference

In order to create lifting pressure, there shall be differential pressure between successive cavities. This requires a seal between the rotor and stator, which is obtained by creating an interference fit between the rotor and stator. The interference provides continuous seal lines. The resulting friction and elastic deformation must be overcome by torque to rotate and operate the PCP.

E.3 Displacement

At zero differential pressure across the PCP, the flow per revolution is the calculated displacement, V_c, and can be obtained with the following formula for 1-2 pumps:

$$V_c = 4\,E \cdot d_r \cdot P_s$$

At zero differential pressure across the PCP, the calculated flowrate, q_c, is directly proportional to the displacement and the rotating speed, N:

Therefore:

$q_c = V_c \cdot N$

E.4 Flowrate and slippage

The actual flowrate, q_a, at any head other than zero, is a function of the calculated flowrate minus the slippage.

Therefore:

$q_a = q_c - q_s$

The slippage, q_s, is a function of:

— the interference between rotor and stator;

— the viscosity of the production fluid;

— the differential pressure between cavities;

— the physical properties of the elastomer;

— the thickness of the elastomer; and

— the geometry of the PCP.

NOTE The slippage is considered to be independent of the rotational speed.

E.5 Head rating

Head rating is expressed in megapascals (MPa).

E.6 Running torque

The hydraulic torque, Γ_h, is equal to:

$\Gamma_h = k \cdot Q_c \cdot \Delta p / N$

where

Γ_h is expressed in newton metres;

q_c is expressed in cubic metres per day;

Δp is expressed in megapascals;

N is expressed in revolutions per minute;

k = 110,6.

E.7 Free gas

Free gas occupies space in the pump cavity. This reduces liquid displacement. In applications where gas is present, attempts should be made to reduce the amount of free gas that enters the PCP. Therefore, consideration should be given to:

— landing the PCP below the bubble point or perforations;

— using a tailpipe below the perforations while maximizing the annular cross-sectional area;

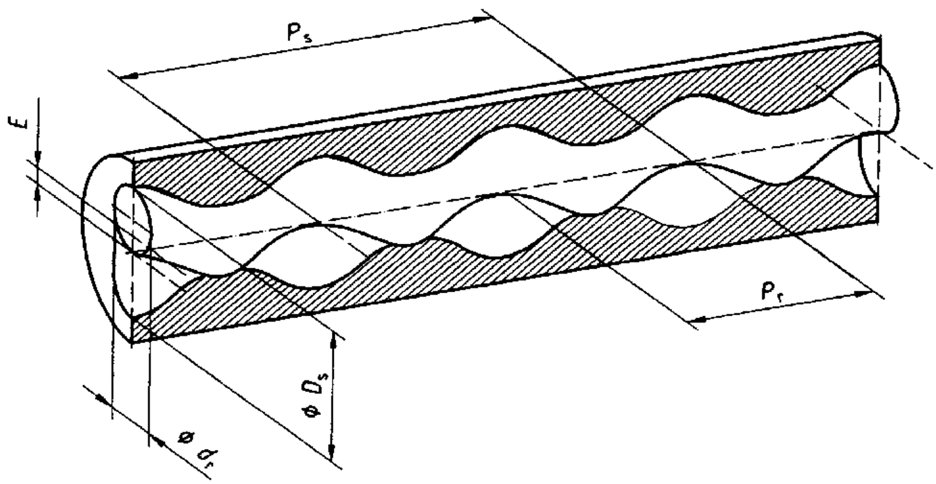
— using a downhole gas separator or a charge pump.

Even when applying the above measures, it is still possible to encounter situations in which the gas/liquid ratio at the inlet is too high to provide adequate cooling and lubrication for the PCP. The producing GOR and the bubble point of the produced fluid should be used to calculate the gas/liquid ratio at the PCP inlet. The highest gas/liquid ratio that can be accepted is a function of:

— pump speed;

— interference;

— rate of heat dissipation.



