BS ISO 8278:2016

BSI Standards Publication

Aerospace series — Hydraulic, pressure compensated, variable delivery pumps — General requirements

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National foreword

This British Standard is the UK implementation of ISO 8278:2016. It supersedes BS M 65:1987 and BS ISO 12334:2000 which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/69, Aerospace hydraulic systems, fluids and components.

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Aerospace series — Hydraulic, pressure compensated, variable delivery pumps — General requirements

Série aérospatiale — Pompes hydrauliques à débit variable régulé en fonction de la pression — Exigences générales

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Contents

Page

Foreword ... **vi**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **2**

4 General requirements ... **6**
4.1 Order of precedence ... 6
4.2 Hydraulic system characteristics ... 6
4.3 Airworthiness requirements ... 7
4.4 Qualification ... 7

5 Functional requirements ... **7**
5.1 Hydraulic fluid ... 7
5.2 Pump pressure ... 7
5.2.1 Rated discharge pressure ... 7
5.2.2 Maximum full-flow pressure ... 7
5.2.3 Pressure pulsations ... 8
5.2.4 Inlet pressure ... 8
5.3 Case drain pressure ... 8
5.3.1 Rated case drain pressure ... 8
5.3.2 Maximum transient case drain pressure ... 8
5.3.3 Maximum case drain pressure ... 8
5.4 Flows ... 9
5.4.1 Pump rated discharge flow ... 9
5.4.2 Pump case flow ... 9
5.4.3 Shaft seal leakage flow ... 9
5.4.4 External leakage ... 9
5.5 Speed and direction of rotation ... 10
5.5.1 Rated speed ... 10
5.5.2 Overspeed ... 10
5.5.3 Direction of rotation ... 10
5.6 Torque ... 10
5.7 Pump overall efficiency ... 10
5.8 Variable delivery control ... 15
5.8.1 General ... 15
5.8.2 Adjustment ... 15
5.8.3 Response time ... 15
5.8.4 Stability ... 16
5.8.5 Maximum transient pressure ... 17
5.9 Rated temperature ... 17
5.10 Acoustic noise level ... 17
5.11 Endurance ... 17
5.12 Environmental requirements ... 18

6 Detail design requirements ... **18**
6.1 Dimensionally critical components ... 18
6.2 Maintainability features ... 18
6.3 Seals ... 19
6.4 Lubrication ... 19
6.5 Balance ... 19
6.6 Self-contained failure ... 19
6.7 Safety wire sealing ... 19
6.8 Electro-conductive bonding ... 19
6.9 Marking ... 19
6.9.1 Nameplate ... 19

6.9.2 Fluid identification 20
6.9.3 Ports 20

7 Strength requirements 20
7.1 General 20
7.2 Pressure loads 20
7.3 Proof pressure 20
7.3.1 Pump case 20
7.3.2 Pump inlet port 20
7.3.3 Pump discharge port 20
7.4 Ultimate pressure 21
7.4.1 Pump case 21
7.4.2 Pump inlet port 21
7.4.3 Pump discharge port 21
7.5 Pressure impulse (fatigue) 21
7.6 Port strength 21

8 Construction requirements 21
8.1 Materials 21
8.1.1 General 21
8.1.2 Metals 22
8.2 Corrosion protection 22
8.2.1 General 22
8.2.2 Ferrous and copper alloys 23
8.2.3 Aluminium alloys 23
8.3 Castings 23

9 Installation requirements 23
9.1 Dimensions 23
9.2 Mass 23
9.3 Mounting 23
9.4 Orientation 24
9.5 Drive coupling 24
9.6 Ports 24

10 Maintenance requirements 24
10.1 Maintenance concept 24
10.2 Service life limitations and storage specifications 25

11 Reliability requirements 25
11.1 Equipment compliance 25
11.2 Requirements 25

12 Quality assurance provisions 25
12.1 Responsibility for inspection 25
12.2 Classification of tests 25
12.3 Test stand requirements 26

13 Acceptance tests 26
13.1 General 26
13.2 Examination of the product 26
13.3 Test programme 26
13.3.1 General 26
13.3.2 External leakage requirements 27
13.3.3 Break-in run 27
13.3.4 Proof pressure test 27
13.3.5 Load cycles 27
13.3.6 Teardown inspection examination 27
13.3.7 Run-in 28
13.3.8 Functional tests 28
13.3.9 Pressure control test 28
13.3.10 Calibration 28

13.3.11 Fluid contamination test 29
13.3.12 Electro-conductive bonding 30
13.4 Storage and packaging 30

14 Qualification tests 30
14.1 Purpose 30
14.2 Qualification procedure 30
14.2.1 Qualification by analogy 30
14.2.2 Pump qualification test report 30
14.2.3 Samples and program of qualification tests 31
14.3 Qualification testing 31
14.3.1 Dimensional check 31
14.3.2 Expanded envelope acceptance tests 32
14.3.3 Calibration 32
14.3.4 Maximum pressure and response time tests 32
14.3.5 Pressure pulsation test 34
14.3.6 Heat rejection test 34
14.3.7 Endurance test 35
14.3.8 Minimum inlet pressure test 40
14.3.9 Environmental tests 41
14.3.10 Structural tests 41
14.3.11 Supplementary tests 43

Bibliography 44

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 10, *Aerospace fluid systems and components*.

This second edition cancels and replaces the first edition (ISO 8278:1986) and ISO 12334:2000, which have been technically revised.

INTERNATIONAL STANDARD **ISO 8278:2016(E)**

Aerospace series — Hydraulic, pressure compensated, variable delivery pumps — General requirements

1 Scope

This International Standard establishes the general requirements for pressure compensated, variable delivery hydraulic pumps, suitable for use in aircraft hydraulic systems at pressures up to 35 000 kPa (5 000 psi).

This International Standard is to be used in conjunction with detail specifications that is particular to each application.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2093, *Electroplated coatings of tin — Specification and test methods*

ISO 2669, *Environmental tests for aircraft equipment — Steady-state acceleration*

ISO 2671, *Environmental tests for aircraft equipment — Part 3.4 : Acoustic vibration*

ISO 2685, *Aircraft — Environmental test procedure for airborne equipment — Resistance to fire in designated fire zones*

ISO 3323, *Aircraft — Hydraulic components — Marking to indicate fluid for which component is approved*

ISO 3601-1:2012, *Fluid power systems — O-rings — Part 1: Inside diameters, cross-sections, tolerances and designation codes*

ISO 7137, *Aircraft — Environmental conditions and test procedures for airborne equipment*

ISO 7320, *Aerospace — Couplings, threaded and sealed, for fluid systems — Dimensions*

ISO 8078, *Aerospace process — Anodic treatment of aluminium alloys — Sulfuric acid process, undyed coating*

ISO 8079, *Aerospace process — Anodic treatment of aluminium alloys — Sulfuric acid process, dyed coating*

ISO 8081, *Aerospace process — Chemical conversion coating for aluminium alloys — General purpose*

ISO 8399-1, *Aerospace — Accessory drives and mounting flanges (Metric series) — Part 1: Design criteria*

ISO 8399-2, *Aerospace — Accessory drives and mounting flanges (Metric series) — Part 2: Dimensions*

ISO 8625-1, *Aerospace — Fluid systems — Vocabulary — Part 1: General terms and definitions related to pressure*

ISO 8625-2, *Aerospace — Fluid systems — Vocabulary — Part 2: General terms and definitions relating to flow*

ISO 8625-3, *Aerospace — Fluid systems — Vocabulary — Part 3: General terms and definitions relating to temperature*

ISO 11218:—[1)], *Aerospace — Cleanliness classification for hydraulic fluids*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8625-1, ISO 8625-2, ISO 8625-3, and the following apply.

3.1
variable delivery hydraulic pump
self-regulating hydraulic pump that supplies hydraulic power to the hydraulic system (or subsystem) at a nominal constant pressure

Note 1 to entry: The pump can be driven by a variety of power sources, including the following:

— by an engine via an accessory gearbox;

— electric motor;

— pneumatic power drive.

3.2
purchaser
organization that has the engineering responsibility for the hydraulic system that includes the pump

Note 1 to entry: Typically, the purchaser is an aircraft manufacturer, an equipment manufacturer that has hydraulic system responsibility or a modification centre.

Note 2 to entry: The purchaser is responsible for the compilation of the detail specification.

3.3
detail specification
document compiled by the purchaser that specifies the following:

a) technical requirements;

b) acceptance and qualification test requirements;

c) reliability requirements;

d) quality requirements;

e) packaging requirements;

f) other requirements

3.4
supplier
organization that provides the pump

Note 1 to entry: Typically, the supplier is the manufacturer of the pump who will be responsible for the design, production and qualification of the pump.

3.5 Ports of the hydraulic pump

3.5.1
pump inlet port
port that receives flow from the hydraulic reservoir to supply the pump

1) To be published. (Revision of ISO 11218:1993)

3.5.2
pump discharge port
port that supplies pressurized flow to the system

3.5.3
pump case drain port
port that drains internal leakage flow to the reservoir

3.5.4
shaft seal port
port that routes any shaft seal leakage from the pump to an overboard drain, collector tank, etc.

3.6 Temperature terms

3.6.1
rated temperature
maximum continuous temperature of the fluid to be supplied at the supply port of the pump

Note 1 to entry: The rated temperature is expressed in degrees centigrade.

3.6.2
minimum continuous temperature
minimum continuous temperature of the fluid to be supplied at the supply port of the pump

Note 1 to entry: The minimum continuous temperature is expressed in degrees centigrade.

3.7 Pressure terms

3.7.1
design operating pressure
normal maximum steady pressure

Note 1 to entry: Excluded are reasonable tolerances, transient pressure effects such as may arise from

— pressure ripple,

— reactions to system functioning, and

— demands that may affect fatigue.

3.7.2 Inlet pressure

3.7.2.1
rated inlet pressure
minimum pressure measured at the inlet port of the pump at which the pump is required to provide performance without any degradation, with all other parameters at their rated values, except for the fluid temperature, which is the minimum continuous temperature

3.7.2.2
maximum inlet pressure
maximum steady-state inlet pressure at which the pump may be required to operate

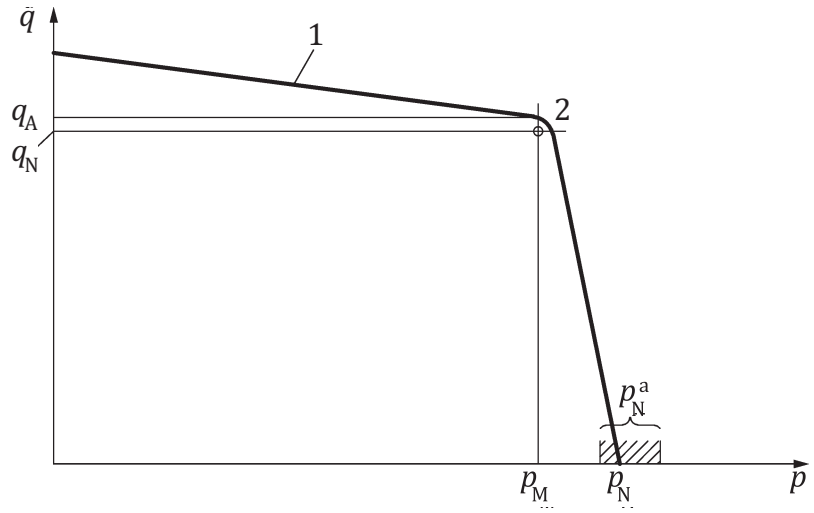
3.7.2.3
minimum inlet pressure
lowest pump inlet port pressure, specified by the purchaser, for which the supplier ensures that the pump might be required to operate without cavitation during a system failure or when the pump is delivering the maximum flow

Note 1 to entry: For the purposes of this International Standard, cavitation is assumed to occur when there is a 2 % reduction in discharge flow with reducing inlet pressure.

3.7.3
discharge pressure
maximum pressure against which the pump is required to operate continuously at rated temperature, at rated speed and at zero flow

Note 1 to entry: See Figure 1.

Note 2 to entry: This diagram is given as an indication. It may be presented in a different way, for example, the axes may be reversed.



