BRITISH STANDARD

BS EN
50216-7:2002

Power transformer and reactor fittings —

Part 7: Electric pumps for transformer oil

The European Standard EN 50216-7:2002 has the status of a British Standard

ICS 29.180

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 50216-7:2002.

The UK participation in its preparation was entrusted to Technical Committee PEL/14, Power transformers, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 20, an inside back cover and a back cover.

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English version

Power transformer and reactor fittings
Part 7: Electric pumps for transformer oil

Accessoires pour transformateurs
de puissance et bobines d'inductance
Partie 7: Pompes électriques
pour transformateur immergé

Zubehör für Transformatoren
und Drosselspulen
Teil 7: Elektrische Pumpen
für Transformatorenöl

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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 14, Power transformers.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50216-7 on 2001-07-01.

The following dates were fixed:

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- latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2004-08-01

EN 50216-7 is to be read in conjunction with EN 50216-1.

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1 Scope

EN 50216-7 covers requirements for electric pumps which generate the circulation of insulating oil in transformers and reactors conforming to the EN 60076 series and their associated cooling systems.

The pumps covered in this standard are rotodynamic pumps driven by a squirrel cage induction motor which is immersed in the insulating oil.

Pump sets conforming to this standard may be of in-line or end suction design.

This standard includes requirements for the electrical and hydraulic performance, mechanical design, routine testing and type testing. Additionally, performance and dimensions of preferred sizes of pump sets are specified (see normative annexes A and B).

The insulating oils considered comply with subclause 2.5 of IEC 60296-1. If other insulating liquids are to be used, the performance and design of the pump shall be agreed between purchaser and manufacturer.

2 Normative references

Addition to EN 50216-1:

EN 809	1998	Pumps and pump units for liquids - Common safety requirements
EN 60034-1	1998	Rotating electrical machines - Part 1: Rating and performance (IEC 60034-1:1996, mod)
EN 60034-9	1997	Rotating electrical machines - Part 9: Noise limits (IEC 60034-9:1997)
EN 60076	Series	Power transformers (IEC 60076 series, mod)
EN 60076-1	1997	Power transformers - Part 1: General (IEC 60076-1:1993, mod)
HD 53.8 S5	1998	Rotating electrical machines - Part 8: Terminal markings and direction of rotation of rotating machines (IEC 60034-8:1972 + A1:1990 + A2:1996)
HD 566 S1	1990	Thermal evaluation and classification of electrical insulation (IEC 60085:1984)
IEC 60279	1969	Measurement of the winding resistance of an a.c. machine during operation at alternating voltage
ISO 179	1993	Determination of Charpy impact strength
ISO 185	1988	Grey cast iron - Classification
ISO 281	1990	Rolling bearings - Dynamic load ratings and rating life
ISO 3522	1984	Cast aluminium alloys - Chemical composition and mechanical properties

ISO 4406	1989	Hydraulic fluid power - Fluids - Methods for coding level of contamination by solid particles
ISO 7005-2	1988	Metallic flanges - Part 2: Cast iron flanges
ISO 9906	1999	Rotodynamic pumps - Hydraulic performance acceptance tests - Grades 1 and 2

3 Definitions

For the purpose of this standard, the following definitions apply:

3.1
in-line pump
a pump having the suction and delivery flanges on the same axis. It can be of the centrifugal or helicoidal type. For transformer oil pumps, the axis of the flanges generally corresponds to the axis of rotation of the pump rotor

3.2
end suction pump
a pump having the suction and delivery flanges on perpendicular axes. It can be of the centrifugal type only. The axis of the suction flange corresponds to the axis of rotation of the pump rotor.

4 Design

4.1 General

The requirements of EN 50216-1, including maximum oil temperature [115 °C], shall apply to equipment covered by this standard. Minimum oil temperature shall be in accordance with EN 60076-1 [-25 °C].

All pumps shall conform to the essential health and safety requirements in accordance with EN 809.

Motor cooling and bearing lubrication shall be by circulation of the oil being pumped. Where rolling element bearings are used, they shall be of standard design with life in accordance with ISO 281 exceeding 200 000 hours at rated conditions. The expected life of the pump without bearing change shall not restrict the expected life of the transformer under normal service conditions.

Pumps shall be suitable for mounting with the axis of the rotating unit either horizontal or vertical. If other positions are to be used, this shall be made known to the manufacturer.

A mechanical or electrical device shall be fitted, unless otherwise agreed by the purchaser, to allow the direction of rotation to be determined. Reverse rotation shall not cause damage to the pump.

All enclosures for electric pumps shall be manufactured to give, as a minimum, protection in accordance with IP 54 of EN 60529.

For pumps used for combined OFF/ON cooling (e.g. with rated pressure of 50 kPa or less), the design of the pump and its impeller shall be such as to minimize the restriction to oil flow with the pump switched off.

To ensure that there is no contamination of transformer oil, pump sets shall be clean and free of foreign bodies.

4.2 Casing/enclosure

Casings/enclosures shall be capable of withstanding a maximum working pressure of 300 kPa under operating conditions without leakage.

Suction and delivery flanges shall conform to PN10 of ISO 7005-2 for end suction pumps and PN6 or PN10 for in-line pumps. These flanges shall generally be suitable to support the pump in normal operation. Where the pump design is such that additional supports are required, e.g. for high power end suction pumps, this shall be made known by the manufacturer.