Key

P_r Pitch length of the rotor

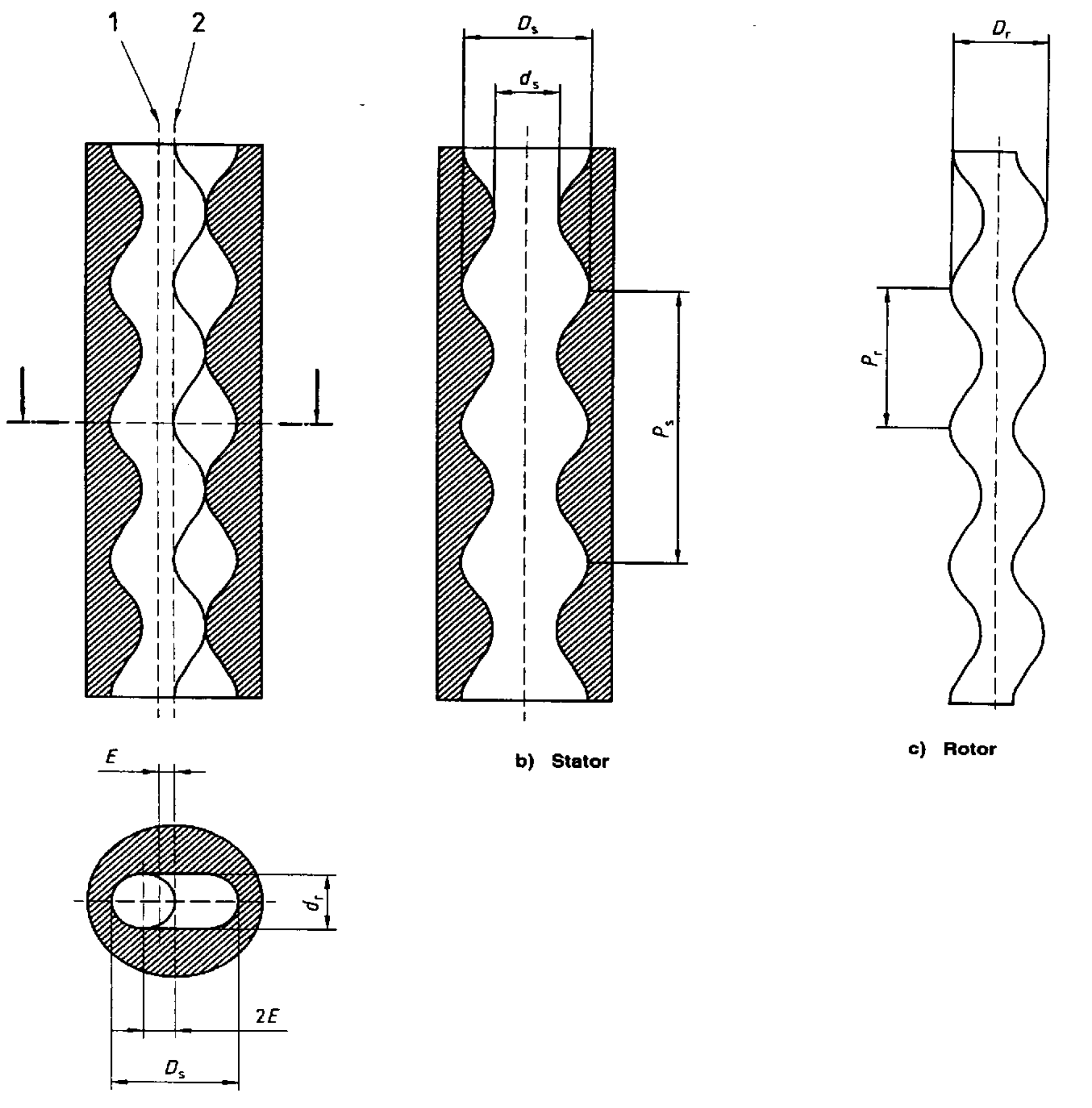
P_s Pitch length of the stator

d_r Minor diameter of the rotor

E Eccentricity

D_s Major diameter of the stator

Figure E.1 — Progressing cavity pump (illustrated rotor and stator geometry)



a) Pump assembly

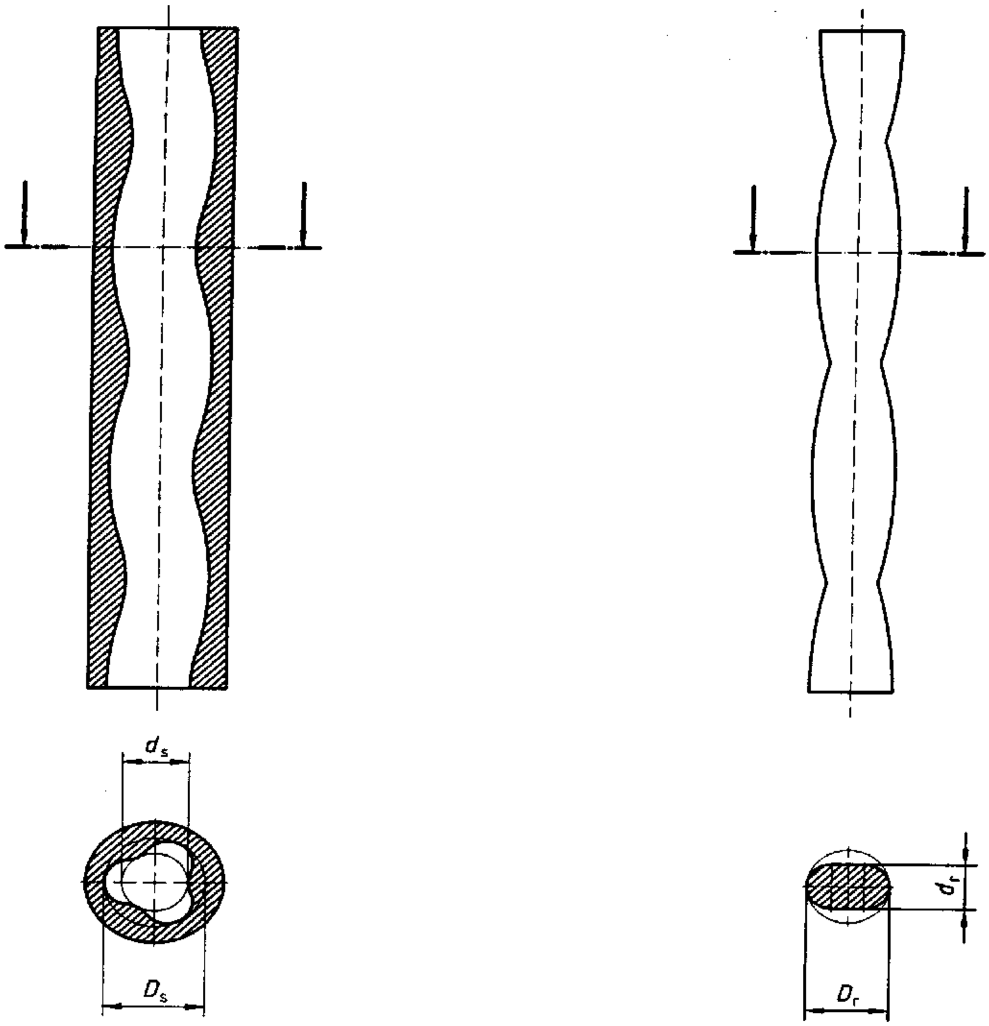
b) Stator

c) Rotor

Key

1 Rotor centreline
2 Stator centreline
P_r Pitch length of the rotor
P_s Pitch length of the stator
d_r Minor diameter of the rotor
d_s Minor diameter of the stator
E Eccentricity
D_r Major diameter of the rotor
D_s Major diameter of the stator

Figure E.2 — 1-2 pump



a) Stator

b) Rotor

Key

d_s Minor diameter of the stator
D_s Major diameter of the stator
d_r Minor diameter of the rotor
D_r Major diameter of the rotor

Figure E.3 — 2-3 pump

Annex F
(informative)

Description of PCP system

F.1 General

A progressing cavity pump comprises two helical gears, one rotating inside the other. The stator and rotor axes are parallel and interspaced. The external helical gear (stator) has one more thread (or tooth) than the internal helical gear (rotor). Whatever the number of threads of the two elements, they must always differ by one. The fluid moves from suction to discharge. The discharge and the suction are always isolated from each other by a constant-length seal line.

The PCP should be installed below the dynamic level, since it requires a positive inlet pressure to operate efficiently. The produced fluid provides lubrication and cooling between the stator and the rotor. If the PCP operates without sufficient positive inlet pressure, there will not be adequate fluid available to enter the inlet cavity of the PCP and the elastomer material will fail due to the subsequent increase in temperature

The rotor is set so that all the threads or teeth are in constant contact with those of the stator. The helical pitches of the two components are proportional, for each cross-section, to the number of teeth.

The cross-sections of helical components consist of coupled profiles achieved by two hypocycloid combinations, whose generated circles have a diameter equal to the distance between the longitudinal axes of the two helical elements.

The helical winding of the profiles around their rotating axes creates, between the two helical elements, cavities whose length is equal to the pitch of the external element. If the rotor turns inside the stator, the cavity will move towards the discharge end, without deformation, in a helical motion along the stator.

Provided the helix of the external element turns more than one revolution, the PCP will enable a discharge under pressure, or a fluid expansion, without a check valve. The pressure will increase only after the first revolution of the external-element helix. This motion leads to the formation of closed cavities which move axially from suction to discharge.