Key

1	actual discharge/pressure characteristic curve
2	at p_M, $q_A > q_N$
p	pressure
p_M	*maximum full-flow pressure* (3.7.3.1)
p_N	rated discharge pressure
p_N^a	tolerance range
q	discharge flow
q_A	maximum *rated discharge flow* (3.8)
q_N	minimum rated discharge flow

Figure 1 — Delivery/pressure characteristic curve of pumps

3.7.3.1
maximum full-flow pressure
maximum discharge pressure at which the pump control will not be acting to reduce pump discharge, at rated temperature, rated speed, rated inlet and case drain pressure

3.7.3.2
maximum pump discharge transient pressure
peak value of the discharge pressure recorded during a discrete transient event (normally found whilst cycling from full-flow pressure to rated pressure (zero flow))

3.7.3.3
pressure pulsations
oscillations of the pump discharge pressure, occurring during nominally steady operating conditions, at a frequency equal to the number of pistons times the drive shaft speed or a multiple thereof

Note 1 to entry: The amplitude of the oscillations is the difference between the average minimum and the average maximum oscillations recorded during a one-second trace.

3.7.4 Case drain pressure

3.7.4.1
maximum case drain pressure
maximum continuous pressure developed by the pump to enable case drain fluid to return to the reservoir

3.7.4.2
rated case drain pressure
nominal pressure at which the pump case is required to operate continuously in the system

3.7.4.3
maximum transient case pressure
maximum pressure peak that may be imposed by the hydraulic system on the pump case drain port

3.8
rated discharge flow
flow rate measured at the pump delivery port under conditions of

— rated fluid temperature,

— rated inlet pressure,

— rated case drain pressure,

— maximum full-flow pressure, and

— using the hydraulic fluid specified in the detail specification

Note 1 to entry: The flow shall be measured in the compressed state.

3.9
rated displacement
maximum theoretical volume of fluid generated by one revolution of the pump drive shaft at full stroke

Note 1 to entry: The rated displacement shall be calculated from the geometrical configuration of the pump, without allowing for the effects of the following:

— permissible manufacturing tolerances;

— distortions of the pump structure;

— the compressibility of the hydraulic fluid;

— internal leakage;

— temperature.

Note 2 to entry: The rated displacement is used to indicate the size of the pump rather than its performance.

3.10
rated speed
maximum speed at which the pump will operate

Note 1 to entry: The rated speed is expressed as a number of revolutions of the pump drive shaft per minute.

3.11
response time
time interval between the moment when an increase (or decrease) of the pump delivery pressure begins and the subsequent time when the delivery pressure reaches its first maximum (or minimum) value, when connected to a specified circuit

3.12
stability
freedom from persistent or quasi-persistent oscillation or "hunting" of the pump (cyclic variations in speed) at any frequency that can be traced to the delivery control mechanism, within stated limits in the detail specification

3.13
pump overall efficiency
pump overall efficiency (including volumetric efficiency) is obtained from the formula:

pump overall efficiency (%) = (output fluid power/input shaft power) × 100

where

input shaft power is shaft torque × RPM;

output fluid power is (full-flow pressure – inlet pressure) × rated flow

Note 1 to entry: This formula ignores compressibility effects. If this formula is to be used, the flow rate measurement should be made on the compressed flow stream.

3.14
rated endurance
total number of hours and cycles of operation to be included in the endurance phase of its qualification testing

3.15
first article inspection
FAI
process that conducts the following:

— verifies that the parts of a component complies with the drawings;

— verifies that the manufacturing processes have been compiled and are adhered to;

— verifies that the assembly processes have been compiled and are adhered to;

— verifies that the acceptance test of the component is in accordance with the test procedure and that the results of the test are in agreement with the test requirements

4 General requirements

4.1 Order of precedence

The detail specification shall take precedence in the case of a conflict between the requirements of this International Standard and the detail specification.

4.2 Hydraulic system characteristics

The hydraulic pump shall be designed to supply the hydraulic system as defined in the detail specification.

The detail specification shall include the characteristics of the hydraulic system in which the pump is to be used. This shall include the flow versus pressure curves for the inlet, discharge and case drain lines for the following hydraulic fluid temperatures:

— normal operating temperature (for example, +20 °C);

— rated temperature;

— minimum continuous temperature.

4.3 Airworthiness requirements

The hydraulic pump shall comply with the applicable airworthiness requirements.

4.4 Qualification

Hydraulic pumps furnished under this International Standard shall be products that have passed the qualification tests specified in the detail specification.

5 Functional requirements

5.1 Hydraulic fluid

The detail specification shall state the applicable hydraulic fluid.

5.2 Pump pressure

5.2.1 Rated discharge pressure

The design of the pump shall be such as to maintain rated discharge pressure at the following combination and range of conditions:

— from 30 °C to rated temperature;

— from 50 % to 125 % of rated speed;

— at rated inlet pressure.

The value of the rated discharge pressure shall be stated in the detail specification and shall be one of the following values of rated discharge pressure listed in Table 1 (derived from ISO 6771):

Table 1 — Rated discharge pressure

Pressure class	**Metric system** kPa basic	**Imperial system** psi basic
A	4 000	600
B	10 500	1 500
C	16 000	2 500
D	21 000	3 000
E	28 000	4 000
J	35 000	5 000

The maximum and minimum tolerance of the rated discharge pressure shall be specified in the detail specification. The permissible tolerance range shall be doubled in each direction for fluid temperatures below 30 °C or pump speeds from 25 % to 50 % of rated speed.

5.2.2 Maximum full-flow pressure

The maximum full-flow pressure of the pump shall be defined as the maximum discharge pressure at which the pump control will not be acting to reduce pump delivery at rated temperature, speed and inlet pressure.

The detail specification shall specify the minimum value of the maximum full-flow pressure (see Figure 1).

5.2.3 Pressure pulsations

The detail specification shall state the maximum permitted amplitude of the discharge pressure pulsations.

The amplitude of pressure pulsations shall be determined by the test procedure of 14.3.5.

5.2.4 Inlet pressure

5.2.4.1 General

The inlet pressure shall be measured at the inlet port of the pump in a manner that indicates the static head.

5.2.4.2 Rated inlet pressure

The detail specification shall state the value of rated inlet pressure, which shall be in kPa (or psi) absolute.

5.2.4.3 Minimum inlet pressure

The detail specification shall state the following:

— the value of the minimum inlet pressure, which shall be in kPa (or psi) absolute and whether it applies during a short term high flow condition or during a steady-state failure case;

— the associated minimum hydraulic fluid temperature;

— any allowable performance degradation when the pump is operating at the minimum inlet pressure.

The purchaser shall specify the inlet conditions that will exist at the pump inlet including the provision of the circuit impedance for the pump inlet and discharge piping system and/or a complete physical description of the circuit. This is to enable the supplier to conduct a dynamic flow analysis to determine the pump operation at the minimum inlet pressure.

5.2.4.4 Maximum inlet pressure

The detail specification shall state the value of the maximum steady-state inlet pressure, which shall be in kPa (or psi) absolute.

5.3 Case drain pressure

5.3.1 Rated case drain pressure

The detail specification shall state the value of the rated case drain pressure for the pump case, which shall be in kPa (or psi).

5.3.2 Maximum transient case drain pressure

The detail specification shall state the value, duration and frequency of occurrence of the maximum transient case drain pressure for the pump case, which shall be in kPa (or psi).

5.3.3 Maximum case drain pressure

The detail specification shall state the value of the maximum case drain pressure for the pump case, which shall be in kPa (or psi).

5.4 Flows

5.4.1 Pump rated discharge flow

The detail specification shall state the value of the rated pump discharge flow, which shall be in l/min (or gpm). The minimum and maximum rated discharge flow (see Figure 1) shall be specified.

5.4.2 Pump case flow

The detail specification shall state that the pump shall be capable of producing at least a minimum case drain flow to limit the differential temperature between the inlet port and the case drain port to a stated maximum value.

The pump case flow rate [which shall be in l/min (or gpm)] shall be specified under the following conditions:

— rated discharge pressure (minimum attainable steady-state flow);

— rated temperature;

— any discharge flow demand between 5 % to 100 % of rated flow;

— a given maximum differential pressure between case pressure and inlet pressure.

The minimum and maximum case drain flow shall be stated at conditions specified in the detail specification.

If the case drain flow is routed to a system heat exchanger, the detail specification shall state the minimum case flow.

5.4.3 Shaft seal leakage flow

The detail specification shall state the value of the maximum dynamic shaft seal leakage (which shall be in drops/min) at the following conditions:

a) new build:

   1) the pump filled with fluid but un-pressurized;

   2) when subject to proof pressure at ambient temperature;

   3) when the pump is supplying rated discharge flow;

b) qualification testing:

   1) over the expanded test envelope;

   2) at the completion of the endurance test;

   3) when subject to proof pressure at rated temperature;

   4) when subject to burst pressure at rated temperature.

5.4.4 External leakage

No leakage sufficient to form a drop from the pump case or from any case static seal shall be permitted. Dynamic shaft seal leakage shall not be considered as external leakage.

5.5 Speed and direction of rotation

5.5.1 Rated speed

The rated speed of the pump shall be defined as the maximum speed at which the detail specification requires the pump to operate continuously at rated temperature and at rated discharge pressure. The rated speed shall be expressed as a number of revolutions of the pump driving shaft per minute.

The rated speed of the pump shall be stated in the detail specification.

NOTE As an indication, the maximum recommended values are given in the Nomograph in

— Figures 2 and 3 for commercial aircraft applications, and

— Figures 4 and 5 for military aircraft applications.

If speeds are kept well below those indicated by the curves, the operating life may be improved. However, several system factors such as fluid, temperature, duty cycle, contamination, expected life, etc. will also influence the values.

5.5.2 Overspeed

Unless otherwise specified in the detail specification, the pump shall be capable of operation at 115 % of rated pump discharge flow for the durations and at the conditions of Table 7.

5.5.3 Direction of rotation

The direction of rotation of the pump drive shall be stated in the detail specification and shall be clearly indicated on the installation drawings and by a label on the pump.

5.6 Torque

The detail specification shall specify the following:

— the maximum value of driving torque for rated operating conditions for the pump;

— the torque value when the pump is operated at zero flow, at rated pressure, temperature and rotation speed.

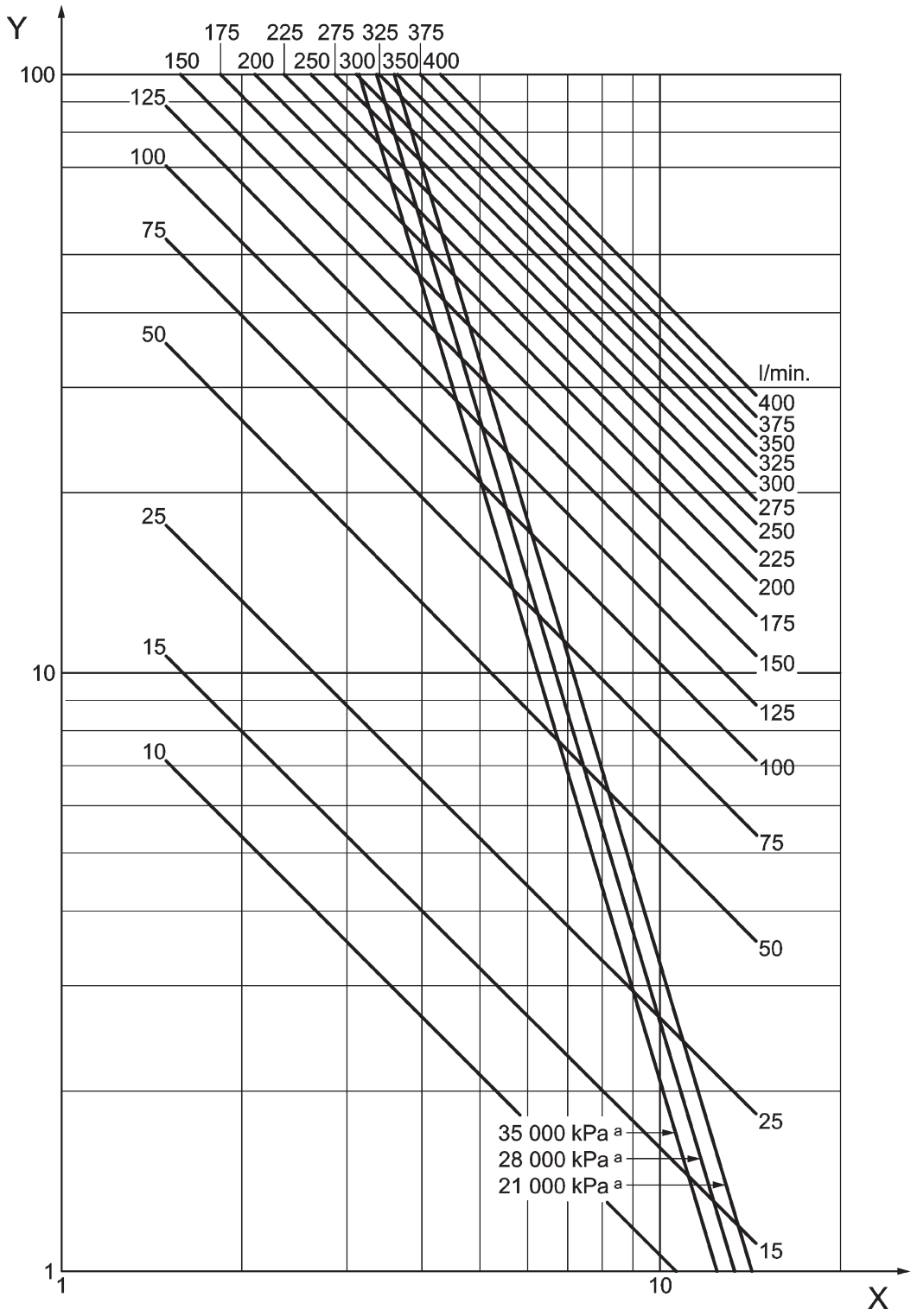
5.7 Pump overall efficiency

The following efficiency values shall be stated in the detail specification:

— the overall efficiency of the pump when new;

— the overall efficiency of the pump after endurance test, this value being considered as an objective.