NOTE It is the responsibility of the transformer/cooling circuit designer to ensure that the pump is correctly supported.

Drain and vent connections shall be provided suitable for the installation positions allowed.

If required by the purchaser, internal surfaces of cast iron shall be finished with an oil resisting protective system.

4.3 Terminal box

Metallic terminal boxes shall have an evacuation hole for condensation.

The manufacturer shall specify the allowable terminal box and cable entry positions. It is preferred that the cable entry may be repositioned without draining oil from the pump.

The mounting support of the gland shall allow entry of cables in an upward direction for any mounting position of the pump. The size of the gland shall be defined by agreement between purchaser and manufacturer.

An earth terminal is to be provided.

A permanent label in accordance with HD 53.8 shall be provided inside the terminal housing cover to show the connections required for correct rotation of the pump.

Stud type terminals shall have a diameter adequate to carry the required current and not less than 6 mm for brass and not less than 4 mm for phosphor bronze or stainless steel.

4.4 Hydraulic performance

Performance curves and nominal ratings for hydraulic performance shall be given for an oil temperature of 60 °C and with the motor being supplied at rated voltage. Performance curves shall define the allowable operating range as specified by the pump manufacturer.

Pumps shall perform free of cavitation under operating conditions.

4.4.1 Hydraulic interchangeability

When replacing one pump with another, it is important that flow velocities in the cooling circuit are not greatly changed. This may be achieved by ensuring that the pump characteristic curves are sufficiently similar.

For the purposes of this standard, hydraulic interchangeability is achieved when, for each point across the allowable operating range, one pump characteristic curve shows flow values within ± 10 % or pressure values within ± 8 % of another curve chosen as a datum (see Figure 1).

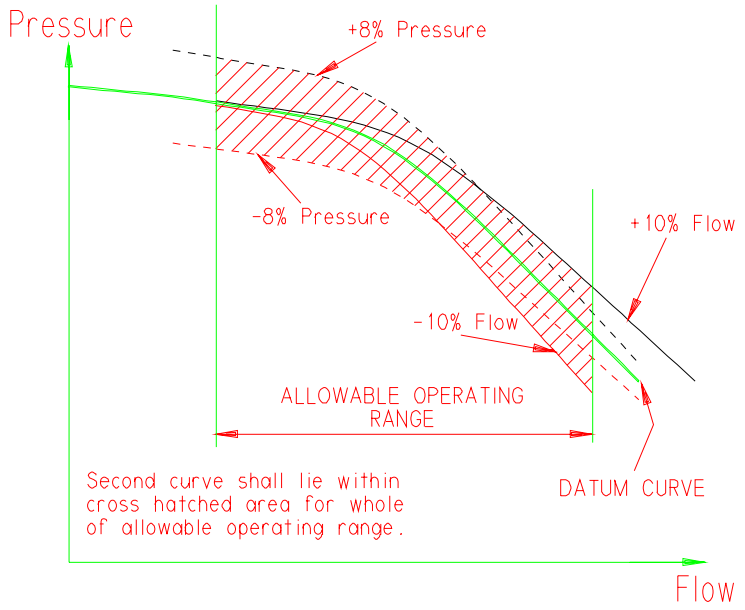


Figure 1 - Hydraulic interchangeability across the allowable operating range

Where, in a specific application, sufficient knowledge of the actual flow range is available, pump characteristic curves may be defined as interchangeable if the above condition is met across the actual flow range (see Figure 2).

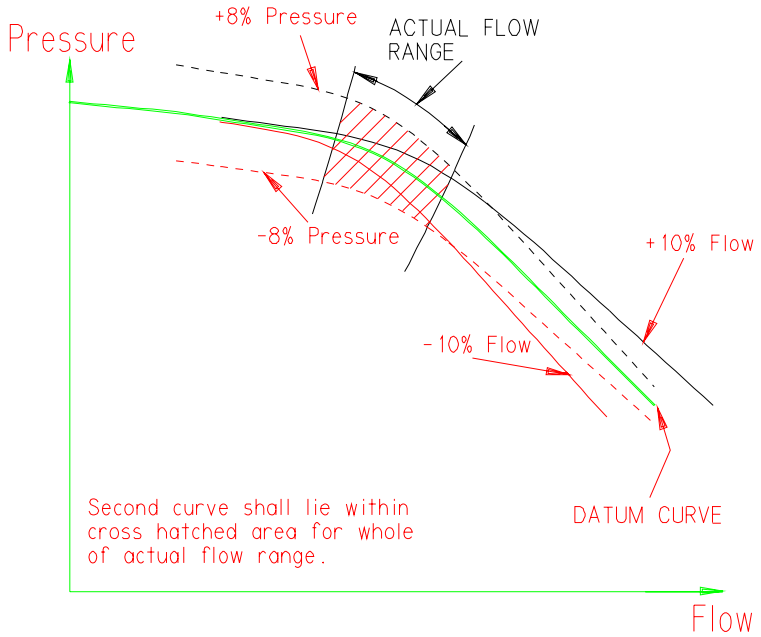


Figure 2 - Hydraulic interchangeability across an actual flow range

Annex D gives examples of the use of these hydraulic interchangeability tolerances.