With this principle, a rotating positive-displacement PCP is achieved which :

— is reversible and self-priming;

— needs no check valve;

— provides a uniform flowrate, with negligible pulsation or jerk;

— is capable of conveying very runny to very pasty fluids, even when containing both solids and gas.

Figure F.1 is an example of a PCP in which the stator is fixed. The rotor (pitch on right) turns clockwise. Cavities are formed between the two helical gears, which are open at the left extremity when the rotor turns. The first cavity discharges. The subsequent isolated cavity moves from suction to discharge.

If the rotor runs in the reverse direction, the closed cavities move from right to left according to the same principle, making the PCP action reversible.

Power is transmitted from the drivehead to the PCP by rotation of an extended drive shaft.

See annex E for further explanation of the geometry and operating principles.

a) Rotor axis is on the top side of the cavity

b) Rotor turned 90° and its axis is located on the stator axis

c) Rotor turned 180° and its axis is located below the stator axis

d) Rotor turned 270° and its axis is located on the stator axis

e) Rotor turned 360°; cycle is completed; another begins

Figure F.1 — PCP operating principle

F.2 Theory of design

Two conditions are necessary to obtain closed cavities (see Figure F.2). The first condition is that the rotor must have one tooth less than the stator and every tooth of the rotor must always be in contact with the inner surface of the stator. The second condition is that the rotor and the stator, as defined above, constitute two longitudinally helical gears.

The hypocycloid H_1 with n teeth, whose base is the circle C_1 (O_1, radius R_1), is connected to the hypocycloid H_2 with (n – 1) teeth, whose base is the circle C_2 (O_2, radius R_2) by the relation $R_2/R_1 = n - 1/n$. These two curves provide two gears, one inside the other. If H_1 is fixed, when H_2 turns in a certain direction its centre O_2 describes, in the opposite direction, a circle with centre O_1 and of radius O_1O_2, such that $O_1O_2 = E$ = eccentricity of the PCP.

During this motion, the vertices of H_2 are always in contact with H_1 and on these curves appear closed surfaces of variable area, S_1, S_2, S_3, whose sum ($S_1+S_2+S_3$) remains constant. H_1 and H_2 are replaced by their envelopes E_1 and E_2 of an identical circle C of any diameter D whose centre would describe H_1 and H_2.

The profiles E_1 and E_2 move longitudinally as helices whose pitch ratio corresponds to the ratio of the number of teeth.

The helical winding of the surfaces S_1, S_2, S_3 make it possible to obtain, between the two helical elements, closed cavities whose length is equal to the pitch of the external element.

To achieve total sealing of the PCP, the engagement length of the rotor in the stator has to be at least equal to one pitch of the stator.

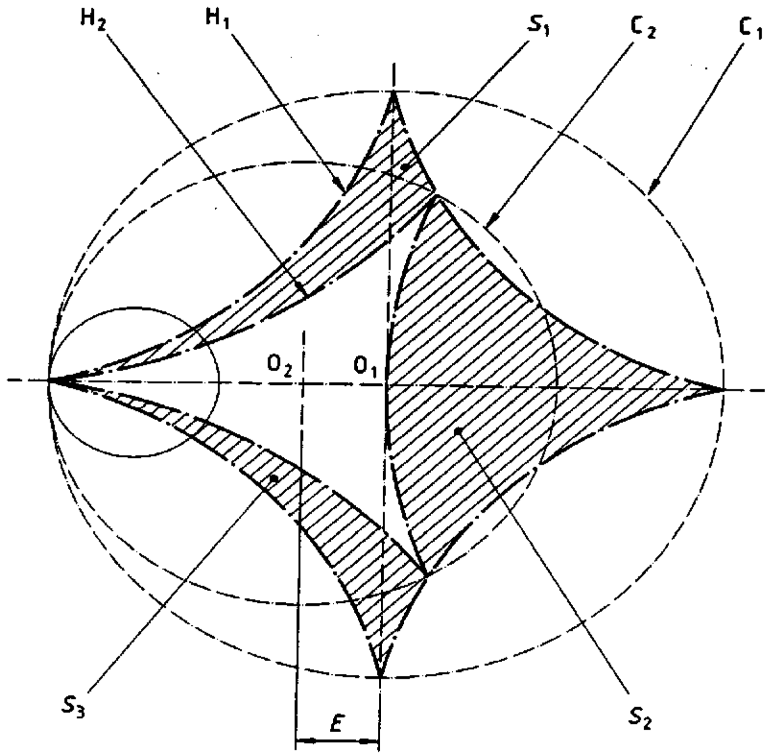
The portion of the contact lines of the rotor and the stator between the high-pressure cavities and the low-pressure cavities constitutes the leakage line.

The transportation of solids requires sufficient fluid velocity above the PCP, in the annular space between the drive string and the tubing, to carry solids to the surface. The following should be taken into consideration:

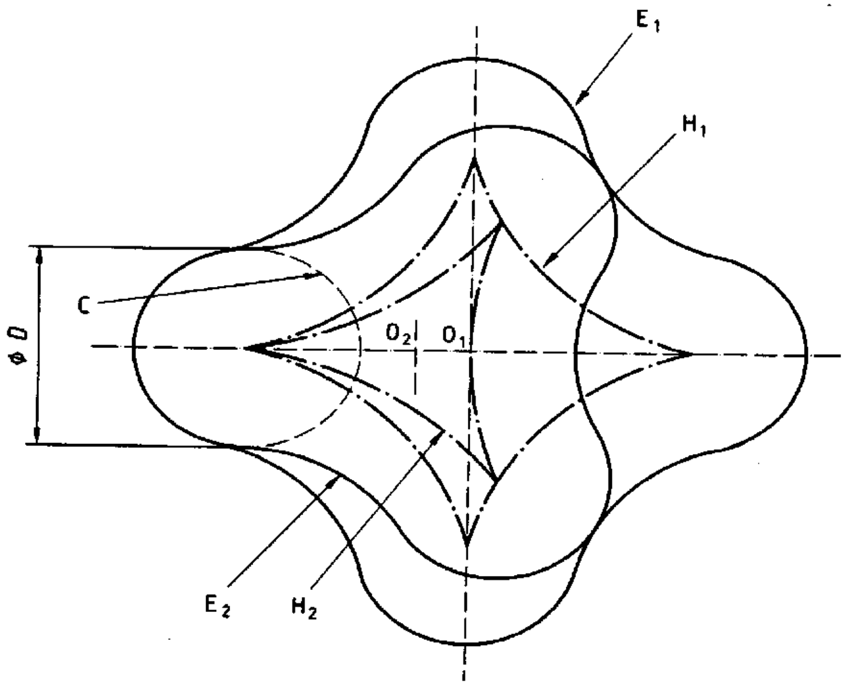
— grain size and density;

— fluid velocity;

— annular cross-sectional area.



a) Hypocycloids H_1 and H_2



b) Envelopes E_1 and E_2 of hypocycloids

Figure F.1 — PCP theoretical geometry

Bibliography

[1] ISO 31 (all parts), *Quantities and units.*

[2] Moineau R.J. *Pompe.* FR Patent No. 695 539 September 30, 1930. US Patent No. 1 892 217, December 27, 1932.