When determining output power by calculation from flow rate and pressure change, only the net pressure difference between inlet and outlet ports of the pump shall be used. The flow rate may be as measured in the low pressure side of the discharge line, provided that adequate compensation is made for compressibility when calculating efficiency.



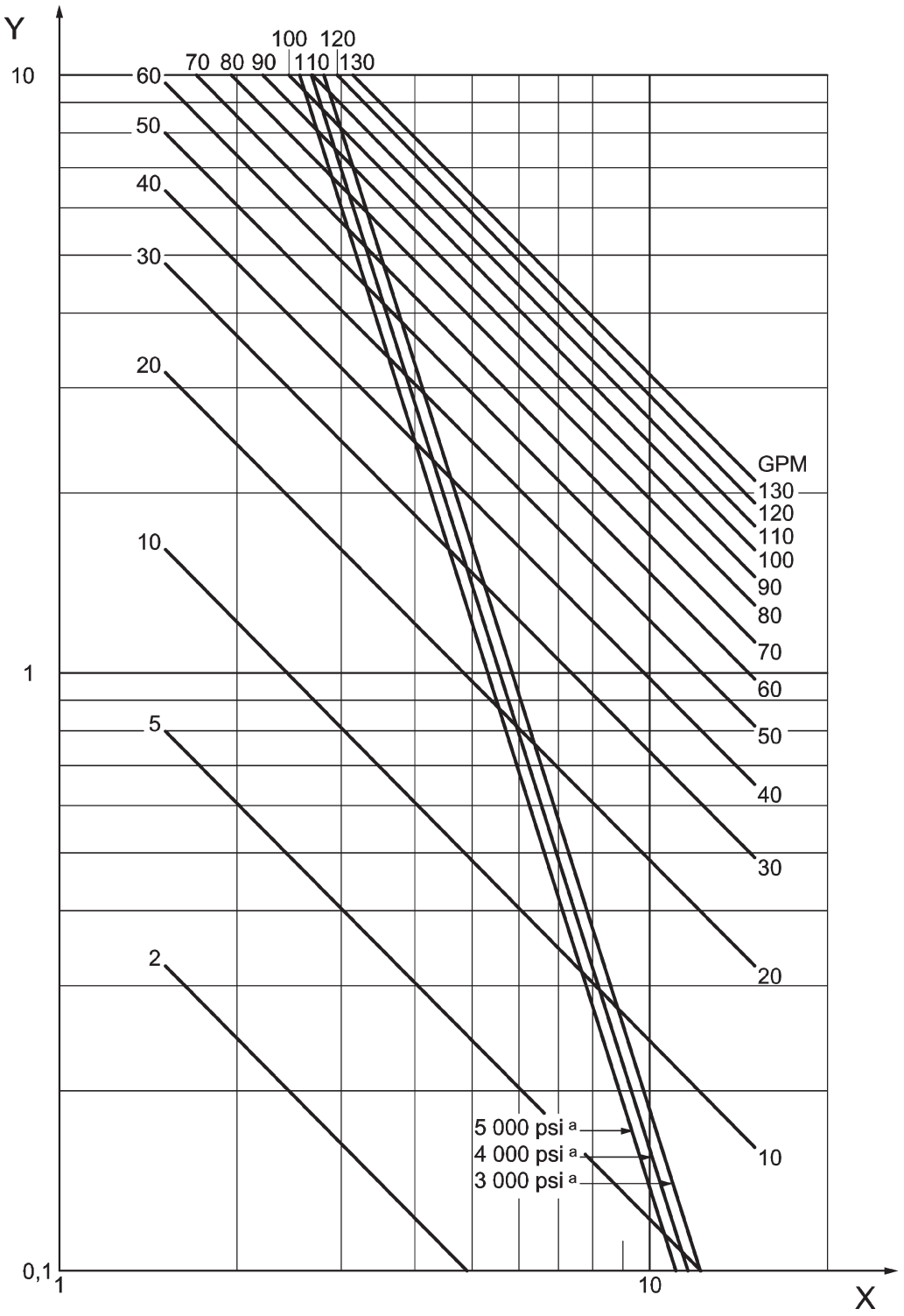
Key

X pump speed in rpm × 1 000

Y rated displacement in millilitres per revolution

a Recommended maximum rated speeds.

Figure 2 — Nomograph of maximum recommended values for rated speeds against pump displacement (Metric units) — commercial aircraft applications



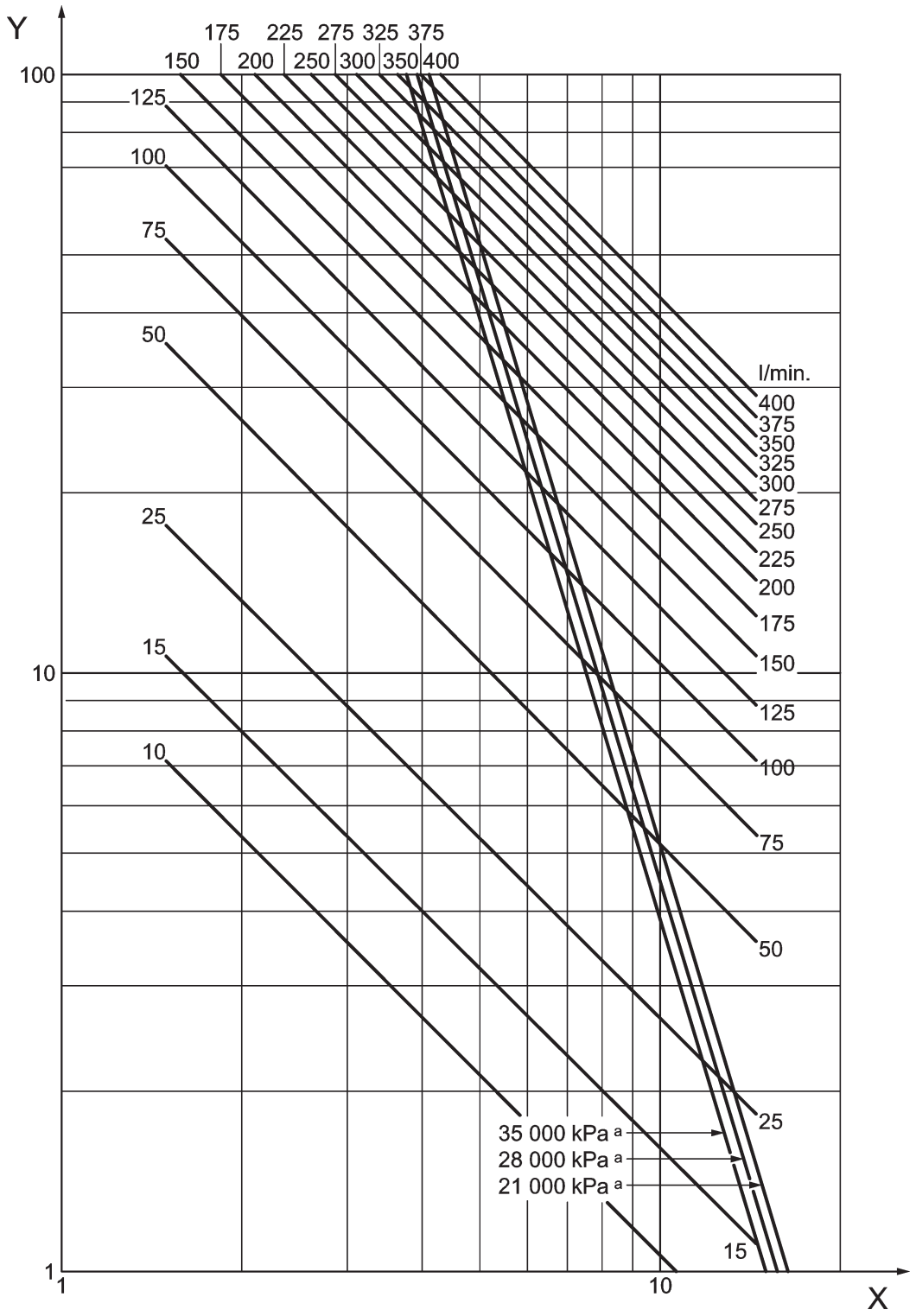
Key

X pump speed in rpm × 1 000

Y rated displacement in cubic inches per revolution

[a] Recommended maximum rated speeds.

Figure 3 — Nomograph of maximum recommended values for rated speeds against pump displacement (American units) — commercial aircraft applications



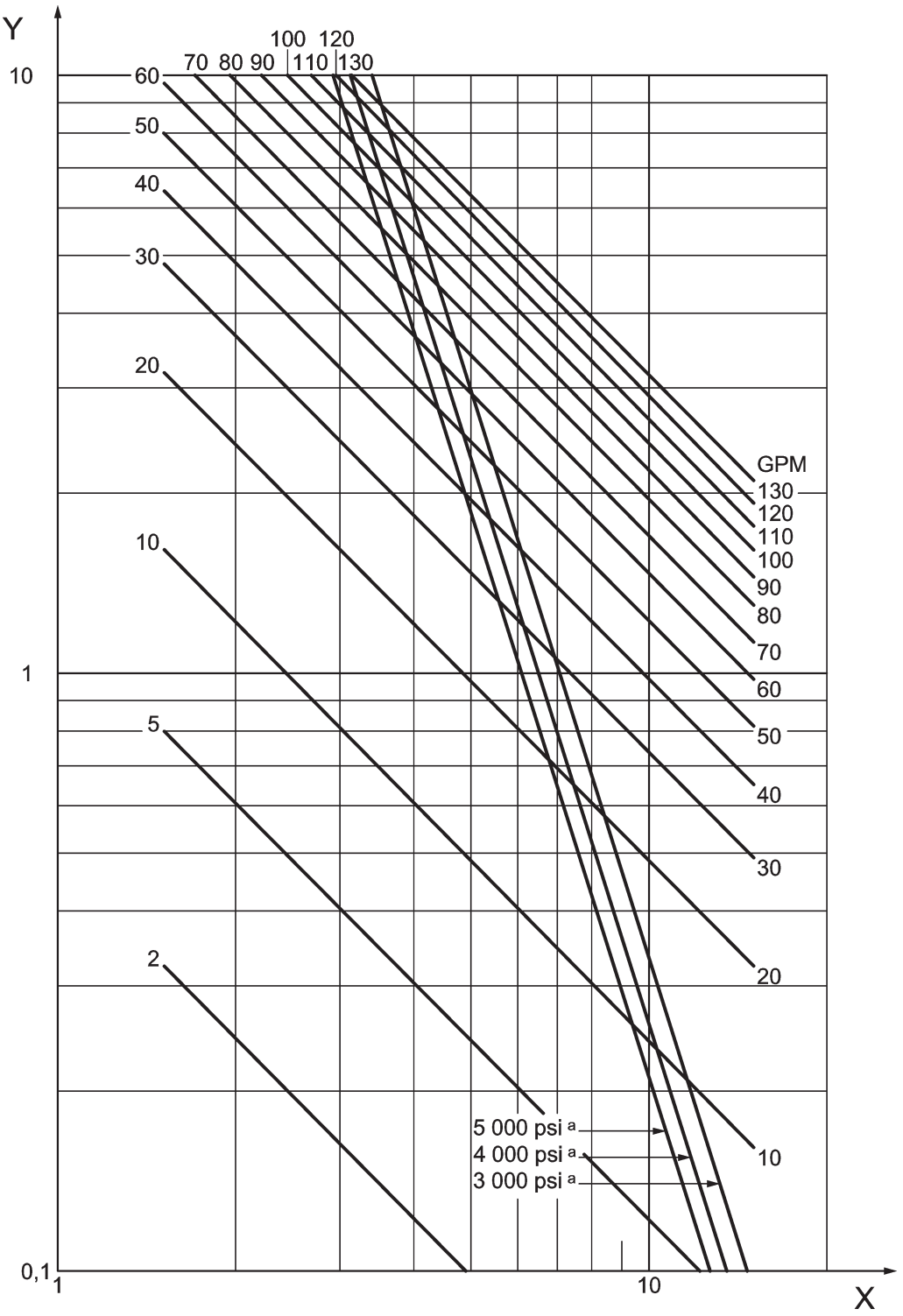
Key

X pump speed in rpm × 1 000

Y rated displacement in millilitres per revolution

[a] Recommended maximum rated speeds.