It should be noted that hydraulic interchangeability does not ensure electrical or mechanical interchangeability and these will require a separate assessment.

4.5 Electrical performance

4.5.1 Electrical supply

Pumps shall be suitable for direct-on-line starting with a supply voltage between 85 % and 110 % of the nominal voltage and within 94 % - 102 % of nominal frequency . Additionally, the pump shall be able to start at 85 % voltage at oil temperatures down to - 20 °C and at 90 % down to - 25 °C without injurious heating.

Motors shall be capable of recovering normal operation in the event of a system disturbance causing temporary loss of supply voltage for a period of up to three seconds followed by a sudden restoration initially to 80 % of the rated voltage.

4.5.2 Insulation class and temperature rise

The stator winding insulation shall conform to HD 566 S1 Class B or F and shall be non-hygroscopic.

The temperature rise of the motor winding when operating in oil at 115 °C shall not exceed the oil temperature by more than 15 K for class B insulation and 40 K for class F.

4.5.3 Starting current

The starting current at rated voltage shall not exceed seven times the rated full load current of the motor subject to the tolerances given in EN 60034-1, as appropriate.

4.6 Noise

Sound power levels shall not exceed the values given in EN 60034-9.

4.7 Labelling

4.7.1 Nameplate

The nameplate shall carry the information as required by EN 60034-1. Additionally, the following shall also be included:

- CE marking (if applicable);
- rated flow (l/s) at 60 °C;
- rated pressure, kPa.

Other data may be added to the nameplate if required by the purchaser.

4.7.2 Direction of oil flow and rotation

The direction of oil flow and the corresponding direction of rotation shall be indicated in distinctive places with a suitable arrow in a permanent form.

5 Materials

The pump casing/enclosure may be manufactured of either cast iron to ISO 185 grade 200 minimum or aluminium alloy to ISO 3522 type Al-Si12. Other suitable materials agreed between the purchaser and manufacturer may also be used.

External bolting shall be corrosion resistant.

Rotating units shall be of all-metal construction to minimise the contribution to the electrostatic charging tendency of the overall system.

The terminal box may be made from a suitable metal or glass reinforced plastic (GRP) having a minimum impact resistance of Charpy: 10 joules/cm^2 in accordance with ISO 179.

6 Preferred sizes

The preferred sizes of pumps given in this standard represent the most usual requirements. Duties and dimensions for these pumps shall comply with the requirements of annex A for end suction pumps and annex B for in-line pumps.

Pumps with other rated duties and / or dimensions may be used by agreement between purchaser and manufacturer. Such pumps shall comply with all other requirements of this standard.

7 Tests

It is essential that all test rigs are kept clean and free of contamination and foreign bodies. Oil used for testing shall be filtered to Level 17-13 of ISO 4406.

7.1 Routine tests

The following tests shall be carried out unless waived by the purchaser:

7.1.1 Winding resistance measurement (cold)

Values of resistance shall be measured and shall be referred to 20 °C.

7.1.2 Direction of rotation

It shall be demonstrated that the direction of rotation is correct when the pump is connected as shown by the label in the terminal box cover.

When fitted, the device indicating correct rotation shall be shown to be clearly operational with the pump running in the correct direction and in reverse.

7.1.3 Hydraulic performance

Each pump shall be tested in accordance with Grade 2 of ISO 9906 except that the test liquid shall be transformer oil at 60 °C as specified in this standard and speed measurements shall not be required. Measurements of flow, pressure, absorbed power and current are to be recorded.

For larger batches of identical pumps, by agreement with the purchaser, a minimum of one in ten pumps may be subjected to a hydraulic performance test provided each pump undergoes the no load and locked rotor tests described in 7.1.4 and 7.1.5.

7.1.4 No load test without oil at rated frequency

Measure the current and losses at rated voltage, U_n.

7.1.5 Locked rotor test

Measure the current and losses at rated voltage, U_n.

7.1.6 Applied voltage test

With the fully assembled pump empty of oil, a dielectric test shall be carried out in accordance with EN 60034-1.

7.1.7 Oil leakage test

The fully assembled pump shall be subjected to a hydrostatic pressure test using transformer oil at 80 °C. The test shall be carried out at a minimum pressure of 500 kPa (gauge) for a period of 3 hours.

Alternatively, if agreed by the purchaser, this test may be carried out using transformer oil at 60 °C at a minimum pressure of 500 kPa for a period of 24 hours.

7.1.8 Mechanical integrity

The pump shall be checked for free running of the rotating unit when turned by hand. When the pump is running, a check shall be made for any unusual noise.

The manufacturer shall indicate the method of test used to ensure integrity of impeller fastening. This test shall, in particular, demonstrate that no movement of the impeller relative to the shaft will occur if the pump is accidentally started in reverse rotation.

7.2 Type tests

7.2.1 Winding resistance measurement (cold)

As 7.1.1.

7.2.2 Direction of rotation

As 7.1.2.

7.2.3 Hydraulic performance test

As 7.1.3 except that cos φ, speed and efficiency shall also be measured. A minimum of six test points shall be taken covering the flow range from zero flow to maximum flow.

Test to be repeated at minimum voltage.

7.2.4 No load test without oil at rated frequency

Measure the current and losses at U_n, $U_n/2$, U_n – 10 %, U_n +10 %, U_n - 20 %, U_n + 20 %.