[3] Cholet H.J. (1997) *Progressing cavity pumps.* Editions Technip. ISBN 2-7108-0724-6.

ICS 75.180.10

Price based on 31 pages

REPORT ON VOTING ON ISO/DIS 15136-1	
Closing date of voting **2000-04-04**	**ISO/TC 67/SC 4**
	Secretariat API/ANSI

1. Result of voting

The above-mentioned document was circulated to member bodies on the date shown in annex A, with a request that the Central Secretariat be informed whether or not member bodies were in favour of registration of the DIS as a Final Draft International Standard.

The replies in annex A have been received.

2. Comments received

3. Observations of the secretariat

See annex B. (This annex is circulated only to the P-members of the committee but is available to any other member body on request.)

4. Decision of the Chairman

☑ The DIS has been approved in accordance with the condition of 2.6.3 of part 1 of the ISO/IEC Directives and will be submitted without change, other than editorial, for circulation as an FDIS to all member bodies

In the light of technical comments received,

☐ a new DIS will be submitted to the Central Secretariat for circulation to the member bodies.

☐ a new committee draft will be distributed for comment.

☐ the DIS and comments will be considered at the next meeting.

Signature of the secretary	**Signature of the chairman**
Jennifer Kelly for David Miller	[signature]
Date: 9/18/00	**Date:**

FORM 13 (ISO)

DIS TABLE OF REPLIES / 2000-09-22 / TABLEAU DES REPONSES DIS

TC 67/SC 4
ISO/DIS 15136-1

VOTING BEGAN ON/DEBUT DU VOTE:1999-11-04
TIME LIMIT FOR REPLY/DELAI:2000-04-04

TITLE: Downhole equipment for petroleum and natural gas industries -- Progressing cavity pump systems for artificial lift -- Part 1: Pumps

TITRE: Équipement de forage et de production pour les industries du pétrole et du gaz naturel -- Pompes de fond à cavité progressive -- Partie 1: Pompes

MEMBER BODY/COMITE MEMBRE		APPROVAL/APPROBATION	DISAPPROVAL/DESAPPROBATION	ABSTENTION	
Argentina (IRAM)	P			X	**
Austria (ON)		X			
Belgium (IBN)		X			
Brazil (ABNT)	O	X			*
China (CSBTS)	O	X			
Denmark (DS)	O			X	
Egypt (EOS)		X			
France (AFNOR)	P	X			*
Germany (DIN)	P	X			*
Indonesia (BSN)	P	X			
Iran, Islamic Repub (ISIRI)					L
Ireland (NSAI)				X	
Italy (UNI)	P	X			*
Netherlands (NEN)	P	X			*
Norway (NSF)	P	X			
Poland (PKN)	P	X			
Romania (ASRO)	P	X			
Russian Federation (GOST R)		X			
Spain (AENOR)				X	
Sweden (SIS)				X	
Switzerland (SNV)				X	
Trinidad and Tobago (TTBS)				X	
United Kingdom (BSI)	P	X			*
USA (ANSI)	S	X			*
Venezuela (FONDONOR)		X			
T O T A L		17	0	7	

* = Comments / commentaires
** = P-member having abstained and therefore not counted in the vote / Membre (P) s'abstenant de voter; n'est donc pas compté dans le vote
L = Late vote / vote tardif

P-MEMBERS VOTING: / MEMBRES (P) VOTANT:	IN FAVOUR OUT OF / EN FAVEUR SUR		REQUIREMENT / CRITERE
	10	10 = 100.00%	>= 66,66%

MEMBER BODIES VOTING: / COMITES MEMBRES VOTANT:	NEGATIVE VOTES OUT OF / VOTES NEGATIFS SUR		REQUIREMENT / CRITERE
	0	17 = 0.00%	<= 25%

THIS DRAFT HAS THEREFORE BEEN APPROVED
in accordance with the ISO/IEC Directives, Part 1, sub-clause 2.6.3.

CE PROJET EST DONC APPROUVE
selon les Directives ISO/CEI, Partie 1, paragraphe 2.6.3

Date 2000-04-28	ISO/DIS 15136-1
Secretariat API/ANSI	ISO/TC 67/SC 4

Member Body	**COMMENTS** Comments shall be reproduced as received either by re-typing them, or directly by pasting them on this form	**OBSERVATION OF THE SECRETARIAT** on each comment submitted
BRAZIL	**6.2.1 – second paragraph** **We suggest you to use the term "total head required" instead of "differencial pressure", because the term "differencial pressure" makes better sense if refered to pressure drop across any device such as a pump or a valve, for example. In addition, the item 6.2.1 it self is about "head requirements".**	Not accepted; the term differential pressure is considered correct as it accounts for all factors.

Member Body	**COMMENTS** Comments shall be reproduced as received either by re-typing them, or directly by pasting them on this form	**OBSERVATION OF THE SECRETARIAT** on each comment submitted
FRANCE	**TITLE :** **The title of the <u>English version</u> was modified between CD and DIS stage we suggest to remain conforming with the other standards in course in ISO/TC 67/SC4 : Petroleum natural gas industries – Downhole equipment – Progressing cavity pump systems for artificial lift – Part 1 : Pumps**	Accepted.
	Modify the <u>French title</u> as follows : Industries du pétrole et du gaz naturel – Equipement de fond de trou – Pompes à cavités progressantes pour activation des puits – Partie 1 : Pompes	
	6.2.3.3 Elastomer data *replace* "manufacturers shall not change the formulation of a designated elastomer" *by* "manufacturers shall not change the formulation of a designated elastomer **except for minor improvement or change of supplier**"	Accepted in principle; see revision.
	6.4.1 Validation parameters *replace* " the following test shall be conducted with water at 500 rpm " *by* " the following test shall be conducted with water at 500 rpm, **except for high volume / high pressure pumps where speed can be reduced to limit power consumption** "	Accepted in principle; see revision.
	7.3.1 Stator code *write* "in MPa" *instead of* "in Mpa "	Accepted.
	Annex A *replace* " Power (Kw) " *by* " Power (kW) "	Accepted
	Annex C *add* "e-mail" after telephone and fax *replace* " mole percent aromatic solvents " *by* " mole percent light monoaromatics (benzene, toluene, xylene) "	Accepted. Accepted.
	Annex E.7 - figure E.1 the "legend" is not in accordance with ISO Directives Part 3.	Accepted.