Figure 4 — Nomograph of maximum recommended values for rated speeds against pump displacement (Metric units) — military aircraft applications



Key

X pump speed in rpm × 1 000

Y rated displacement in cubic inches per revolution

[a] Recommended maximum rated speeds.

Figure 5 — Nomograph of maximum recommended values for rated speeds against pump displacement (American units) — military aircraft applications

5.8 Variable delivery control

5.8.1 General

All pump models shall incorporate means to control the delivery which shall act to increase the delivery of the pump from zero to its maximum full-flow value for any given operating speed, as the discharge pressure is reduced from rated discharge pressure to maximum full-flow pressure and vice versa.

5.8.2 Adjustment

Means shall be provided to adjust the delivery control mechanism to cause zero flow to occur at rated discharge pressure. This adjustment shall, preferably, be continuous or it is acceptable for it to be in steps of less than 1 % of the rated discharge pressure over a minimum range from 95 % to 105 % of the rated discharge pressure.

The adjustment device shall be capable of being securely locked and it shall be possible to carry out adjustment and locking using only standard hand tools. Where practicable, the adjustment device shall be fitted in such a way that adjustments can be made while operating under full system pressure with negligible loss of fluid.

5.8.3 Response time

The real-time plot of discharge pressure against time shall be used as the criterion of movement of the discharge control mechanism. All pumps shall have a maximum response time in accordance with the detail specification when changing the flow demand, unless otherwise specified in the detail specification when

a) operating at rated inlet temperature,

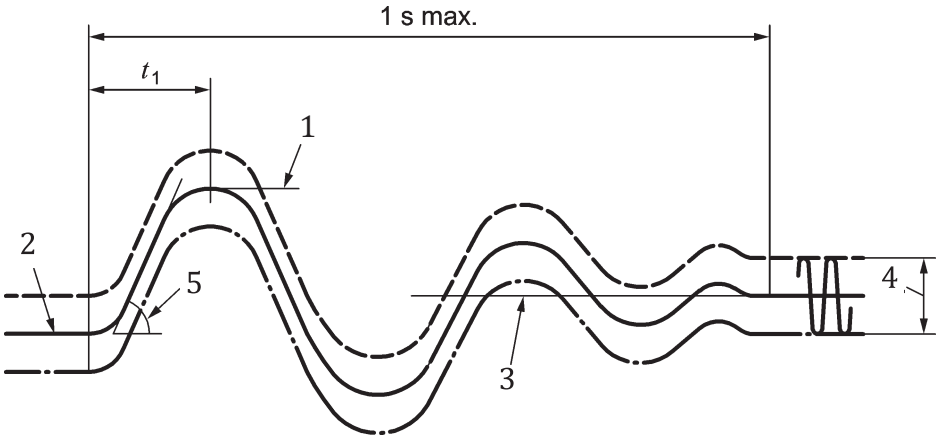
b) at rated flow, and

c) in a circuit, with the system impedance defined in 14.3.4.2.2.

In Figures 6 and 7, the time intervals t_1 and t_2 are the response times of the pump as a function of the system impedance.

The pump discharge pressure shall be stabilized within ±2 % of the rated discharge pressure after a decreasing flow transient (at the end of 1 s after the initiation of the transient flow demand).

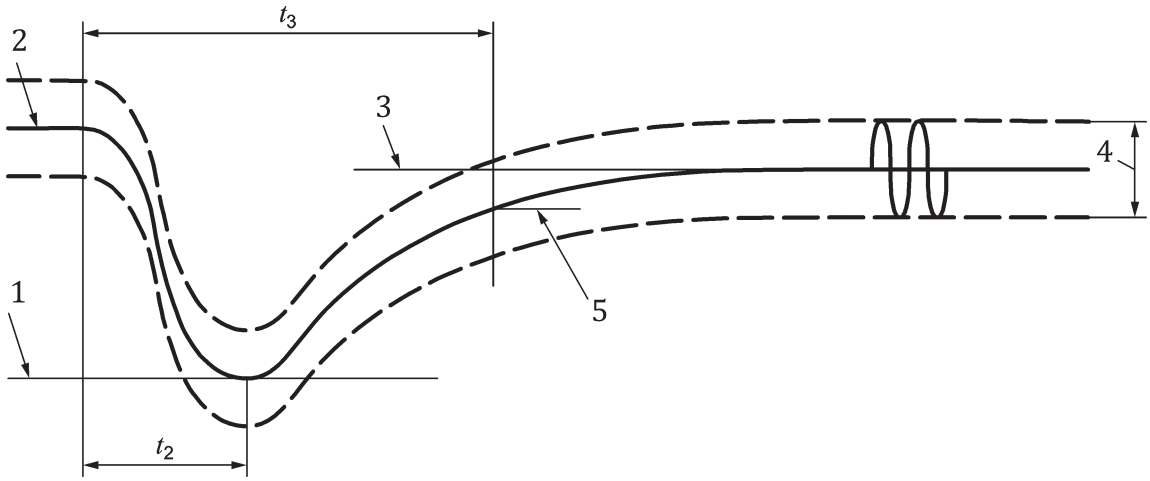
The detail specification may state the minimum and maximum response time for the pump to decrease the flow from full-flow to zero (t_1) and a separate minimum and maximum response time for the pump to increase the flow from zero to full-flow (t_2).



Key

1 maximum transient pressure (see 5.8.5)
2 maximum full-flow pressure (see 5.2.2)
3 rated discharge pressure (see 5.2.1)
4 allowable discharge pressure pulsations (see 5.2.3)
5 rate of pressure rise (dP/dT)

Figure 6 — Typical variation of pressure against time — Transient from maximum full-flow pressure to rated discharge pressure (zero flow)



Key

1 minimum transient pressure
2 rated discharge pressure (see 5.2.1)
3 maximum full-flow pressure (see 5.2.2)
4 allowable discharge pressure pulsations (see 5.2.3)
5 90 % maximum full-flow pressure (see 14.3.4.4)

Figure 7 — Typical variation of pressure against time — Transient from rated discharge pressure to maximum full-flow pressure (full-flow)

5.8.4 Stability

The oscillographic trace of discharge pressure against time shall be used as the criterion of stability.

All pumps shall recover steady-state operation other than permissible pressure pulsations as specified in 5.2.3 within not more than 1 s after the initial response to that change in flow demand, under the following conditions:

a) under any operating condition within the limits stated in the detail specification;

b) at any flow rate greater than 50 % of the rated discharge flow rate;

c) after a change in the flow demand.

When required by the purchaser, the supplier shall provide adequate pump parameters to permit the system designer to integrate the pump dynamic performance into the complete pump/system analysis.

5.8.5 Maximum transient pressure

The value of the maximum transient pressure, as determined in the transient pressure test specified in 14.3.4.3, shall not exceed

a) 7 000 kPa (1 000 psi), as determined in the transient pressure test,

b) 125 % of the rated discharge pressure, or

c) the maximum pressure as specified in the detail specification.

The maximum transient pressure is dependent on the hydraulic system characteristics. The purchaser shall provide the circuit impedance for the pump outlet piping system and/or a complete physical description of the circuit. This is to enable the supplier to conduct a dynamic flow analysis to determine the maximum transient pressure.

5.9 Rated temperature

ISO 8625-3 provides the requirements for temperature classification (type I, type II or type III) if the pump is to be used in a military aircraft or helicopter.

If the application is for a commercial aircraft or helicopter, the detail specification shall state the rated temperature.

5.10 Acoustic noise level

If required, the pump shall have a maximum acoustic noise level at rated operating conditions. The detail specification shall state its value together with the measuring procedure, when applicable.

When conducting the acoustic noise test, the hydraulic test rig shall have the circuit impedance as specified in 14.3.4.2.3. To the extent possible, acoustic noise contributions from other hydraulic or structural members attached to or in the vicinity of the pump shall be accounted for separately.

5.11 Endurance

The detail specification should specify the duration and the conditions of the endurance test. However, if they are not specified in the detail specification, then the endurance test shall be in accordance with Table 2 and 14.3.7.

The endurance test shall be conducted with the fluid cleanliness of the hydraulic fluid at the maximum class specified for the application.

Table 2 — Duration of endurance test

Pump Application	Duration of endurance test h
Used for military applications	2 000
Used for commercial applications	4 000

5.12 Environmental requirements

The detail specification shall state the environmental and operating conditions to which the pump is exposed, based on the following criteria:

a) temperature and altitude (in accordance with ISO 7137);

b) humidity (in accordance with ISO 7137);

c) fluids susceptibility (in accordance with ISO 7137);

d) vibrations (in accordance with ISO 7137);

e) acoustic vibrations (in accordance with ISO 2671);

f) steady-state acceleration (in accordance with ISO 2669);

g) resistance to fungus and mould (in accordance with ISO 7137);

h) salt spray (in accordance with ISO 7137);

i) water resistance (in accordance with ISO 7137);

j) sand and dust (in accordance with ISO 7137);

k) shock (in accordance with ISO 7137);

l) ice formation (in accordance with ISO 7137);

m) fire resistance (in accordance with ISO 2685) – pumps in fire zones only.

6 Detail design requirements

6.1 Dimensionally critical components

Parts shall include mechanical means to prevent them from being installed incorrectly if

a) they are likely to cause incorrect operation,

b) they can cause damage if the installation direction is reversed, and

c) they are incorrectly located on assembly.

6.2 Maintainability features

In addition to the requirements of 6.1, components that are not functionally interchangeable shall not be physically interchangeable.

All wear surfaces shall be replaceable or repairable.

Connections, mounting, and wiring provisions shall be designed to prevent incorrect coupling.

The design shall permit the line replacement of the unit or a module of the unit using standard tools only.

The design shall be such that special or unique equipment is kept to a strict minimum for shop repair, overhaul, and maintenance checks.

6.3 Seals

Static and dynamic seals shall be in accordance with ISO 3601-1:2012, series A. Non-standard seals, necessary to demonstrate compliance with the requirements of this International Standard, may be used subject to the approval of the purchaser.

For pumps used in commercial aircraft and military type III systems, back-up rings used shall be subject to the approval of the purchaser.

6.4 Lubrication

The pump shall be self-lubricated, with no provision for lubrication apart from the circulating hydraulic fluid.

6.5 Balance

The individual rotating parts of the pump shall be inherently balanced about their own primary operating axis. The pump shall not vibrate due to self-generated accelerations in such a way that any part of it yields or is otherwise structurally compromised throughout the speed range up to the maximum specified overspeed condition.

6.6 Self-contained failure

The pump shall be designed to completely contain all internal parts in the event of a failure due to the following:

a) when the supply of hydraulic fluid to the pump is zero or is less than the volume the pump displaces, for any duration up to the maximum flight time. The detail specification shall state the time period and the running speed when the pump will be running under these conditions;

b) during an overspeed condition. The maximum overspeed conditions shall be specified in the detail specification.

No loss of fluid from the pump shall occur as a result of these failures, other than the external and shaft seal leakages specified in the detail specification.

6.7 Safety wire sealing

A manufacturer's non-metallic seal of guarantee may be used to indicate if the pump has been tampered with internally.

Lead-type safety wire sealing shall not be used.