7.2.5 Locked rotor test

Measure the current and losses at U_n, $U_n/2$, U_n - 20 %, U_n + 20 %.

7.2.6 Starting current test

If required by the purchaser, the following test shall be carried out. This may be either in addition to or as an alternative to the test described in 7.2.5.

The starting current shall be measured at rated voltage.

7.2.7 Voltage test

As 7.1.6.

7.2.8 Oil leakage test

As 7.1.7.

7.2.9 Temperature rise test

A temperature rise test shall be carried out at nominal voltage for 1 hour. During this test, the flow and pressure shall be adjusted to the nominal values.

This test shall be immediately followed by a 1 hour temperature rise test at U_n - 20 % and a further 1 hour test at U_n + 20 %. During these tests, pressure and flow shall not be adjusted.

The average temperature rise of the stator winding for oil at 60 °C ± 5 K shall be determined by the method of measurement of resistance variation i.e. determination of the temperature rise of the winding from the resistance increase according to EN 60034-1 and IEC 60279.

The temperature rise shall not exceed 15 K for class B insulation or 40 K for class F insulation according to HD 566.

7.2.10 Mechanical integrity

In addition to the tests detailed in 7.1.8, the pumps shall be run at 125 % of nominal speed without oil for two minutes in accordance with EN 60034-1, clause 21.

7.2.11 Cold start test

The pump shall be started at minimum voltage with the oil at minimum temperature. The pump shall reach full running speed without overheating or any other adverse observations.

A full hydraulic test loop is not required but arrangements shall be made (orifice plates etc.) to simulate the system resistance corresponding to the nominal duty.

If required by the purchaser, means shall be provided (e.g. thermocouples) to monitor the winding temperature.

Current, rotational speed, inlet oil temperature, outlet oil temperature and, if applicable, winding temperature, shall be continuously recorded until the pump is running at nominal speed.

7.2.12 Noise test

Sound power level is to be determined by testing in accordance with EN 60034-9.

7.3 Special tests

Additional tests may be agreed between purchaser and manufacturer.

8 Preparation for despatch

8.1 Painting

All external surfaces shall be protected by an oil resistant, anti-corrosion paint system, the details of which shall be specified in the enquiry and/or order documents.

The finish coat will not generally be applied by the manufacturer.

8.2 Preparation for transport and storage

It shall be ensured that pumps are clean and free of all foreign matter and contamination.

Covers shall be provided and securely attached to the pump flanges during transport and/or storage and steps taken to ensure that there is no deterioration caused by condensation.

Annex A
(normative)