Member Body	COMMENTS Comments shall be reproduced as received either by re-typing them, or directly by pasting them on this form					OBSERVATION OF THE SECRETARIAT on each comment submitted
	no	clause	actual text	modification proposed	justification / general remark	
GERMANY	1	general			Also compare with EN 12723 "Liquid pumps – General terms for pummps and installations. (CEN/TC 197/SC 2)	Noted.
	2.	3 11, NOTE	. (see Figure 3A)	... (see Figure E2)	wrong reference	Accepted
	3.	(new)	...	add: "3.15 rubbing speed average value of rubbing speed between outside surface of rotor and inside surface of stator during one revolution."	"3.15 slippage" moving to "3.16..." etc	Not accepted; not common term used in this context.
	4.	4	L_r number of lobes	L_r number of lobes (of rotor)	Index "r" too small	Accepted.
	5.	6.2.3.1. 2nd indent	friction effect due to interference, ...	friction and kneading action of the rotor on the stator due to interference, .		Accepted in principle; added new indent point.
	6.	6.2.3.4 4th indent	rotational speed	rubbing speed between rotor – and stator surfaces	Rotational speed (rpm) has varying influence for different pump sizes (diameters). An independant value (from pump size) is the rubbing speed , between rotor – and stator surfaces.	Not accepted: rotational speed implies both angular speed and diameter.
	7.	6.2.3.5	The PCP requires a positive inlet pressure to operate efficiently		Basicly a PCP is a negative pressure pump. Positive inlet pressure is only necessary if vapour pressure of pumped product is very low.	Noted.
	8.	6.2.3.6		— rubbing speed between rotor – and stator surfaces	Proposal for addition between 2nd and 3rd indent Remark: Rotational speed (rpm) has varying influence for different pump sizes (diameters). An independant value (from pump size) is the rubbing speed , between rotor – and stator surfaces.	Not accepted; see #6.
	9.	6.4.2	— prepare stator lube mix (water + oil) for	— prepare stator lube mix (water +	Water and oil mix is a bio hazard.	Not accepted; bio-hazards are covered under regional regulatory requirements.

Member Body	COMMENTS Comments shall be reproduced as received either by re-typing them, or directly by pasting them on this form					OBSERVATION OF THE SECRETARIAT on each comment submitted
	no	clause	actual text	modification proposed	justification / general remark	
GERMANY		10[th] indent	easier installation	soap or other suitable/friendly mixture) for easier installation		
	10.	7.3.1	vvv is the flow rate in m^3/d at 500 rpm;	vvv is the flow rate in m^3/d at 100 rpm;	This is a specific value only. More simple for calculation is at 100 rpm.	Not accepted; 500 rpm was agreed by the TG.
	11.	7.3.1	hh is the maximum ... in MPa;		more common is "bar". Or explain in addition: 1 Mpa = 10 bar = 142,3 PSI	Not accepted; ISO uses SI units.
	12.	7.3.2	vvv is the flow rate in m^3/d at 500 rpm;	vvv is the flow rate in m^3/d at 100 rpm;	This is a specific value only. More simple for calculation is at 100 rpm.	Not accepted; see #10.
	13.	Annex A, diagram	Curve "0"		better: geometrical (or calculated or theoretical) displacement	Not accepted; unclear what is meant.
	14.	Annex D, NOTE at the beginning	The following definitions ... International Standard.	The following definitions ... International Standard (also see figure D.1 and D.2).		Accepted
	15.	D.19	...	add: — visco brake		Not accepted; cover by hydraulic brake.
	16.	...	...	add: D.20 Pup joint		Not accepted; common component in tubing string.
	17.	E.1, 2[nd] indent	— a rotation in the opposite direction ..... rotor head rotates.	— an orbital movement in the opposite direction..... rotor head moves.		Not accepted; current description is more clear.
	18.	E.2, 3[rd] sentence	..... and the resulting friction must be	..... and the resulting friction and keading action of the rotor on the stator must be		Accepted in principle; modified text.
	19.	E.3	At zero differential pressure across the PCP, the flow per revolution is the displacement, V, and can be	The geometrical (or theoretical or calculated) displacement, V_c, can be calculated		Accepted in principle; modified text
	20.	E.3	$V = 4 E dr P_s$	$V_c = 4 E dr P_s$		Accepted
	21.	E.3	At zero differential pressure across the PCP, the calculated flow rate, Qc, is directly proportional to the displacement and	The geometrical flow rate, Q_c, is directly proportional to the geometrical displacement and		Not accepted; Consistency of terms-see 19.
	22.	E.3	Therefore: $Q_c = V \times N$	Therefore: $Q_c = Vc \times N$		Accepted.
	23.	E.4	The actual flow rate, Q_a, at any head other than zero, is a function of the calculated flow rate minus the slippage	The actual flow rate, Q_a, is a function of the geometrical flow rate minus the slippage		Not accepted; see 21.

Member Body	COMMENTS Comments shall be reproduced as received either by re-typing them, or directly by pasting them on this form	OBSERVATION OF THE SECRETARIAT on each comment submitted
GERMANY		

no	clause	actual text	modification proposed	justification / general remark	OBSERVATION OF THE SECRETARIAT
24.	E.5	...(Mpa)		see German comment on 7.3.1	Not accepted; see 11.
25.	E.6	$\Gamma_h = k \times Q \times \Delta P/N$ where: Q in m³/d,	$\Gamma_h = k \times Q_c \times \Delta P/N$ where: Q_c in m³/d,		Accepted.
26	Figure E.1	LEGEND	letters not legible;		Accepted.
27	Figure E.2	pump assembly stator rotor	add measure of "E" add measure of "ds" position of the "centre line" to be in the centre of the rotor		Not accepted-redundant. Accepted. Accepted
28.	F.1, 7th para, 3rd indent	— providing a uniform flow rate, without any pulsation or jerk;	— providing a uniform flow rate, with low pulsation or jerk;		Accepted in principle; modified text.
29.	F.1, 8th para, 4th sentence	The first cavity expands.	The first cavity exhausts.		Accepted in principle; used "discharges".