6.8 Electro-conductive bonding

The pump shall have a facility to enable it to be effectively bonded to the airframe. The detail specification shall state the bonding requirements.

6.9 Marking

6.9.1 Nameplate

A nameplate shall be securely attached to the pump. The information marked in the spaces provided shall be as required in the format given in Table 3.

Table 3 — Format for nameplate

Pump, hydraulic, pressure-compensated, variable delivery
Name of manufacturer:.....
Manufacturer's code:.....
Manufacturer's part number:.....
Serial number:.....
Fluid:.....
Displacement:.....
Rated delivery:.....
Rated pressure:.....
Rated speed:.....

6.9.2 Fluid identification

The fluid for which the pump is approved to use shall be identified in accordance with ISO 3323.

6.9.3 Ports

Each port, including the case drain and the seal drain ports, shall be clearly and indelibly marked on each pump.

7 Strength requirements

7.1 General

The strength requirements shall be maintained over the entire ambient and fluid temperature range.

7.2 Pressure loads

The detail specification shall state the design operating pressure for the inlet, discharge and case drain parts of the pump.

7.3 Proof pressure

7.3.1 Pump case

Unless the detail specification states a different value, the pump case shall statically withstand a pressure of at least equal to or greater than 3 500 kPa (500 psi) or 1,5 times the design operating pressure for the case (whichever is the greater) without permanent damage being done or performance being impaired.

7.3.2 Pump inlet port

Unless the detail specification states a different value, the pump inlet port shall statically withstand a pressure equal to 1,5 times the design operating pressure for the pump inlet without any permanent damage being done or performance being impaired.

7.3.3 Pump discharge port

Unless the detail specification states a different value, the pump discharge port shall statically withstand a pressure equal to 1,5 times the design operating pressure without permanent damage being done or performance being impaired.

7.4 Ultimate pressure

7.4.1 Pump case

Unless the detail specification states a different value, the pump case shall be designed to withstand a pressure of at least 5 000 kPa (750 psi) at the case-drain port or 2,5 times the design operating pressure for the case (whichever is the greater) with no structural failure.

7.4.2 Pump inlet port

Unless the detail specification states a different value, the pump inlet port shall statically withstand a pressure equal to 2,5 times the design operating pressure for the pump inlet with no structural failure.

7.4.3 Pump discharge port

Unless the detail specification states a different value, the pump discharge port shall statically withstand a pressure equal to 2,5 times the design operating pressure for the pump discharge with no structural failure.

7.5 Pressure impulse (fatigue)

The pump shall withstand the fatigue effects of all cyclic pressures, including transients and externally induced loads.

The detail specification shall state the following:

— the overall predicted duty cycle for the different parts of the pump, throughout the lifetime of its application;

— the scatter factor that is to be applied for analysis or fatigue (pressure impulse) testing;

— any externally induced loads (for example, structural or thermal).

In addition, when defining the duty cycle for the impulse testing, the following should be considered:

a) the pressure variations due to the pump pulsation levels;

b) the peak transient pressure generated by the pump as it reacts to changes in flow demands.

7.6 Port strength

The structure of the ports and the relevant area of the pump case shall be such that it withstands a torque 2,5 times the maximum torque resulting from attaching or removing the unions and lines on installation or removing the pump during maintenance operations.

The detail specification shall state the maximum torque value.

No permanent distortions or alterations in the correct operation shall occur.

8 Construction requirements

8.1 Materials

8.1.1 General

All materials shall be compatible with the hydraulic fluid that is specified in the detail specification.

Materials and processes used in the manufacture of the pump shall

— be of aerospace quality,

— be suitable for the purpose, and

— comply with the applicable official standards.

Materials that comply with the supplier's material specifications are acceptable provided that these specifications are acceptable to the purchaser and include provisions for adequate testing. The use of the supplier's specifications does not constitute a waiver of other applicable standards.

8.1.2 Metals

8.1.2.1 General

All metals shall be compatible with any fluids with which it will be in contact, with the service and storage temperatures, and functional requirements to which the components will be subjected. Those metals not in direct contact with the hydraulic fluid shall have the appropriate corrosion-resistant properties or they shall be suitably protected as specified in 8.2.

If the properties or operating safety of the pump are likely to be jeopardized by the use of the materials and processes specified above, other materials and procedures may be used subject to the purchaser's approval. In this case, materials or processes shall be chosen to provide the maximum corrosion resistance compatible with the operating requirements.

8.1.2.2 Pumps for type I systems

Except for the internal surfaces in constant contact with the hydraulic fluid, ferrous alloys shall have a chromium mass fraction of at least 12 % or shall be suitably protected against corrosion as specified in 8.2.

Tin, cadmium, and zinc platings shall not be used for internal parts or for internal surfaces in contact with the hydraulic fluid or exposed to its vapours. The grooves for external O-rings seals shall not be considered as internal surfaces in constant contact with hydraulic fluid.

Magnesium alloys shall not be used.

8.1.2.3 Pumps for type II and III systems and for commercial aircraft applications

Ferrous alloys used shall be suitably protected against corrosion as specified in 8.2.

Tin, cadmium and zinc platings shall not be used for internal parts that are in contact with the hydraulic fluid or exposed to its vapour.

Magnesium alloys shall not be used.

8.2 Corrosion protection

8.2.1 General

Metals that do not inherently possess sufficient corrosion-resisting characteristics shall be suitably protected, in accordance with the following subclauses, to resist corrosion that may result from conditions such as the following:

— dissimilar metal combinations;

— moisture;

— salt spray;

— high temperature deterioration.

8.2.2 Ferrous and copper alloys

Ferrous alloys requiring corrosion-preventive treatment and all copper alloys, except for parts with bearing surfaces, shall receive surface plating selected from the following:

a) electrolytic nickel plating;

b) electrolytic silver plating;

c) electrolytic tin plating, in accordance with ISO 2093;

d) electrodeless nickel plating.

Electrolytic tin shall not be used for internal parts or internal surfaces in contact with the hydraulic fluid or exposed in its vapours or on surfaces subjected to abrasion. Where not indicated, the class and type of plating are at the supplier's discretion.

Exceptions shall be submitted to the purchaser for approval.

8.2.3 Aluminium alloys

All aluminium alloys shall be anodized in accordance with ISO 8078 and ISO 8079 (except that in the absence of abrasive conditions, they may coated with chemical film in accordance with ISO 8081), unless otherwise authorized.

Exceptions shall be submitted to the purchaser for approval.

8.3 Castings

Castings shall be of high quality, clean, sound and free from cracks, blow holes, excessive porosity, and other defects.

Defects not materially affecting the suitability of the castings may be repaired at the foundry or during machining by peening, impregnation, welding or other methods acceptable to the purchaser. The inspection and repair of castings shall be checked by quality control techniques and standards that are satisfactory to the purchaser.

9 Installation requirements

9.1 Dimensions

Dimensions pertinent to the installation of the pump in aircraft shall be specified on the supplier's installation drawing and in the detail specification.

9.2 Mass

The dry mass of the completely assembled pump shall be stated on the supplier's installation drawing.

The supplier and the purchaser shall agree on the mass of fluid contained in the pump.

9.3 Mounting

Unless otherwise specified in the detail specification, all pumps shall incorporate a standard mounting flange, which shall be in accordance with ISO 8399-1 and ISO 8399-2.

When the mounting flange is in conformity with ISO 8399-1 and ISO 8399-2, the relation between the maximum displacement of the pump and the type of mounting flange shall be in accordance with Table 4.

Table 4 — Relation between displacement and flange type

Maximum displacement cm^3/r	**Maximum displacement** in^3/r	**Flange type — Spigot reference**
2,5	0,15	150
5	0,31	200
10	0,61	300
15	0,92	350
20	1,22	
30	1,83	
40	2,44	
50	3,05	

9.4 Orientation

The mounting conditions of the pump shall be defined by agreement between the manufacturer and the purchaser.

9.5 Drive coupling

An easily removable drive coupling, incorporating a shear section, shall be interposed between the pump drive shaft and the drive shaft by which the pump is to be driven.

The drive shaft shall be held in place by means of a positive locking system.

The drive shaft shall include a shear section.

The end of the drive shaft shall comply with ISO 8399-1 and ISO 8399-2 unless otherwise specified in the detail specification.

The following shall be specified in the detail specification:

— shear torque;

— the coupling lubrication mode.

9.6 Ports

The port configuration shall be in accordance with ISO 7320, unless otherwise specified in the detail specification.

10 Maintenance requirements

10.1 Maintenance concept

The detail specification shall state the specified maintenance concept, for example, “On Condition”.

10.2 Service life limitations and storage specifications

The detail specification shall state the specifications and appropriate definitions and shall include the following:

a) the time between overhauls (if applicable);

b) the storage life;

c) the service life limit.

11 Reliability requirements

11.1 Equipment compliance

All of the reliability specifications shall be met throughout the service life of the equipment, assuming that all approved maintenance cycles have been carried out.

11.2 Requirements

The detail specification shall state the specifications and the appropriate definitions, which shall include the following:

a) the defect rate;

b) the failure rate;

c) the safety rate (if applicable);

d) the failure mode and effect analysis (FMEA).

12 Quality assurance provisions

12.1 Responsibility for inspection

Unless otherwise specified in the contract or order, the supplier

— is responsible for carrying out all the inspection operations specified in this International Standard, and

— may use his own inspection and testing facilities or the services of any industrial laboratory approved by the national authorities.

The national authorities reserve the right to carry out any of the inspection operations specified in this International Standard where it is deemed necessary to ensure supplies and services that comply with stipulated specifications.

12.2 Classification of tests

The following test program shall be performed for the purposes of checking whether the pumps comply with this International Standard:

a) acceptance tests (see Clause 13);

b) qualification tests (see Clause 14).

12.3 Test stand requirements

The following tolerance limits are set for the required steady-state operating conditions for the test stands that are employed for the acceptance tests and the qualification tests, unless otherwise agreed between the supplier and the purchaser:

a) inlet pressure: ±2 % of rated inlet pressure but not more than ±35 kPa; (±5 psi);

b) case pressure: ±2 % of rated case pressure but not more than ±100 kPa; (±15 psi);

c) discharge pressure: ±2 % of rated discharge pressure but not more than ±200 kPa; (±30 psi);

d) inlet/temperature: –57 °C to +43 °C, within ±3 °C;

+43 °C to +107 °C, within ±6 °C;

e) flow: within ±2 % of rated flow;

f) shaft speed: ±100 r/m;

g) torque: ±2 % of maximum pump input torque. The accuracy of the instrumentation shall be consistent with the measurement tolerances required.

The test stands shall use sufficient filtration so as to maintain the cleanliness of the fluid to ISO 11218:—[2] Class 5, or better, except for the qualification endurance testing (see 14.3.7).

The hydraulic fluid in the test circuit shall be the same as that specified for the application (see 5.1).

13 Acceptance tests

13.1 General

Each pump submitted for delivery under a procurement contract shall be subjected to the examinations and acceptance tests specified in this subclause. The acceptance or approval of material during manufacture shall, in no case, be construed as a guarantee of the acceptance of the finished product.

Acceptance tests, for the purposes of this International Standard, shall consist of the following:

a) visual examinations;

b) a test program to determine quality design and check whether the pumps conform to the performance requirements of this International Standard.

The first production pump shall undergo a first article inspection (FAI) in the presence of the purchaser's representatives. Any deviations recorded in the FAI shall be corrected, or agreed, prior to the delivery of the first pump.

13.2 Examination of the product

The pump shall be examined to determine conformance with the applicable standards and all the requirements of this International Standard and the detail specification, for which there are no specific tests.

13.3 Test programme

13.3.1 General

Filters shall be installed in all the lines to and from the pump, as applicable.

2) To be published. (Revision of ISO 11218:1993)

The supplier shall repeat the applicable parts of the conformance test procedure if, at any phase of testing, working parts require replacement. The break-in run portion may be omitted if the rotating group assembly was not affected.

13.3.2 External leakage requirements

13.3.2.1 General leakage

Other than at the shaft seal, no external leakage of sufficient magnitude to form a drop shall be permitted.

13.3.2.2 Shaft seal leakage

During acceptance and calibration tests, the shaft seal leakage shall not exceed the values specified for new build conditions (refer to 5.4.3).

13.3.3 Break-in run

The break-in run may be conducted at any desired operating conditions as deemed appropriate by the supplier but shall include at least 15 min of operation at rated speed and temperature while operating at maximum full-flow pressure.