Preferred sizes of end-suction pumps

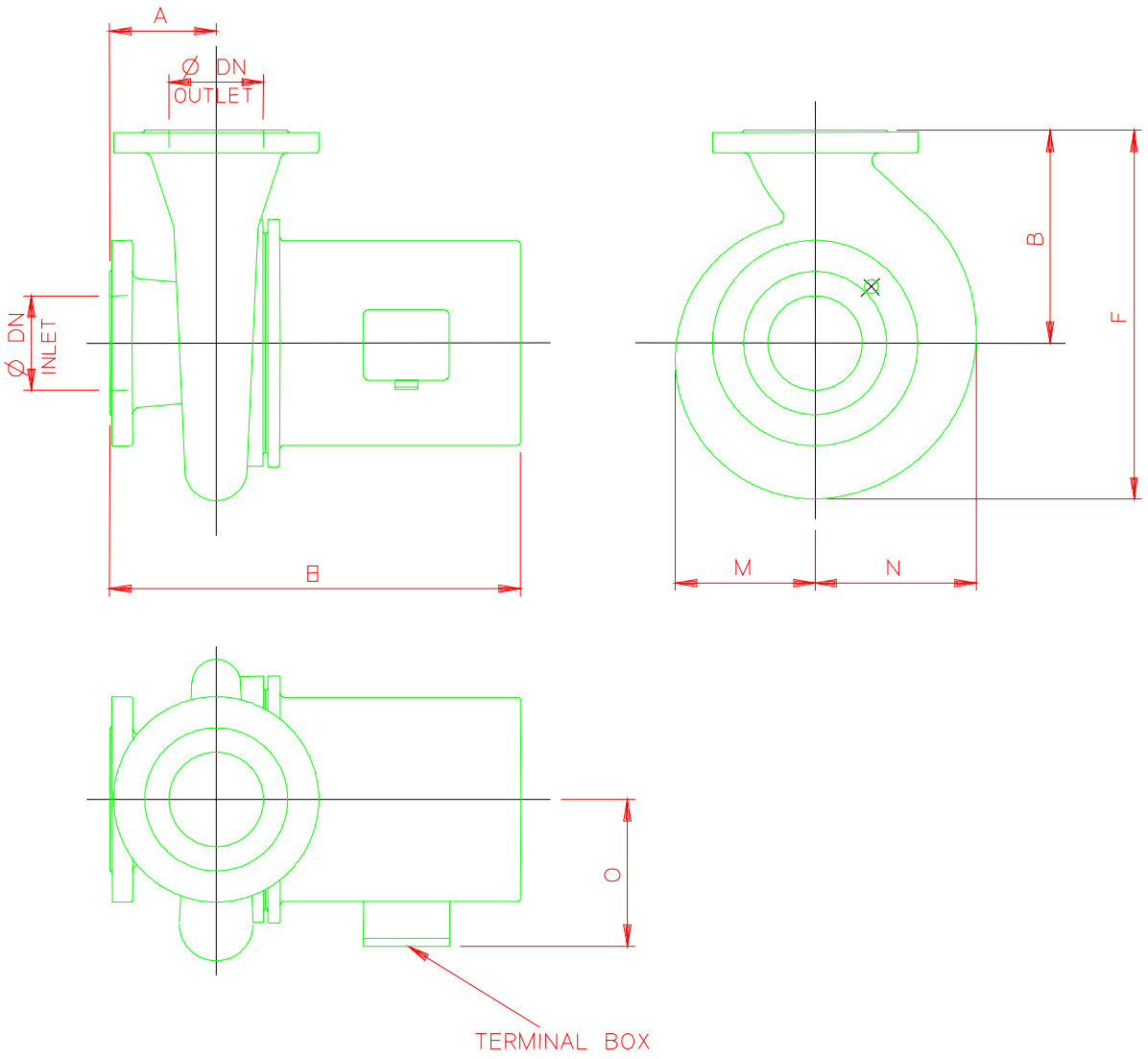


Table A.1 - Dimensions of preferred sizes of end-suction pumps (mm)

Ø D_n	A ± 1	B ± 1	E max.	F max.	M max.	N max.	O max.
65	85	160	452	265	100	100	190
100	125	220	530	400	170	170	200
125	140	280	560	475	210	210	224
150	140	300	710	500	224	224	250
175	160	315	710	500	265	265	265

Table A.2 - Nominal performance data for 50 Hz operation at 60 °C

Size designation		Nominal rating		Maximum full load current	
D_n	Type	Flow m^3/h	Pressure bar	at 230 V - 15 % A	at 400 V - 15 % A
65	A	25	0,5	8	4,6
65	B	35	0,68	10	5,5
100	A	40	1,1	19	11
100	B	70	0,8	19	11
125	A	125	0,88	33	19
125	B	150	0,3	33	19
125	C	150	0,4	33	19
125	D	150	0,5	33	19
125	E	180	0,25	33	19
150	A	90	1,1	48	26
150	B	150	0,9	48	26
175	A	215	0,55	53	30
175	B	225	0,9	75	43
175	C	240	1,1	100	57
175	D	250	0,63	53	30
175	E	250	1,3	100	57

Annex B
(normative)