Member Body	COMMENTS	OBSERVATION OF THE SECRETARIAT
	Foreword — The last part beginning with "ISO 15136 consists ..." fits better into the introduction and is partially repeated there.	Accepted in principle; remove from introduction.
	Clause 3.2 — delete, since the definition is repeated in Annex E (E.1.1.2), where it is used.	Accepted in principle; modified text of Annex E.
	Clause 3.11 — The definition is not clearly understandable. The number of the figure in the note is wrong. Definition is partially repeated in Annex E.1.2	Accepted in principle; modified text & added definition of "seal line".
	Clause 3.14 — delete "or tag bar, or landing nipple is" at the beginning of the definition and add "landing nipple" to the examples in the second part of the sentence, if necessary.	Accepted in principle; modified definition.

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GERMANY	Clause 4	add "PCP" to the abbreviations or insert it into the title of the document just behind "Progressing cavity pump (PCP)".	Accepted.
	Clause 6.1	6.1 only indirectly responds to the functional specification (Clause 5) via the informative annex C.	Noted.
	Clause 6.1.1	Replace the number by 6.2 and change the following subclause numbers accordingly.	Accepted. Accepted in principle; modified text.
		At the end of the paragraph delete the reference to figure D. Neither D1 nor D2 is appropriate to show an enlarged tubing section.	
	Clause 6.4	should be reformated to show the activities which are usually required. The postulated minimum requirements are not clear enough as far as they don't tell anything about the verification activity, which might be a physical test, calculations or ...	Accepted in principle; modified text.
	Clause 6.4.1	replace "RPM" by "rpm"	Accepted.
	Clause 6.4.2	The second paragraph of the note at the end of 6.4.2 should be moved to 7.5 functional tests. .	Accepted in principle; modified 6.4.2, 6.6, and 7.5.
	Clause 6.6	Please check the wording or replace the text by "Each PCP shall be functionally tested in accordance with 7.5 of this International Standard".	Accepted; see comment above.
	Clause 7.2	Replace "The PCP is compatible" by "The PCP shall be compatible" at the beginning.	Accepted.

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GERMANY	Clause 7.3	A product data sheet is missed. 7.3 provides some data but it seems not complete.	Accepted. Added 7.2.2.
	Clause 7.3.1	in the legend for the rotor code delete one "v" and add for vv at "zero discharge pressure".	Accepted.
	Clause 7.3.2	in the legend for the stator code delete one "v" and add for vv at "zero discharge pressure".	Accepted.
	Clause 7.5	add "Each PCP shall be functionally tested" and at the end of the paragraph replace "respectfully" by "respectively".	Accepted.
	Question:	The validation test (6.4) and the functional test (6.6 and 7.5) are identical and each PCP shall be functionally tested. Then, why a validation test is required?	Noted
	Annex A	The table shows an ISO code, which should be the required PCP idendification code (6.4.2). Both are not explained in the document. The document only gives the stator and rotor codes. The last two entries don´t correspond with the performance curve and the code.	Accepted in principle; changed ISO code to rotor code
	Annex B	is conceptually referred to the validation test, but the Information (purchase order, customer) is more related to the functional test. Note 1 shows a requirement to test at different speeds. But there is no guide on this and the form sheet doesn´t consider it. 6.4 only requires to test at 500 rpm.	Noted; Form may be used for Functional and Validation test. Accepted in principle; changed note 1.
	Annex E	delete the note at the top of the annex.	Accepted.
	E 1.1.2	delete the second "dr is", "Dr is" .... At the end replace "NB" by "Note"	Accepted.

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ITALY	**-) General** The title refers to "**Progressive cavity pump systems**". The ISO document refers only to the rod driven PCP system while at least two different systems are available and used in the oilfield: the rod driven PCP and the electric submersible motor driven PCP. It is suggested that any reference to rod used as power transmission to the pump is removed.	Noted; scope excludes intermediate components.
	-) Point 3.5: dynamic level The definition is not clear, It is suggested to change it with the follow: "vertical distance between the estimated producing fluid level and the surface".	Not accepted; description is clear.
	-) Point 3.16: static level The definition is not clear. It is suggested to change it with the follow: "vertical distance between the estimated static fluid level and the surface".	Not accepted; same as above.
	-) Point 3.18: submergence The definition is not complete. It is suggested to modify as follow: "vertical difference between the dynamic fluid level and the PCP setting depth".	Not accepted; same as 3.16.
	-) Point 3.19: tubing conveyed pump The definition is not clear. It is suggested to modify as follow: "pump in which the stator is screwed onto, and becomes a part of, the tubing".	Accepted in principle; modified text.
	-) Chapter 5: Functional specification This chapter contains both functional specification and Reservoir/well data. It is suggested to divide the content in two parts, adding another chapter titled "Reservoir and well data". The information listed in "Reservoir and well data" should be divided in two groups, "necessary data" and "additional data", because some data could be not available like Ph, oil/emulsion viscosity, etc.; furthermore selection of material shall be responsibility of manufacturer (see rotor/elastomer material), according to others ISO documents (see ISO 14310 etc.).	Not accepted; WG4 conforms to standard format.
	-) Point 5.1: General It is suggested to conform it with the others ISO documents (16070, 14310 etc.)	Accepted.
	-) Point 6.2.3.1 Thermal effect - Elastomers It is suggested to modify the title as follow: "Thermal effect – **Stator's elastomers**"	Not accepted; does not add clarity.

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ITALY	-) **Point 6.2.3.1 Chemical effect - Elastomers** It is suggested to modify the title as follow: "Chemical effect – **Stator's elastomer**"	Not accepted; makes it restrictive.
	-) **Point 6.4.2: Test procedure** 6^{th} line: "Record flowrate, pressure, power, torque, etc.." It is suggested to modify as follow: Record flowrate, **intake and discharge** pressure, power, torque, etc.."	Accepted in principle; rephrased
	8^{th} line: "The acceptance criteria shall be that the PCP flow rate and torque shall be ..." It is suggested to modify as follow: "The acceptance criteria shall be that the PCP flow rate, **head and** torque shall be ...".	Not accepted; accurate as written.
	Annexe C, page 15	
	4^{th} line: "PERFORATION DEPTH" It is suggested to modify as follow: PRODUCING LEVEL REFERENCE DEPTH (Measured = ...; Vertical = ...)	Accepted in principle; modified form
	5^{th} line: "PUMP SETTING DEPTH (MEASURED DEPTH)" It is suggested to modify as follow: "PUMP SETTING DEPTH (Measured = ... ; Vertical = ...)"	Same as above.
	6th line: "TOTAL TUBING LENGTH (MEASURED DEPTH)" It is suggested to modify as follow: TOTAL TUBING LENGTH (Measured = ... ; Vertical = ...)	Same as above.