13.3.4 Proof pressure test

This test may be conducted either statically or with the pump in operation. There shall be no evidence of permanent deformation following the test.

The test comprises the following:

a) pressurizing the discharge port at least 2 min to the proof pressure stated in the detail specification;

b) pressurizing the case drain and inlet ports for at least 2 min to the proof pressures stated in the detail specification with the outlet port at rated pressure.

During this test, the shaft seal leakage may exceed the requirements as stated in 5.4.3. If this does occur, it shall not be considered as a test failure.

13.3.5 Load cycles

A step-function load shall be imposed causing the pump to cycle from rated discharge pressure (no flow) to maximum full-flow pressure at 6 cycles/min for at least 15 min, or as specified in the detail specification, with equal dwells at each load condition.

There shall be no external leakage sufficient to form a drop except that the shaft seal may leak at a rate not to exceed 5 cm^3/h. There shall be no evidence of any malfunctions.

13.3.6 Teardown inspection examination

13.3.6.1 Sampling requirements

A teardown inspection shall be conducted on a minimum of 10 pumps of a given model of an initial production run or as specified in the detail specification.

The teardown inspection shall be redone whenever either of the following changes in a production programme occurs:

a) continuity of manufacturing is interrupted. Permissible periods of production interruption shall be designated in the detail specification;

b) alternative tooling and production facilities are chosen.

13.3.6.2 Inspection procedure

After the break-in run and proof tests, dismantle and inspect the pump. If all parts are in acceptable condition, re-assemble and run in the pump in accordance with 13.3.7.

If, at any phase in the testing, working parts require replacement, the entire conformance test procedure shall be repeated.

The run-in in accordance with 13.3.7 may be deleted when the teardown inspection is no longer required.

13.3.7 Run-in

The run-in after teardown inspection shall be performed at 50 % to 100 % of rated speed for a period determined by the supplier with the discharge pressure varied between maximum full-flow pressure and rated discharge pressure at a frequency of 6 cycles/min.

13.3.8 Functional tests

Throughout the functional tests, the hydraulic fluid used shall be that specified in the detail specification. Rated inlet pressure shall be maintained within the tolerance specified in this International Standard. Inlet temperature shall be at the rated condition.

The functional test shall comprise the following:

a) running at rated speed and maximum full-flow pressure;

b) running at rated speed with discharge pressure varied between maximum full-flow pressure and rated discharge pressure at a frequency of 6 cycles/min;

c) running at rated speed and rated discharge pressure, except that at 10 min intervals, the discharge pressure shall be reduced to maximum full-flow pressure for 1 min.

The time spent at each of these conditions shall be agreed between the supplier and the purchaser.

13.3.9 Pressure control test

Rated discharge pressure shall remain within the limits specified in the detail specification as pump speed is varied from 50 % to 100 % of rated speed or to the speed specified in the detail specification.

There shall be no indication of pressure control instability as pump speed is varied from 50 % to 100 % of rated speed throughout the flow range. System conditions shall be defined in the detail specification.

The hysteresis characteristics of the pressure control from zero to rated flow at rated speed shall not exceed the value as specified in the detail specification.

13.3.10 Calibration

On completion of the other acceptance tests, the torque required to drive the pump and the case drain flow shall be measured and recorded for the following conditions:

a) rated speed;

b) rated discharge pressure;

c) rated inlet pressure;

d) case pressure of 140 kPa (20 psi), or as specified in the detail specification, above inlet pressure;

e) rated inlet temperature or as specified in the detail specification.

The delivery of the pump at rated speed, rated maximum full-flow pressure, and at rated inlet pressure shall be measured and recorded.

The measured values for torque, case drain flow and delivery shall be within the limits specified in the detail specification. Flow may be measured in the low pressure side of the discharge line, provided adequate compensation is made for compressibility in stating the delivery.

13.3.11 Fluid contamination test

13.3.11.1 General

This test shall be conducted to prevent shipment of a functionally acceptable but materially deteriorating pump (incipient failure). The fluid from the pump case drain and/or discharge of the pump shall be checked for contamination as agreed to between the supplier and the purchaser.

13.3.11.2 Inline particle counters

Inline particle counters should be used to check for an incipient pump failure by continuously monitoring the particle sizes. The pump shall be stopped and removed for a tear down inspection if there is a noticeable increase in the number of particles in the case drain line after the break-in run has been completed.

13.3.11.3 Filter patch test

13.3.11.3.1 General

If inline particle counters are not available, then the use of filter patches check for an incipient pump failure is an acceptable alternative means. The definition of a patch standard is either initially established by the manufacturer and, in that case, shall be specified in the detail specification or may possibly be established during the functional tests of the first 25 pumps.

Unless otherwise specified in the detail specification, all the filters used during the test shall be able to filter to a value less than or equal to 5 µm absolute.

13.3.11.3.2 Filter sampling method

Install filters in the outlet and case drain or cooling port lines of the test set-up. Check the fluid in the filter bowls by the procedure specified in 13.3.11.3.3 for contamination accumulated during the functional test performed in accordance with 13.3.8.

13.3.11.3.3 Patch preparation

Collect the fluid in each filter bowl in clean containers. Rinse both the filter bowl and element with the appropriate volume of a suitable fluid solvent and add to the applicable container. The total resulting fluid shall be passed through a membrane having a diameter of approximately 47 mm (1,85 in), which will trap contaminant in each filter bowl. The detail specification shall state the membrane material. Wash the membrane free of fluid with the appropriate volume of fluid solvent. After drying, the resultant filter patch shall be coated with clear lacquer and permanently attached to the log sheet of the test.

All fluid solvent shall be filtered through a 0,45 µm pore size membrane prior to use in all stages of the patch preparation procedure.

13.3.11.3.4 Patch comparison

Each filter patch specified in the acceptance test procedure shall be compared with the standard patch then in effect and any discrepancy noted in the test log.

If the contamination level exceeds that of the standard, the filter patch test may be repeated. The second patch shall show equal or less contaminant than the standard patch to be acceptable. If it does not, up to two additional patch tests may be run to establish the trend. If the patches remain unacceptable, the pump should be disassembled to determine the source of the contamination and corrective action taken.

13.3.12 Electro-conductive bonding

If required, measure the electrical resistance between any point on the mounting flange face and specified points on the pump (for example, at the pipe connections). It shall not be greater than the value specified in the detail specification.

13.4 Storage and packaging

The detail specification shall state the procedures for preservation and packing.

The packaging used for the shipment of the pump shall consider the normal handling damage that may occur during transportation. Care shall be taken to avoid damage to any electrical connectors, thin metal parts, etc.

The packaging shall be suitable for storage according to the shelf life requirements specified in the detailed specification, considering that adequate care shall be taken by the storage agency. If the pump relies on the hydraulic fluid internal to the unit for corrosion protection, then the hydraulic plugs shall form a leak-free seal.

14 Qualification tests

14.1 Purpose

Qualification tests, with the purpose of checking whether the pump design is in conformity with the requirements of this International Standard, shall consist of the tests specified in 14.2.3.

14.2 Qualification procedure

14.2.1 Qualification by analogy

All or some of the qualification tests may be waived if the following requirements are met:

a) the pump incorporates the same or similar working parts as another pump that has already been qualified by a controlling authority;

b) the operating conditions are not more restrictive than those for which the other pump has already been qualified.

A report, substantiated by drawings showing the similarity with the already qualified pump, shall be submitted instead of carrying out the tests.

14.2.2 Pump qualification test report

A report of the tests carried out and the test results shall be compiled. This report shall include a full assessment of the extent to which the pumps tested comply with the detail specification and a detailed account of the way in which the tests were carried out. The report shall also include a description of the instruments used, schematic diagrams and photographs, as appropriate. The complete test results shall be given in the report in table form. Hydraulic test systems shall be described with all the details for each test. Assembly drawings and installation drawings shall be appended to the test report.

14.2.3 Samples and program of qualification tests

The qualification tests shall be conducted on one or two sample pumps (A and B). It is essential that these sample pumps be representative of the pumps to be manufactured. The qualification tests, to be carried out in the suggested order, are given in Table 5.

Table 5 — List and sequence of qualification tests

Tests	Specimen			Corresponding subclause
	A		B	
Dimensional check	X			14.3.1
Expanded envelope acceptance	X		X	14.3.2
Flow rate and driving torque	X		X	14.3.3.2
Minimum operating speed	X		X	14.3.3.3
Maximum transient pressure			X	14.3.4.3
Determination of response time			X	14.3.4.4
Pressure pulsation			X	14.3.5
Heat rejection			X	14.3.6
Endurance[a]	X			14.3.7
Air ingestion	X			14.3.7.8
Thermal cycles	X			14.3.7.9
Thermal shock	X			14.3.7.10
Minimum inlet pressure test			X	14.3.8
Environmental	X	or	X	14.3.9
Low temperature[b]			X	14.3.9.2
Fire Resistance[c]			X	14.3.9.3
Vibration			X	14.3.10.1
Fatigue (pressure impulse)			X	14.3.10.2
Port strength			X	14.3.10.3
Proof pressure at rated temperature			X	14.3.10.4
Ultimate pressure			X	14.3.10.5
Drive coupling shear			X	14.3.10.6
Additional tests	X	or	X	Detail specification

[a] The shaft seal leakage is permitted to degrade to the limit specified in the detail specification (refer to 5.4.3).

[b] An additional test specimen shall be used if a fire resistance test is required.

[c] An additional test specimen shall be used if a fire resistance test is required.

14.3 Qualification testing

14.3.1 Dimensional check

Prior to the start of the qualification test, conduct the full acceptance test of both test sample pumps. The run-in specified in 13.3.7 may be carried out, if necessary, after reset and before the test sequence is continued.

Check the critical wear dimensions and record the dimensions of each test sample pump. Check these dimensions again for comparison purposes once the qualification tests have been completed.

14.3.2 Expanded envelope acceptance tests

The acceptance tests shall be repeated but the pump shall be run with the following:

a) the fluid temperatures from minimum continuous to rated;

b) flows from zero to rated discharge.

No malfunctions shall be recorded.

14.3.3 Calibration

14.3.3.1 Pump inlet pressurized

Regulate the pressure at the pump inlet port to the rated inlet pressure at full flow and rated speed conditions.

14.3.3.2 Flow rate and driving torque values

Determine values of flow rate and driving torque at minimum operating speed, at 25 %, 50 %, 75 %, 100 %, and 110 % of rated speed. At each of these speeds, make four sets of flow and torque recordings at 25 %, 50 %, 75 %, and 100 % of maximum full-flow pressure and at five equally spaced increments of flow between maximum full-flow pressure and rated discharge pressure.

Unless otherwise specified in the detail specification, perform calibrations at the inlet condition specified in 5.2.4.2 and flow measurements may be made in the line downstream of the load valve but shall be corrected for fluid compressibility.

14.3.3.3 Minimum operating speed

Reduce the speed to below 25 % of the rated speed to determine the speed at which the discharge flow or pressure becomes erratic. Record this point and designate it as the minimum operating speed for that condition.

14.3.4 Maximum pressure and response time tests

14.3.4.1 General

Pressure transducers and recording equipment shall be used to provide a permanent record of the dynamic pressure/time history of the pressure/time function of the pump and its hydraulic circuit throughout the transient and steady-state periods described in the following three tests.

The pressure transducers and recording equipment shall be capable of meeting the repeated accuracy requirements as stated in 12.3 over a frequency range of 0 times to 5 times the pump piston fundamental frequency. An essential consideration is that the dynamic calibration of the pick-up and recording equipment is valid for the dynamic conditions. The pressure transducers shall be located in the pump discharge line as close to the pump outlet fitting as is physically possible. The pressure pulsations shall be measured with a pressure transducer with a minimum additional volume and shall have a frequency range from 20 Hz to 100 kHz. Tests shall be conducted at the rated conditions, unless otherwise noted below or in the detail specification.

14.3.4.2 System impedance

14.3.4.2.1 General

The impedance is calculated from the system configuration, the pump rated discharge and the fluid bulk modulus at rated temperature and rated discharge pressure.

14.3.4.2.2 System impedance for determination of response time

The system impedance of the test circuit when determining the pump response shall meet the following requirements:

a) the pump is operating over the specified flow range and at rated inlet temperature;

b) the rate of pump discharge pressure rise when the flow in the system is suddenly stopped shall be 340 000 kPa/s (50 000 psi/s) minimum.

NOTE The pump discharge pressure rise rate is defined as the average value of the slope of dP/dT during the initial pressure transient increase, prior to the peak value (see Figure 6).