Preferred sizes of in-line pumps

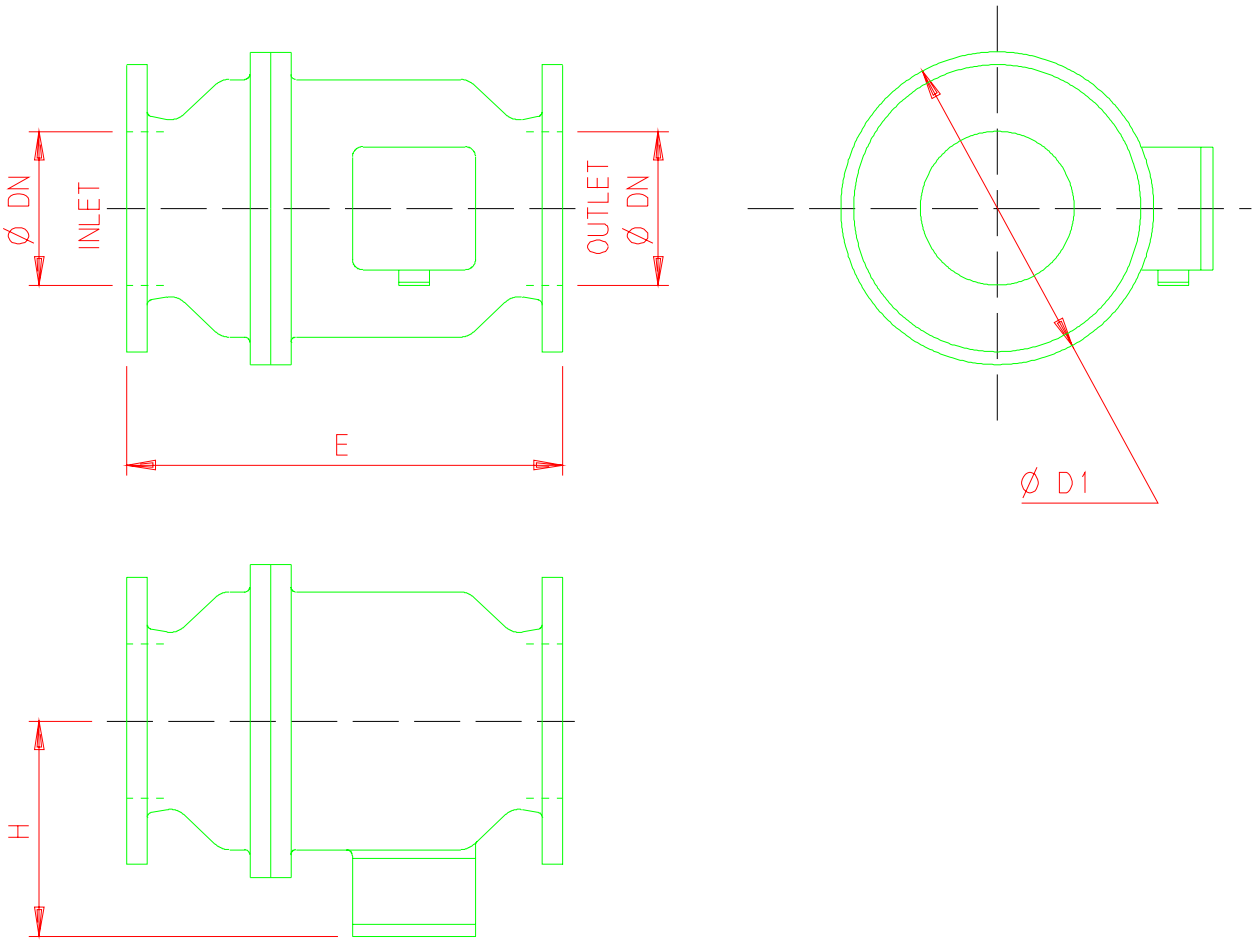


Table B.1 - Dimensions of preferred sizes of in-line pumps (mm)

Ø D_n	D1 max.	E max.	H max.
65	303	510	215
80	303	510	215
100	323	554	225
125	375	664	250
150	405	664	275
200	455	774	312
250	410	550	265
300	525	750	370

Table B.2 - Nominal performance data for 50 Hz operation at 60 °C

Size designation		Nominal rating		Maximum full load current	
D_n	Type	Flow m^3/h	Pressure bar	at 230 V -15 % A	at 400 V -15 % A
80 (65)	A	25	0,24	8,5	5
80 (65)	B	25	0,40	10	6
80 (65)	C	25	0,66	12	7
100	A	60	0,54	16	9
100	B	70	0,655	18	10
100	C	80	0,8	25	14
125	A	80	0,8	25	14
125	B	90	0,93	28	16
125	C	110	0,97	35	20
125	D	140	0,87	40	23
125	E	150	0,98	44	25
150	A	90	0,175	N/A	3,5
150	B	150	0,98	44	25
200	A	190	1,125	75	43
200	B	240	1,17	78	45
200	C	250	0,21	N/A	10
200	D	290	0,27	N/A	10
250	A	200	2		
300	A	300	2,2		

Annex C
(informative)

Information required with enquiry, proposal and purchase order

Flow	m^3/h	}
		} for oil at 60 °C
Differential pressure	bar	}

Confirmation of type of liquid pumped
- specific gravity
- viscosity at - 20 °C
- viscosity at 60 °C

Nominal voltage	V
Full load current	A
Frequency	Hz
Connection	Y or Δ

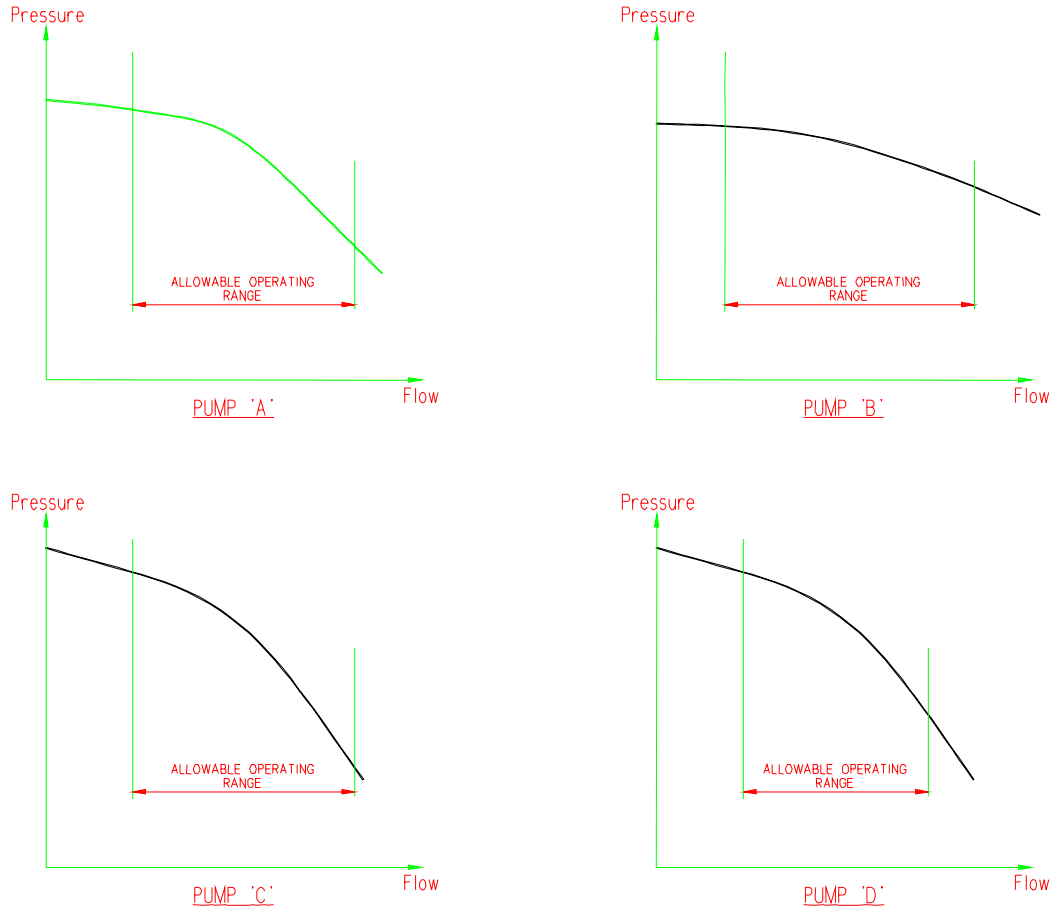
The following list indicates by clause or subclause number where a decision is required by the purchaser or agreement is required between purchaser and manufacturer:

3	in-line or end suction pump required;
4.1	mounting arrangement if other than with the axis of the rotating unit horizontal or vertical;
4.1	inform if a device to determine direction of rotation is not to be fitted;
4.2	flange dimension standard (PN6 or PN10) for in-line pumps;
4.2	finishing of internal surfaces of cast iron;
4.3	size and type of cable gland;
4.8.1	additional nameplate data required;
5	materials of construction if other than those specified in clause 5;
6	if preferred size and/or duty is required and, if so, the size designation;
7.1	confirmation of routine test requirements;
7.1.3	whether 1 in 10 pumps being subject to a hydraulic performance test is agreed;
7.1.7	inform if oil leakage test at 60 °C for 24 hours is agreed;
7.2.6	type testing - inform if a starting current test is to be carried out;
7.2.11	inform if winding temperature is to be monitored;
7.3	special tests;
8.1	external painting requirements.

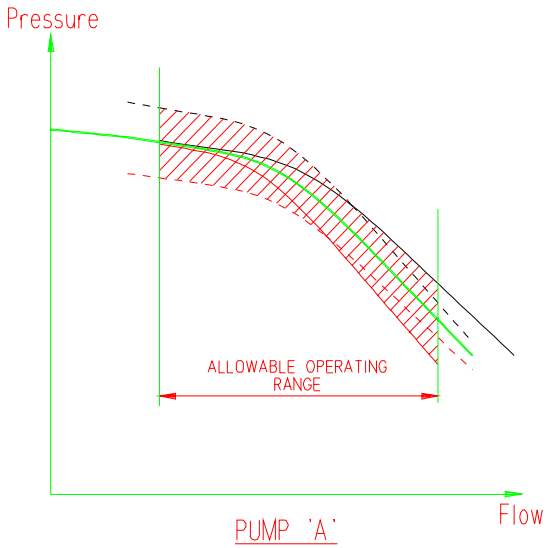
Annex D
(informative)

Example of use of hydraulic interchangeability tolerances

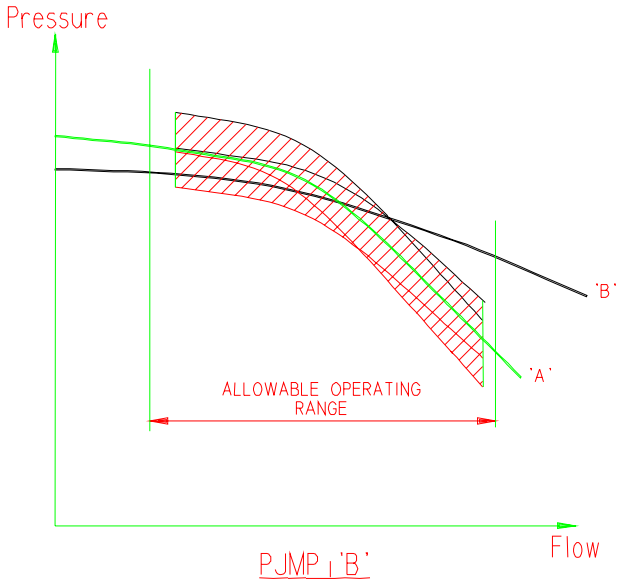
Consider four similar size pumps where it is desired to replace pump A with one of pumps B, C or D. The pressure-flow characteristics of the four pumps are as shown below:



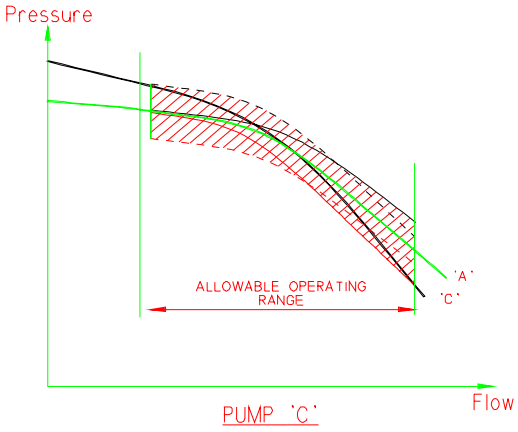
The first step is to apply the tolerances as given in 4.5.1 to pump A.