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NETHERLANDS	General: A useful document that will hopefully increase the usage of this type of equipment. Technical comments: - Foreword " Insert new standard fourth paragraph: "Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights."	Accepted; will be added by ISO.
	Considering the first reference of the Bibliography, the NNI assumes that ISO/TC67/SC4 have fulfilled the requirements of ISO/IEC Directives Part 2 Annex A. Have the necessary formal statements been obtained (if required) and are they available for ISO/CS. If such statements are not required then suggest that the first bibliographic reference is deleted.	Not accepted; useful information.
	- Introduction In order to make clearer how a Moineau pump works suggest a revised wording of the second paragraph of the Introduction as follows. "A progressive cavity pump comprises two helical gears, one rotating inside the other. The external helical gear (stator) has one more thread (or tooth) than the internal helical gear (rotor). Whatever the number of threads of the two elements, they must always differ by one. The fluid moves from suction to discharge. The discharge and the suction are always isolated from each other by a constant length seal line. The principle was developed by Mr Rene Moineau." Note: Remove word essentially. Rephrase second and third sentences and delete the final sentence (which is covered by the scope and clause 3). Add final sentence to replace final phrase of the first paragraph of the scope. The same change should be applied in the first paragraph of F.1.	Accepted in principle; modified text.

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NETHERLANDS	- 4, Lr, "number of lobes" should be "number of rotor lobes".	Accepted.
	- As from 6.2.3.1 "elastomers" come into the picture. It is nowhere explained where elastomers are applied in a PCP. As a coating on the rotor, stator or both ? Or otherwise ? Clarification needed.	Accepted in principle; modified stator definition.
	- 6.4.1, 6.4.2, 6.4.2.2, 7.3.1, 7.3.2, Annex A, Annex B, E.6, "RPM" or "rpm" should, according to ISO 31, be "r/min".	Accepted.
	- 6.4.2, Annex A and Annex B refer to "ISO code". This is nowhere explained. What is meant?. Replace by "ISO 15136-1"?	Accepted; changed to rotor code.
	- 7.1 first sentence, "relate to this International Standard" should be "relate to equipment to this part of ISO 15136.". i.e. also add "equipment to".	Not accepted; no value.
	- 7.2, "is compatible" and "is achieved" should be "shall be compatible" and "shall be achieved", respectively.	Accepted in principle; modified text.
	- 7.3.1 and 7.3.2, in the code there are two v's, in the explanation three v's. Why different ?	Accepted; previously corrected
	- Annex B: in "key" the unit V is listed. V does not appear in the table. Should it be in ?	Accepted; removed from Annex.
	- E.1.1.2 last sentence, insert "minor" before "diameters".	Accepted
	- E.4, Qs is called "leak rate". The first sentence suggests that Qs is also "slippage". What is right?	Accepted in principle; modified text
	- E.7 second hyphenated item, what is meant with "cross the perforations" ? Should "cross" be "blank off" or "block" ?	Accepted in principle; modified text.
	- Figure E.1, the legend lists Dr. Where is Dr in the figure ?	Accepted in principle; revised legend.
	- Figure E.3, is the figure ROTOR complete/correct ? It looks too simple (which may be good!).	Noted; "yes".
	- F.2 "Theory of design" attempts to explain the theory but especially the second and third para make for hard reading. In the third para it is especially difficult to make sense of the second half of the second sentence ("any diameter D which...."). Suggest to rephrase second and third para for more clarity.	Noted.

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NETHERLANDS	Normative references:	
	- End of first sentence of introductory paragraph: "this International Standard" should read "this part of ISO 15136."	Not accepted; Part 1 is a standard.
	- No references found in text to the three ISOs listed. Either insert reference at appropriate place in text, or delete (in which case clause 2 is deleted) or place in Bibliography.	Noted.
	Cross-references:	
	- 3.11 refers to Figure 3A, should be to Figures E.1 and E.2.	Accepted; previously incorporated.
	- 6.1 last sentence refers to "annex D, Figure D". For clarity suggest to change to "see pup joint in Annex D, Figure D.2".	Accepted.
	Editorial comments:	
	- Table of Contents: Delete subclause titles of annexes D.1, D.2 etc.	Accepted. ISO template
	- Foreword * fourth para, insert "was" before "prepared"; place titles of TC 67 and SC4 in italics. * penultimate line, "an integral" should be "a normative"; insert "part of" before "ISO 15136". * last line, delete "provided".	Accepted.
	- Introduction: Delete first and third paragraphs. They are both covered by the standard text in the Foreword.	Accepted in principle; 1st par not accepted.
	- Scope: Delete final phrase of first paragraph and move to introduction.	Not accepted; intentionally here.
	- Scope: Replace first paragraph by: This part of ISO 15136 gives requirements and recommendations for the design, materials, fabrication, inspection, testing and preparation for shipment for subsurface progressing cavity pumps (PCP) used in the petroleum and natural gas industry for the production of single and multiphase fluids."	Not accepted; Scope is considered adequate.
	- Replace final sentence of second paragraph by: "Definitions of the accessories, basic engineering methodology and description of the PCP system, including illustrations, are provided in Annexes D, E and F."	Accepted in principle; placed in introduction.
	- Terms and definitions: It is not clear why some terms are in both clause 3 and annex D. (Example Drive string). Suggest only have each one once, I.e if defined in clause 3 delete from Annex D.	Not accepted; Annex D is not intended to define terms.
	- Terms and definitions: Replace in first sentence International Standard by "this part of ISO 15136". (ISO/CS may change the references to the illustration to a Note throughout this clause). - For consistency, throughout text ensure that "flowrate", "flowline" and "bottomhole" are spelled as one word.	Accepted.

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NETHERLANDS	- 3.9, "pump in which" should be "pump of which". - 3.10, insert space after "(3.13)".	Accepted.
	- 3.12 Insert Progressing Cavity Pump as new line between 3.12 and PCP (Reason: this is where you define PCP).	Not accepted; dealt with in 5.2.
	- 3.14, Insert new lines (bold) tag bar and landing nipple under rotor stop. These are equivalent terms ?. Then remove words "is a". Replace: "consisting in" by "consisting of". - 3.19, place hyphen in "tubing-conveyed" (also in 5.2); "in which" should be "of which"; "at" should be "onto". Final note in clause 3: Should be deleted. It is covered by initial sentence in clause 3. - 5.7 and 6.4.2 NOTE, "customer" should be "purchaser". - 6.1 contains a hanging paragraph; suggest to delete "6.1.1 PCP characteristics" (only this subclause number and title). - 6.1 last para, "sufficient" should be "sufficiently large". - 6.2.1 last item, place hyphen in "back-pressure".	Accepted.
	- 6.2.3.3, second para, Replace sentence by "Manufacturers may keep their formulations confidential".	Not accepted; existing phrasing preferred.
	- 6.2.3.8, end of first sentence, insert "the" before "pump". - 6.3, at end of second item should be a semicolon (;). - 6.4.1, third hyphenated item, insert "the" before "PCP"; last hyphenated item, delete hyphen and change "for" to "to". 6.4.1: First, fourth, fifth and sixth sentences, replace "is" by "shall be". Second sentence replace "are" by "shall be". (Reason: Correct verbal term). - 6.4.2 contains a hanging clause. Insert new heading under 6.4.2 titled 6.4.2.1 General. Renumber existing 6.4.2.1 and 6.4.2.2 as 6.4.2.2 and 6.4.2.3. - 6.4.2 first para, third sentence, "system, flows" should be "system and flows"; fifth sentence, place hyphen in pressure-measurement". Fourth para, insert "a performance" before "curve". Three-but-last hyphenated item, place hyphen in "no-load".	Accepted.

