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Aerospace series — AC induction electric motor driven, variable delivery, hydraulic pumps — General requirements

Série aérospatiale — Pompes hydrauliques à débit variable, actionnées par des moteurs électriques à induction CA — Exigences générales

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Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 10, *Aerospace fluid systems and components*.

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Aerospace series — AC induction electric motor driven, variable delivery, hydraulic pumps — General requirements

1 Scope

This document establishes the general requirements for electric motor driven, variable delivery, hydraulic pumps suitable for use in aircraft hydraulic systems.

This document includes the general requirements for Alternating Current (AC) induction electric motor powered units. The AC power electrical power supply can be either controlled to provide a Constant Frequency (CF) or uncontrolled to provide a Variable Frequency (VF) AC supply to the electric motor.

This document is intended to be used in conjunction with the detail specification that is particular to each application.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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 6771, *Aerospace — Fluid systems and components — Pressure and temperature classifications*

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 8278, *Aerospace series — Hydraulic, pressure compensated, variable delivery pumps — General requirements*

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*

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ISO 11218:1993, *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, and ISO 8625-3 and the following apply.

NOTE See ISO 8278 for terms and definitions that relate to the variable delivery hydraulic pump.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
electric motor driven variable delivery, hydraulic pump
EMP
hydraulic pump driven by an electric motor that is able to supply hydraulic power to the hydraulic system (or sub-system) to meet a variety of functions within the aircraft system

Note 1 to entry: Examples of these functions are listed below:

— as the primary power source for the hydraulic system to supply fluid as demanded by the system, either continuously operating or switched on for particular phases of the aircraft operation e.g. for take-off and landing;

— as a back-up source when the primary source has failed; and

— as a power source to be used when the aircraft is on the ground to operate various utility functions or for ground maintenance purposes.

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Note 2 to entry: To operate the EMP, the electrical supply may be derived from various electrical sources, including the main engine driven generators, auxiliary power unit driven generators, or ground cart generators.

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:

— technical requirements;

— acceptance and qualification test requirements;

— reliability requirements;

— quality requirements;

— packaging requirements; and

— other requirements.

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3.4
supplier
organization that provides the EMP

Note 1 to entry: Typically, the purchaser is the manufacturer of the EMP 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

3.5.2
pump discharge port
port that supplies pressurised 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

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

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

3.6.2
minimum continuous temperature
minimum temperature of the fluid at the supply port of the pump at which the pump is able to function

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

Note 2 to entry: This temperature is generally higher than the survival temperature.

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.

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3.7.2 Inlet pressure

3.7.2.1
rated inlet pressure
minimum pressure measured at the inlet port of the EMP 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 EMP 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 EMP might be required to operate without cavitation during a system failure or during a system high-flow transient condition

Note 1 to entry: For the purposes of this document, 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 EMP is required to operate continuously at:

— rated supply voltage;
— rated supply frequency;
— rated fluid temperature;
— rated inlet pressure;
— rated case drain pressure;
— zero flow; and
— using the hydraulic fluid specified in the detail specification.

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Note 1 to entry: The diagram in Figure 1 is given as an indication. It may be presented in a different way, for example, the axes may be reversed.

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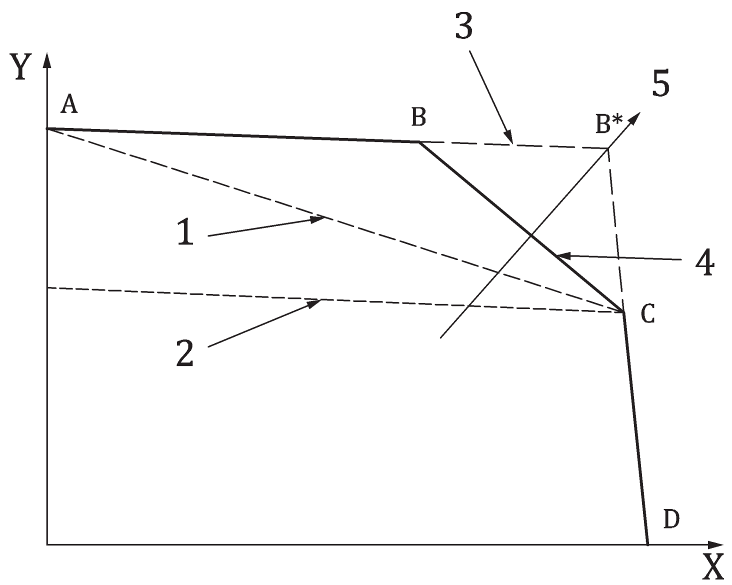

Key

1	differential pressure type pump characteristics	A	rated pressure
2	constant pressure type pump characteristics	B	minimum flow at maximum pressure point
3	constant pressure type pump characteristics	B*	cut-off pressure for constant pressure pump
4	constant power type pump characteristics	C	full flow at minimum pressure point
5	increasing power and weight	D	maximum flow point
		X	flow in l/min
		Y	pressure in kPa

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Figure 1 — Discharge pressure

3.7.3.1
maximum full-flow pressure
maximum discharge pressure at which the EMP 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 EMP 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 EMP 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 EMP to enable case drain fluid to return to the reservoir

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

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

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

— rated supply voltage;

— rated supply frequency;

— 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.

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

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

— permissible manufacturing tolerances;

— distortions of the pump structure;

— the compressibility of the hydraulic fluid;

— internal leakage; and

— 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 EMP pump will operate at based on:

— maximum AC supply frequency;

— rated voltage.