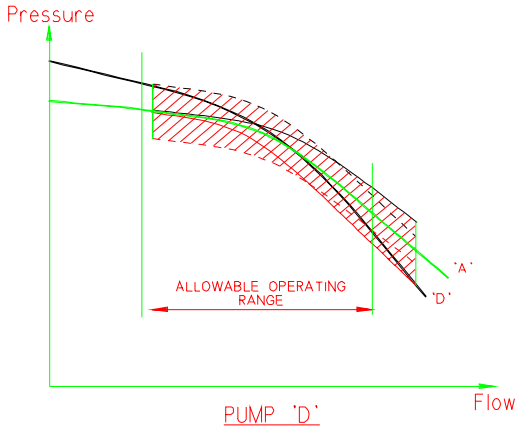


The pressure-flow characteristic of each of the other pumps is then superimposed on the characteristic of pump A and its tolerance band (note that the tolerance band has minimum and maximum flow boundaries equal to those of the allowable operating range of pump A):



Pump B has an allowable operating range greater than pump 'A' but is not hydraulically interchangeable as part of its pressure-flow characteristic lies outside the tolerance band.

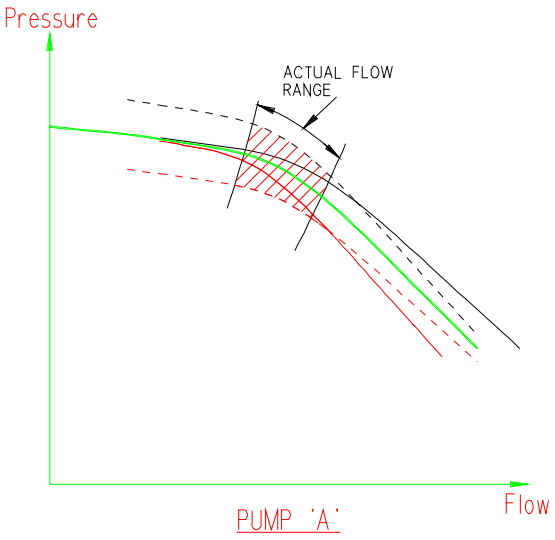


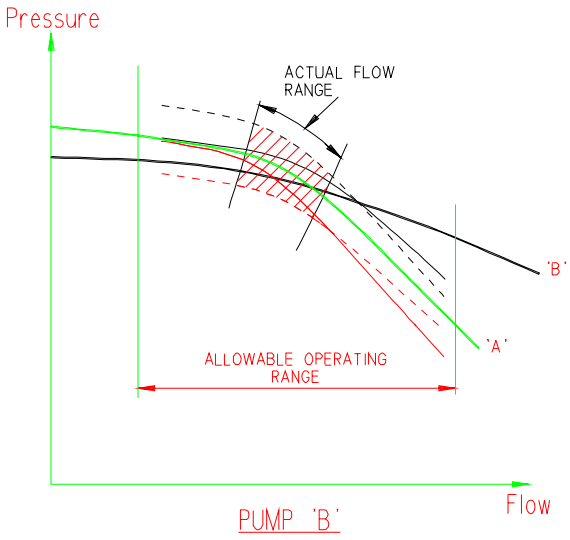


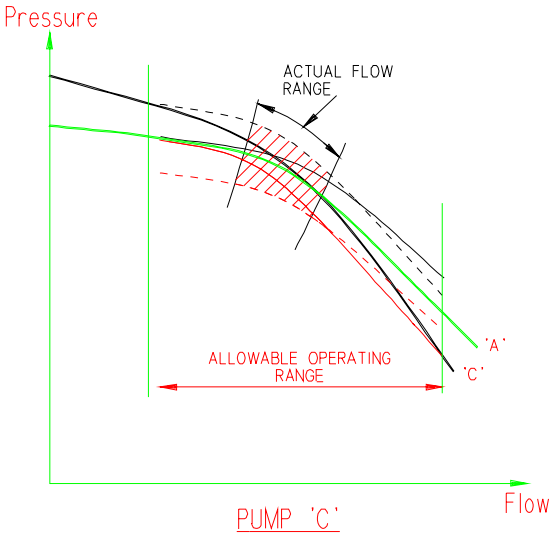
The pressure-flow characteristic of pump 'C' lies within the tolerance band across the flow range and its allowable operating range covers that of pump A. Pump C is deemed to be hydraulically interchangeable with pump A.

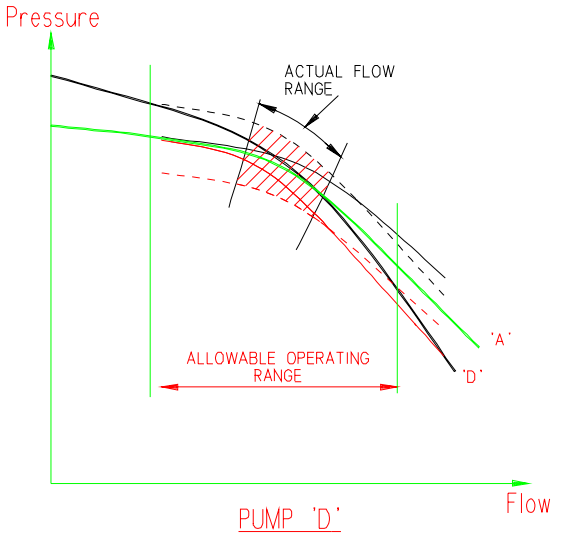
The pressure-flow characteristic of pump 'D' also lies within the tolerance band across the flow range but pump 'D' is not hydraulically interchangeable since its allowable operating range does not cover that of pump A.

If, in a specific application, the actual possible flow range is known to be bounded by the curves as shown below, then the assessment is made only for that range. It can be seen that, in the example, all four pumps would be considered interchangeable (but only for that one specific application).









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