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NETHERLANDS	- 6.4.2 final sentence of current hanging paragraph note. Replace "will apply" by "applies". - 6.4.2.2, "manufacturer" should be "manufacturer's". - 6.6, "to 6.4.2" should be "in accordance with 6.4.2"; at end, "respectfully" should be " , respectively" (also at end of 7.5). - 7.1 third sentence, insert "a" before "suitable". - 7.2, end of first para, "details" should be "detail"; fourth hyphenated item, place hyphens in "start-up/shut-down". - 7.3.1, "Mpa" should be "MPa". - 7.4, "includes" should be "include". - In titles of all annexes, "Annexe" should be "Annex". - Annex A, "Kw" should be "kW". - Annex B, definition of delta p, replace hyphen before "intake" with "minus". - Annex B, Annex E and Annex F symbols should be italicized (but not their subscripts). Use consistent bracket form for units. - Annex C Use correct units i.e. "m" for "meters". "superscript small o" for degrees in "degrees C".	Accepted.
	- Annex D, Replace text of Note at start of annex to : "The terms described in this annex are provided, for information only, to provide common terminology for the accessories to the PCP. See also Figure D.1 and Figure D.2". (Reason: to link with text in Scope). Note that it is probably necessary to replace the Note by a new "D.1 General" with above new text, otherwise the note is part of a Hanging paragraph which is not allowed by ISO/CS.	Accept in principle; removed note
	- D.2, place hyphen in "wear-reducing". - D.8 title, place hyphen in "Variable-speed". - D.12, "operation" should be "operating".	Accepted.
	- D.13 Insert "standard or specification agreed between user and supplier" before "local government codes and regulations". Note regulations not laws.	Accepted
	- D.15, insert "the" before "drivehead". - D.16, D.17, D.18 titles, place hyphens in "Lock-out", "Solid-shaft" and "Hollow-shaft", respectively.	Accepted.
	- Figures D.1 and D.2, lettering of legends needs to be in accordance with ISO/CS requirements. i.e. in numbered legend not in main figure.	Noted
	- Annex E, Delete Note at start of annex. This annex contains more than just definitions. The remaining headings are self explanatory. If not numbering will need changing similar to comments on Annex D.	Accepted.

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NETHERLANDS	- E.1.2, first word "It" should be "This term". - E.1.3, place period at end of first sentence. Same with E.5. - E.7, start of first sentence, change to "Free gas occupies....". Third sentence, suggest to change "considerations" to "attempts". End of third sentence, "enters in the PCP" should read "enters the PCP". - E.7 second paragraph, "Even with these considerations," should read "Even when applying above measures,". - Figure E.1, legend is printed too small, barely legible. - F.1 third and fourth para and Figure F.1, place hyphen in "cross-section". Sixth para, delete brackets before and after "closed cavities". - F.2, "which" should be "whose" (5 instances, in paragraphs 2, 3, 4 and 5). Third para, "verteces" should be "vertices". Fifth para, delete << and >> signs before and after "closed cavities". Seventh para, "constitute" should be "constitutes". - Figure F.2: Envelopes . Not Envelops. - Bibliography. Second reference: Not clear why this reference is included (not referenced in text), nor what its full bibliographic details are. i.e. from where can it be obtained?. (The name of the author is recognizable!).	Accepted.

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UK	5	6.2.1	The head rating needs to be further qualified in terms of the fluid and temperature, eg metres of water at 20 deg C. Otherwise different pressures can be applied to the pump for the same head rating.	Not accepted; see definitions 3.7, E.5, and text of 6.2.1.
	9	6.4.1	Amend the beginning of the first sentence to read 'The following test shall be conducted with water at a rotor speed of 500 rpm....'	Accepted.
	9	6.4.2	In the first paragraph it is essential that the inlet pressure is also measured.	Accepted.
	9	6.4.2	Amend the beginning of the second paragraph to read 'Record pump shaft speed, flowrate, inlet pressure, outlet pressure (hence calculate differential pressure), power,(is this pump shaft power or electric motor input power-what about motor & drive line losses?) torque (define- motor torque or pump shaft torque?).....'	Accepted.
	9	6.4.2	This sentence appears to be out of place here and is virtually repeated later in section 6.4.2.2. Incorporate in 6.4.2.2.	Accepted.
	10	6.4.2	In the test procedure guidelines 'turn circulation pump on and bring the test fluid up to the test temperature' clarify what the temperature is and the limits or operating range allowed (eg 20-30 deg C).	Not accepted; clarified in note.
	10	6.4.2.1	Clarify whether the 'input power' is electric motor shaft power input, or pump shaft input power. Give consideration to potential drive losses between motor and pump.	Not accepted; see note in 6.4.2. Accepted in principle; modified text
	11-12	7.3.2	The description is head, but the SI units quoted: - MPa - are for pressure. Incompatible description and units of measurement - the units/description are inconsistent.	Not accepted; see 6.2.1 response.
	13	Annex A Table/Graph	The units for 'Head rating' are those for pressure (MPa), see comment on 7.3.2.	Not accepted; see 6.2.1 response.
	14	Annex B	'torque' needs to be defined - pump shaft torque? 'power' needs to be defined - pump shaft power or electric motor input power? (motor losses, transmission losses?)	Accepted on torque. Not accepted on power; this std is on pumps only.
	23	E.5	See comments on 7.3.2 and Annex A regarding expressing head rating in terms of pressure.	Not accepted; see 6.2.1 response.

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USA	The Progressive Cavity Pump (PCP) standard as written is inaccurate with regards to how power is supplied. The weakness with this standard is that it does not address the current industry capability of providing power to the PCP assembly using an electric submersible pump (ESP) motor. Reference is made to Section D – Accessories where it is implied that the only source of power for a PCP pump is using rods and some form of surface drive unit. It is our recommendation that Section D be modified to include the ESP power option. The balance of the standard regarding the pump itself is satisfactory.	Not accepted; 15136-1 deals with pump only, not the pump drive.