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 EMP delivery pressure begins and the subsequent time when the delivery pressure reaches its first maximum (or minimum) value, when connected to a specified circuit

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

3.13 Electrical terms

3.13.1
nominal electric supply condition
nominal system voltage and frequency without consideration of any distribution drop or cable impedance

3.13.2
starting in-rush current
RMS value of the current ignoring any initial half cycle transient effects

3.13.3
voltage drop
reduction in voltage across a given wire length for each phase of an AC electrical supply

3.14
EMP overall efficiency
ratio of the EMP pump output fluid power to the EMP electric motor input electrical power when the EMP is operating at rated conditions or any other operating conditions if so specified in the detail specification. It is derived from the following formula:

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$$\text{EMP overall effiency (\%)} = [(\Delta P_p \times Q_p)/(V \times I \cos \phi)] \times 100 \quad (1)$$

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where

ΔP_p differential pressure between the EMP pump delivery and inlet ports (kPa);

Q_p EMP pump delivery flow (l/min);

V supply Voltage (volts) for AC volts the Root Mean Square (RMS) value shall be used;

I supply Current (amps) for AC current the Root Mean Square (RMS) value shall be used;

Φ phase angle between voltage and current

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

Note 2 to entry: For a three-phase AC supply, the power should be derived from the summation of the powers for each phase, i.e. $V_A I_A + V_B I_B + V_C I_C$ multiplied by the power factor ($\cos \phi$). For a balanced supply, the input power equates to ($3 \times V_A \times I_A \cos \phi$).

3.15
rated endurance
total number of hours and cycles of operation to be included in the endurance phase of its qualification testing

3.16
first article inspection
FAI
process that conducts:

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

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

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

— 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 document and the detail specification.

4.2 Electrical system characteristics

The detail specification shall define the range of electrical supply characteristics for normal and abnormal operation. This shall include any of the normal faults such as power interruption. Any deviation from the nominal performance due to variations in the electrical supply shall be agreed between the supplier and the purchaser as early as possible in the design phase. The effect of the aircraft feeder cables shall be considered as part of the electrical supply.

4.3 Hydraulic system characteristics

The detail specification shall include the characteristics of the hydraulic system in which the EMP is to be used in order to assist in the integration of the EMP into the hydraulic system.

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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:

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— normal operating temperature;

— rated temperature; and

— minimum continuous temperature.

4.4 Airworthiness requirements

The EMP shall comply with the applicable airworthiness requirements.

4.5 Qualification

EMPs furnished under this document shall be products that have passed the qualification tests specified in the detail specification.

5 Functional requirements

5.1 Functional requirements - electrical

5.1.1 AC power requirements

5.1.1.1 General

The power supply should be compliant with the specifications provided in ISO 1540. Any non-compliance should be defined in the detail specification.

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5.1.1.2 Rated voltage

The detail specification shall define the rated voltage at the point of regulation (POR), taking into consideration all potential sources of power that will be applied to the EMP. The rated voltage shall be defined at the interface with the EMP, i.e. at the electrical connector. The rated voltage range shall be defined under normal operating conditions and the minimum shall be defined for start-up.

The rated voltage at the POR shall be defined and will typically be a nominal value of either 115 or 230 V AC per phase (single or three phases). The voltage drop between the POR and the electrical motor connector shall be defined in the detail specification to allow for reduction in voltage under all operating conditions. The voltage drop and the phase shift between the rated voltage and the current that is introduced between the POR and motor connector shall be defined in the detail specification. Alternatively, the feeder cable impedance should be defined in the detail specification.

The voltage drop in the return path should be taken into consideration when determining the power available to run the electric motor, particularly for those aircraft that are manufactured from composite materials.

5.1.1.3 Rated AC frequency

5.1.1.3.1 Constant AC frequency supply

The detail specification shall define the rated frequency taking into consideration all potential sources of power that will be applied to the EMP. Typically, a constant frequency supply will maintain the frequency within the range from 385 Hz to 415 Hz with a nominal value of 400 Hz. However, each application should specify the actual application range.

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5.1.1.3.2 Variable AC frequency supply

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The detail specification shall define the rated frequency taking into consideration all potential sources of power that will be applied to the EMP. The frequency range for engine driven generator derived power sources will be dependent on the engine speed range for each application; the ratio between the minimum and maximum frequencies may exceed 2:1. Typically, the frequency range lies between 360 Hz min to 800 Hz max.

5.1.1.4 Input current

5.1.1.4.1 Rated input current

The electrical current supplied to the motor in steady state when operating at nominal electrical supply conditions and in normal temperature conditions (+20 °C) shall be specified in the detail specification.

For VF systems, a specific frequency or frequency points should be specified.

The maximum electrical current supplied to the equipment in steady state at full output shall be specified in the detail specification at the minimum ambient and fluid operating temperatures.

The maximum electrical current at maximum ambient and fluid temperatures should also be specified; typically, these are 70 °C and 107 °C. A de-rated performance at extreme temperatures should be provided in the detail specification.

The power factor of the EMP shall be specified in the detail specification with the relevant operating conditions, for example, during the EMP start up and when running in steady state conditions at full power.

5.1.1.4.2 Starting (in-rush) current

The starting in-rush current of the EMP, whatever the voltage at the POR and considering the voltage drop between POR and EMP terminals shall be defined in the detail specification.

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