14.3.4.2.3 All other tests

The detail specification shall state the system impedance of the test circuit when determining maximum pressure, pressure pulsations, stability and the remaining qualification tests. The pump shall be installed in a hydraulic circuit that simulates the aircraft system, details of which shall be provided in the detail specification. The system volume may be simulated using tubing of the discharge line diameter while being careful to avoid a line length whose natural frequency is resonant with pulsation frequency.

The high-pressure circuit shall be representative of the pump application.

The system impedance can get very small due to circuit isolation or degraded modes. If it is considered to be appropriate for the pump, the test circuit shall replicate the different system impedances to check for potential pump instability.

14.3.4.3 Maximum transient pressure test

The test circuit specified in 14.3.4.2.2 shall be used. For this test, all gases shall be evacuated from the pump inlet and discharge lines. Flow changes shall be initiated by means of a solenoid-operated valve with a response time, from full closed to full open and vice versa, of 0,02 s or less, or a response time as specified in the detail specification.

Operate the test pump between steady-state maximum full-flow pressure and steady-state rated discharge pressure and make an oscillographic record of the pressure/time function through the transient period. Run the test at 50 %, 60 %, 70 %, 80 %, 90 % and 100 % of rated pump flow. Keep air entrainment in the hydraulic fluid to a minimum. The peak pressure transient as measured on the above record shall not exceed the requirements of 5.8.5, at rated fluid temperature.

14.3.4.4 Determination of response time

This test shall be conducted at the rated fluid temperature. The test set up shall be as follows:

a) the test circuit specified in 14.3.4.2.2;

b) load valves set at a flow condition equivalent to maximum full-flow pressure at 50 %, 75 % and 100 % of pump rated speed.

Use the solenoid valve that changes the discharge line from fully open to fully closed, or vice versa, to conduct the test.

Carry out runs at 50 %, 75 % and 100 % of rated flow or as specified in the detail specification. With the solenoid valve open and the test pump operating at steady-state maximum full-flow pressure, make a record of the pressure/time function through the transient period associated with the closing of the solenoid valve and the establishing of steady-state rated discharge pressure. This record shall be similar to the typical variation shown in Figure 6 and the response time, t_1, as indicated in Figure 6, shall not exceed the specified time at 100 % of rated flow. At 50 % and 75 % of rated speed, t_1 shall not exceed the value specified in the detail specification.

Record the response time t_2 for the change from rated discharge pressure to minimal pressure and, as indicated in Figure 7, t_2 shall not exceed 0,05 s at 100 % rated flow. At 50 % and 75 % of rated speed, t_2 shall not exceed the value specified in the detail specification.

Record the response time t_3 for the change from rated discharge pressure to 90 % maximum full-flow pressure and, as indicated in Figure 7, t_3 shall not exceed 1 s at 100 % rated speed.

Check the response time for small incremental changes of flow as follows:

a) introduce a parallel flowpath which includes an orifice and a downstream solenoid valve with a 0,02 s response time or a response time as specified in the detail specification;

b) adjust this orifice to pass 5 % of maximum full-flow and adjust the main load throttling valve to pass 90 % of maximum full-flow for each of the three pump speed settings;

c) check the response time at each speed setting when the small flowpath solenoid is opened and closed with the main flowpath solenoid valve both opened and closed. The response time at rated speed should not exceed 0,05 s;

d) check the response time at rated speed, rated pressure, minimum inlet pressure and fluid temperature as specified in the detail specification.

14.3.5 Pressure pulsation test

Equip the test circuit specified in 14.3.4.2.3 with a pressure transducer of zero volume and sensitive to 20 kHz to 100 kHz, installed in the pump discharge line.

During this test, the following conditions shall be maintained:

— the pump at rated discharge pressure;

— pump inlet pressure to be at the rated inlet pressure;

— pump case pressure to be at the nominal case pressure;

— fluid temperature to be 50 °C ± 10 °C.

Run the pump to deliver 25 % of rated flow. Make an oscillographic record of the pulsation pattern. Repeat the test with the pump supplying 50 %, 75 % and 100 % of rated flow. The values of pressure pulsations shall not exceed the limits specified in 5.2.3.

14.3.6 Heat rejection test

14.3.6.1 Principle

The principle of this test is to demonstrate the ability of the pump to reject the heat that it generates. When the pump is running at the rated fluid temperature, the fluid temperature in the pump case drain ports should not exceed a specified maximum temperature.

14.3.6.2 Determination of heat rejection

Run the pump at zero pump discharge flow rate and with rated inlet temperature. Measure the pump inlet and pump case drain temperatures when the temperatures have stabilized. Repeat the test with the pump running at rated flow and at least two additional flow points between these values.

Check that the fluid temperatures in the pump case drain port does not exceed the specified maximum temperatures.

14.3.7 Endurance test

14.3.7.1 General

The sample pump shall undergo an accelerated endurance test, as outlined in Tables 6 and 7.

The total endurance time for the pump applications is specified in Table 2. The detail specification shall state any modification of any of the test conditions.

The pump under test shall satisfactorily complete the test with no failure of parts or excessive wear.

The test circuit for the endurance tests shall be as specified in 14.3.4.2.3. Modification of any of the test conditions given in Tables 6 and 7, or additional endurance testing, in the form of additional cycles in any of the phases may be required by specifying such modifications or additions in the detail specification.

The sample pump shall undergo the following endurance tests:

a) normal test

   1 200 h for pumps used for military applications and 3 500 h for pumps used for commercial applications, consisting of the nine phases specified in Table 6 in the order listed, plus two calibrations, the stop-start cycles, filter checks and air ingestion cycles as specified in the following subclauses;

b) overload test

   800 h for pumps used for military applications and 500 h for pumps used for commercial applications, consisting of the four phases specified in Table 7 in the order listed, plus two calibrations, the stop start cycles, thermal cycles and thermal shock test.

Table 6 — Endurance testing — Normal test

Phase[a]	Percentage of the test[b]	Percentage of rated speed	Duration time min	Percentage of nominal inlet pressure	Drain port pressure	Cycles													
						Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as a percentage of rated delivery	Percentage of rated discharge pressure	Duration time s	Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as a percentage of rated delivery	Discharge pressure	Duration time s
1	1,67	70	5	[c]	[d]	70	[e]	120	0	100	30	52,5	[f]	30	14	[f]	90	35	[f]	30
2	3,33	70	10	100	[d]	70	[e]	120	0	100	30	52,5	[f]	30	14	[f]	90	35	[f]	30
3	1,67	70	5	200	[d]	70	[e]	120	0	100	30	52,5	[f]	30	14	[f]	90	35	[f]	30
4	3,33	100	10	[c]	[d]	100	[e]	120	0	100	30	75	[f]	30	20	[f]	90	50	[f]	30
5	73,34	100	220	100	[d]	100	[e]	120	0	100	30	75	[f]	30	20	[f]	90	50	[f]	30
6	3,33	100	10	200	[d]	100	[e]	120	0	100	30	75	[f]	30	20	[f]	90	50	[f]	30
7	1,67	100	5	[c]	[d]	100	[e]	120	0	100	30	82,5	[f]	30	22	[f]	90	55	[f]	30
8	8,33	100	25	100	[d]	100	[e]	120	0	100	30	82,5	[f]	30	22	[f]	90	55	[f]	30
9	3,33	100	10	200	[d]	100	[e]	120	0	100	30	82,5	[f]	30	22	[f]	90	55	[f]	30

[a] Test temperature.

For each range of 125 h or 25 series of the 9 phases above (100 h or 20 series of the 9 phases above for the last range of the 600 h endurance test):

a) If the rated temperature (see 3.6.1) is equal to 45 °C (type I systems), all phases shall be run at this temperature.

b) If the rated temperature is equal to 110 °C (type II systems),

— 3 series of 9 phases shall be run with inlet temperature equal to 70 °C;

— 15 series (10 series for the last range of the 600 h endurance test) of 9 phases shall be run with inlet temperature equal to 90 °C;

— 7 series of 9 phases shall be run with inlet temperature equal to 110 °C.

c) If the rated temperature is equal to 170 °C (type Ill systems),

— 3 series of 9 phases shall be run with inlet temperature equal to 70 °C;

— 15 series (10 series for the last range of the 600 h endurance test) of 9 phases shall be run with inlet temperature equal to 150 °C;

— 7 series of 9 phases shall be run with inlet temperature equal to 170 °C. For type III systems, the full schedule for the normal endurance test shall be as specified in the detail specification.

[b] A time tolerance of ±1 % is permissible on the duration of each phase. The total test duration shall be as specified in 14.3.7.1 a) as a minimum.

[c] The inlet pressure for these phases shall be equal to 1 bar absolute or 1,1 times the minimum inlet pressure (defined in 14.3.8), whichever is the greater.

[d] The drain port pressure shall be as specified in the detail specification. It shall be set by means of a fixed restriction at maximum drain flow condition.

[e] The discharge pressure shall be equal to 95 % of maximum full-flow pressure.

[f] Pressure shall be adjusted to provide the flow stipulated.

Table 7 — Endurance testing — Overload test

Phase[a]	Percentage of the test[b]	Percentage of rated speed	Duration time min	Percentage of nominal inlet pressure	Drain port pressure	Cycles														
						Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as a percentage of rated delivery	Discharge pressure	Duration time s	Flow as percentage of rated delivery	Percentage of rated discharge pressure	Duration time s
1	40	100	240	100	c	100	d	120	75	e	30	50	e	30	20	e	90	0	115	30
2	10	100	60	200	c	100	d	120	75	e	30	50	e	30	20	e	90	0	115	30
3	40	115[f]	240	g	c	100	d	120	94	e	30	62,5	e	30	25	e	90	0	115	30
4	10	115[f]	60	g	c	100	d	120	94	e	30	62,5	e	30	25	e	90	0	115	30

[a] Test temperature.

For each series of 4 phases above:

a) If the rated temperature (see 3.6.1) is equal to 45 °C, all phases shall run at this temperature.

b) If the rated temperature is equal to 110 °C,

— 1/5 of the overload test shall be run with inlet temperature equal to 70 °C;

— 3/5 of the overload test shall be run with inlet temperature equal to 90 °C;

— 1/5 of the overload test shall be run with inlet temperature equal to 110 °C.

c) If the rated temperature is equal to 170 °C,

— 1/5 of the overload test shall be run with inlet temperature equal to 70 °C;

— 3/5 of the overload test shall be run with inlet temperature equal to 90 °C;

— 1/5 of the overload test shall be run with inlet temperature equal to 170 °C.

For type III systems, the full schedule for the overload endurance test shall be as specified in the detail specification.

[b] A time tolerance of ±1 % is permissible on the duration of each phase. The total test duration shall be specified in 14.3.7.1 b) as a minimum.

[c] The drain port pressure shall be as specified in the detail specification. It shall be set by means of a fixed restriction at maximum drain flow condition.

[d] The discharge pressure shall be equal to 100 % of maximum full-flow pressure.

[e] Pressure shall be adjusted to provide the flow stipulated.

[f] The overspeed of phases 3 and 4 will apply to all pumps, the rated speed of which meets the requirements laid down in 5.5.2. Where the rated speed laid down in the detail specification exceeds those shown, subtract 20 % of the overspeed percentage for every 10 % the pump is rated above the value given in 5.5.2, except that the overspeed cannot be less than 110 % of the rated speed in phases 3 and 4.

[g] The inlet pressure for phase 3 shall be as defined by the manufacturer. For phase 4, the inlet pressure shall be doubled relative to phase 3.

14.3.7.2 Hydraulic fluid

The test system shall be filled at the start of the endurance test and no fluid shall be added before the endurance tests are completed, except in the following cases:

a) the amount of fluid unavoidably lost from the system when filters are checked may be replaced;

b) in the event of damage to the test system away from the pump, resulting in loss or contamination of the fluid not related to the endurance qualities of the pump, the system fluid may be completely replaced;

c) in order to maintain the fluid within the physical and chemical property limits drawn up by the purchaser.

A record shall be made of when and how much fluid is added.

14.3.7.3 External leakage permissible during endurance testing

Throughout the endurance test (including the recalibration time), there shall be no external leakage sufficient to form a drop, except for the shaft seal [refer to 5.4.3 b)].

14.3.7.4 Filtration for endurance tests

14.3.7.4.1 General

Pass the hydraulic fluid used for the endurance tests through a 5 µm absolute filter before entering the test system.

Unless the detail specification states the contamination class or filter capability, install 15 µm absolute filters on the fluid inlet, outlet and drain lines during the endurance tests. If the detail specification states the contamination class, install the required filters to achieve the required level of fluid contamination.

14.3.7.4.2 Filter check

The use of inline particle counters installed in the pump case and discharge lines is recommended to monitor the cleanliness of the fluid during the endurance test.

However, if these are not available, then the monitoring of the particulates in the test rig filters is required. Unless otherwise specified in the detail specification, install clean filter elements in all three filters at intervals of 100 h ± 20 h during the endurance tests. Resume the endurance test schedule for 2 h, at the end of which remove these filter elements and replace with clean filter elements. Check the filter elements removed after 2 h operation in accordance with 13.3.11.3.4.

14.3.7.5 Calibration

Calibrate the pump using the procedure specified in 13.3.10 before starting phase 1 of both the normal and the overload endurance tests for each test series and also on completion of the full test schedule. Plot the results of these three calibrations on one chart to show the effect of the endurance test on the performance of the pump.

NOTE The calibration tests can be conducted more frequently if required in the detail specification.

14.3.7.6 Start-stop cycles

14.3.7.6.1 General

Start-stop cycles shall be conducted at the beginning and at the end of the endurance test. Fluid temperatures may range from ambient to rated temperature but the actual values shall be recorded.

For those cycles run following the overload test, the compensator shall be left adjusted at its maximum pressure.

14.3.7.6.2 Full-load cycles

Unless otherwise specified in the detail specification, accelerate the pump to rated speed within 2 s, with the load orifice adjusted to 95 % of maximum full-flow pressure for the first half of the cycles and to 110 % of rated pressure for the last half of the cycles. Allow the pump to coast to a stop immediately after reaching rated speed. Record the deceleration time.

Perform one full-load start-stop cycle for each 3 h of endurance testing performed. Carry out half the cycles before the start of the normal endurance test and perform the other half following the overload endurance test.

14.3.7.6.3 No-flow cycles

Follow the same procedure as specified in 14.3.7.6.2, except the discharge line shall be blocked during starts and stops and between cycles the discharge pressure shall be reduced to approximately 700 kPa (100 psi).

The number of start-stop cycles, at no flow, shall be half the number of cycles at full capacity.

Carry out half of the cycles before the start of the normal test and perform the other half following the overload endurance test. If the pump includes a depressurization device that is used as an engine starting aid, deactivate the device when the pump reaches 50 % of rated speed.

14.3.7.7 Pump case pressure cycles

Throughout all the 13 phases of the endurance test, the pump case shall be subjected, at approximately equal intervals of running time, to internal pressure impulses originating in the case drain (or by-pass) line and reaching at least 3 500 kPa (500 psi) or 150 % of actual case drain pressure, whichever is the greater. Unless otherwise specified in the detail specification, the time from the start of the pressure impulse to the initial return to normal case pressure shall be not less than 0,1 s and not more than 0,5 s.

Apply at least 20 000 pressure cycles to the pump case, distributed with reasonable uniformity over the 13 phases of the endurance test. Make an oscillographic, or equivalent, record of the pressure impulse within the first hour of the endurance test and with each 200 h thereafter to keep a check that the pressure-time history of the impulse is maintained.

14.3.7.8 Air ingestion

A test shall be carried out simulating the ingestion of air by the hydraulic circuit as a result of the replacement of elements during maintenance operations, after the completion of the overload test. For the air ingestion test, use the aircraft's reservoir, or an agreed equivalent, and use the aircraft suction line size, length, and configuration together with rated inlet pressure of the applicable aircraft in question.

Unless otherwise required in the detail specification, this test shall also be performed during endurance testing according to the periodicity defined below.

Arrange the line supplying fluid to the pump so that a 1,20 m (50 in) length of line immediately adjacent to the pump can be disconnected, vented, drained, and reconnected without draining the rest of the test system. Stop the test while the pump is operating at full flow at a frequency agreed between the supplier and the purchaser. Depressurize the reservoir, disconnect, vent, drain and reconnect the 1,20 m (50 in) length of inlet line. Restart the pump with the test system set to develop maximum full flow. 30 s after the restart, record the discharge pressure, then pressurize the reservoir and resume the endurance test schedule.

14.3.7.9 Thermal cycles

After completion of the overload test, eight thermal cycles of the pump from –30 °C to rated temperature shall be carried out.

With the pump delivering no flow, stabilize the pump and test system at –30 °C for 1 h. Then start and operate the pump at maximum rated pressure, flow and rated inlet pressure until the fluid reaches rated temperature. This operation shall comprise one cycle. The detail specification shall state the heating rate.

14.3.7.10 Thermal shock

After completion of the overload test, a thermal shock cycle shall be completed.

Cool the pump and fluid in the pump to a temperature of –55 °C or the temperature specified in the detail specification. Maintain the hydraulic reservoir temperature at rated temperature. The reservoir shall contain a volume of fluid equal to that in the aircraft system or as specified in the detail specification. Start the pump and bring up to rated speed in a time interval specified in the detail specification. The pump shall not malfunction.

14.3.7.11 Part failure

Should the endurance test program be interrupted because of a part failure, the pump shall be replaced or repaired using a part or parts of modified design. In the event of a material defect or manufacturing error, it may be possible to fit a part of the same design as the broken part, without the defect.

The program shall be considered to be complete if all the pump parts have fulfilled the program requirements specified in the detail specification without failure. Should the pump tests be continued, after failure of one or more parts, with repaired or replaced parts, subsequent failure of parts which have fully met the endurance requirements shall not be considered as a reason for rejection.

14.3.7.12 Tear-down inspection

14.3.7.12.1 Pump inspection

After the completion of the endurance tests, dismantle the pump, inspect all parts visually and prepare a dimensional statement of the working parts, to enable an analysis of the wear effects to be conducted.

The general condition of the parts shall be reported.

14.3.7.12.2 Filter inspection

At the completion of the endurance tests, remove the filter elements and check for evidence of abnormal wear particles.

14.3.7.13 Additional endurance test

The detail specification may also specify a dedicated endurance test that closely resembles the aircraft duty cycle. If this is required, the detail specification shall state the total endurance test time and provide sufficient details to enable a representative test to be conducted.

14.3.8 Minimum inlet pressure test

Operate the pump at rated flow rate, rated inlet temperature and 90 % of maximum discharge pressure. Adjust the fluid pressure at the pump inlet port to 120 % of rated inlet pressure. Measure the rate of flow and discharge pressure as inlet pressure is reduced down to the minimum inlet pressure. Confirm that there is no degradation in performance with the pump running at the minimum inlet pressure.

Continue reducing the inlet pressure until cavitation occurs (i.e. 2 % reduction in the pump discharge flow).

Confirm that the margin between the critical inlet pressure (i.e. when cavitation occurs) and the minimum inlet pressure is appropriate for the pump application.

14.3.9 Environmental tests

14.3.9.1 General

Tests shall be conducted on the pump, or relevant parts of the pump, if it cannot be demonstrated by analogy or analysis that the pump complies with the environmental requirements of 5.12.

14.3.9.2 Low temperature test

The test circuit for the low temperature test shall be as specified in 14.3.4.2.3. All temperature requirements apply equally to the pump body, hydraulic fluid and ambient environment. The ambient environment may vary ±10 °C. Start up the pump and uniformly accelerate to 50 % of rated flow rate in not more than 10 s, unless otherwise specified in the detail specification, after

a) at least 18 h at the minimum inlet temperature specified in the detail specification, or

b) between –50 °C to –55 °C unless otherwise specified in the detail specification.

Carry out 20 runs with the outlet pressure at low as practicable and the inlet pressure as specified in the detail specification. Rated flow rate should be reached within 20 s after start-up; when it has been reached, maintain it for at least 10 s; observations shall indicate whether the pump displaces fluid through the hydraulic system.

Then carry out five start-ups and runs, with the pump discharge line terminating in a relief valve set to pass fluid at rated pressure. In addition, carry out five starts with the pump discharge line completely closed so that the pump will operate at the stalled condition.

If the pump includes a depressurization device that is used as on engine starting aid (for example), activate the device during starts and deactivate it when the pump reaches 50 % of rated speed.

Throughout the tests, after each run, allow the pump and fluid to stand idle long enough for them to be restored to the above soaking temperature before starting the next run.

Throughout the tests, the test circuit shall contain a volume simulating operating conditions in the aircraft system or as specified in the detail specification.

14.3.9.3 Fire resistance test

The detail specification shall state the pump running speed and discharge flow rate to be used for this test.

14.3.10 Structural tests

14.3.10.1 Vibration tests

14.3.10.1.1 General

See ISO 7137.

14.3.10.1.2 Position of the pump under test

Mount the test pump successively on a vibration-generating mechanism in each of at least three axes that shall be representative of the pump installation in terms of the application. Carry out all of the

testing specified in each of the mounting positions. One of these mounting positions shall be chosen so that the direction of vibratory motion shall be parallel to the shaft axis of the pump.

14.3.10.1.3 Pump operating during vibration tests

If it is determined that more potential damage to the pump will be incurred as a result of it being non-operational during the vibration tests, then it is permissible to conduct the vibration tests with the pump in a static unpressurized condition.

However, if it is determined that the pump will incur more damage with it being run during the vibration tests, and then the following applies.

Throughout the vibration tests specified in 14.3.10.1.4, 14.3.10.1.5 and 14.3.10.1.6, the pump shall be operated in the test circuit given in 14.3.4.2.3. Fluid temperature at the pump inlet shall be maintained at 60 °C, regardless of the rated temperature of the pump being tested, and ambient temperatures shall be maintained at room ambient conditions. The pump discharge flow shall fluctuate in continuous cycles from zero flow to approximately 50 % of rated discharge. These flow cycles shall be abruptly accomplished by operating solenoid valves at a rate of 5 cycles/min. Transition from one condition of flow to the other condition of flow shall be accomplished in a valve time of less than 0,5 s.

If the pump is equipped with a control device (shut-off valve, etc.), the detail specification shall state the cycles between the different modes.

14.3.10.1.4 Resonant frequency vibration test

Search for resonant frequencies in accordance with the double amplitude and frequency charts in ISO 7137. The detail specification shall state the applicable procedures and test values.

14.3.10.1.5 Cyclic frequency vibration test

On completion of the resonant frequency vibration test, apply a cycling vibration in accordance with ISO 7137. The detail specification shall state the applicable procedures and test values.

14.3.10.1.6 Other vibration tests

Other vibration tests shall be specified in the detail specification when a special installation imposes particularly severe environmental conditions.

14.3.10.2 Fatigue (pressure impulse) tests

The pump shall be subjected to a pressure impulse test to demonstrate that the pump complies with the requirements of 7.5. The detail specification shall state the following:

— the method of testing;

— the frequency of the application of the pressure impulse;

— the shape of the pressure impulse wave form;

— if the fluid temperature is at room temperature only or at various temperatures including the minimum continuous, ambient and the rated temperature.

A permanent record of the dynamic pressure/time history of the pressure impulse test shall be made. Unless otherwise agreed between the purchaser and the supplier, this shall be repeated at every 15 000 cycles to ensure that the pressure/time history of the impulse is maintained.

No evidence of cracks in any part of the component shall occur.

14.3.10.3 Port strength

The ports on the pump shall be subjected to a port strength test to demonstrate that the pump complies with the requirements of 7.6.

No permanent distortions or alterations in the ports and the relevant areas of the pump case shall occur.

14.3.10.4 Proof pressure test at rated fluid temperature

Prior to the test, take measurements of key dimensions. Then conduct the proof pressure tests as specified in 13.3.4 but with the hydraulic fluid at its rated temperature.

Then measure the same dimensions and check that no permanent damage has been caused to the pump.

14.3.10.5 Ultimate pressure test

The ultimate pressure test to show compliance with the requirements of 7.4 shall be applied once for 5 min.

Conduct the test with the hydraulic fluid at its rated temperature.

This test should be conducted last on one specimen since no further operations on that pump are specified.

14.3.10.6 Drive coupling shear test

Remove the drive coupling from the pump and install it in a suitable test fixture for the torsion test. Load the coupling torsionally until failure occurs. Record the load at which the failure occurs. The failure shall take place at the shear section of the coupling.

14.3.11 Supplementary tests

Supplementary tests such as a bench handling drop test and a package drop test (together with the test procedures to be used) may be specified in the detail specification.

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[1] ISO 6771, *Aerospace — Fluid systems and components — Pressure and temperature classifications*

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