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Aerospace — Linear hydraulic utility actuator — General specifications

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Linear hydraulic utility actuators are designed to move structural elements of a flight vehicle from one position to another to allow the functioning of various flight vehicle systems, such as landing gear, cargo doors, in-flight refuelling probes, etc.

It is noted that, while ISO standards should normally refer only to SI units, large segments of the aerospace industry refer to other measurement systems as a matter of common working practice. All dimensions used in this document are in SI units with the non-SI units given in addition for the convenience of those users more familiar with these.

It is further noted that the standard ISO decimal symbol "," (comma) is not used as common working practice for inch dimensions. A decimal point is used in the inch dimensions in this document as in many other aerospace standards.

NOTE The use of non-SI units and the decimal point in this document does not constitute general acceptance of measurement systems other than SI within International Standards.

Aerospace — Linear hydraulic utility actuator — General specifications

1 Scope

This document establishes the general requirements for a linear hydraulic utility actuator, herein referred to as a "utility actuator", for use in flight vehicle hydraulic systems at pressures up to 35 000 kPa (5 000 psi).

These requirements include:

— design requirements;

— test requirements.

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

NOTE Although Brake pistons and Landing Gear Bogie (Truck) Pitch Trimmers are utility actuators, they are outside the scope of this document. This is because these devices are considered to be specialist actuator devices due to their specific duty cycles requiring a separate set of tailored requirements.

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.

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

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

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 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, *Aerospace — Cleanliness classification for hydraulic fluids*

SAE AS4088, *Aerospace Rod Scraper Gland Design Standard*

SAE AS4716, *Gland Design, O-Ring and Other Elastomeric Seals*

SAE AS5781, *Retainers (Backup Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Single Turn, Scarf-Cut, For Use in AS 4716 Glands*

SAE AS5782, *Retainers (Backup Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Solid, Un-Cut, For Use in AS 4716 Glands*

SAE AS5857, *Gland Design, O-ring and Other Elastomeric Seals, Static Applications*

SAE AS5860, *Retainers, (Back-Up Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Single Turn, Static Gland*

SAE AS5861, *Retainers, (Back-Up Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Solid, Static Gland*

MIL-STD-810, *Environmental Engineering Considerations and Laboratory Tests*

MMPDS *Metallic Materials Properties Development and Standardization Handbook*

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.

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

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

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

3.1
utility actuator
two-position hydraulic utility actuator that is controlled by an external selector valve

Note 1 to entry: The scope of this document is not limited to those utility actuator configurations shown in Figures 1 to 6, as these are only examples.

3.2
single acting hydraulic utility actuator
utility actuator (3.1) that is hydraulically powered in one direction and returned to the other by a spring or externally applied mechanical force

Note 1 to entry: A typical configuration of a single acting utility actuator is shown schematically in Figure 1.

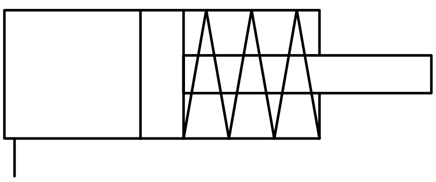

Figure 1 — Single acting utility actuator

3.3
double acting hydraulic utility actuator
utility actuator (3.1) that is hydraulically powered in both directions

Note 1 to entry: Typical configurations of double acting hydraulic utility actuators are shown schematically in Figure 2, Figure 3, Figure 4, Figure 5 and Figure 6.

Note 2 to entry: Figure 3 shows an actuator with piston rods that are equal in diameter. However, this type of actuator may have unequal rod diameters.

Note 3 to entry: The utility actuators can incorporate restrictors to control the extension and/or the retraction time.

Note 4 to entry: The utility actuators can incorporate *end of travel snubbing* (3.5.2) at one or both ends of the actuator stroke.

Note 5 to entry: If the utility actuator is an unequal area actuator, pressure can be applied at both ports to extend the utility actuator by permitting the fluid to circulate from the annulus side to the piston side.

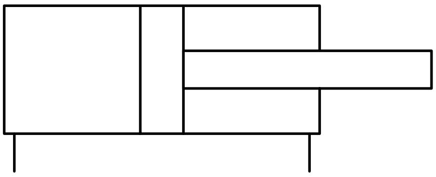

Figure 2 — Simple utility actuator with extend and retract port

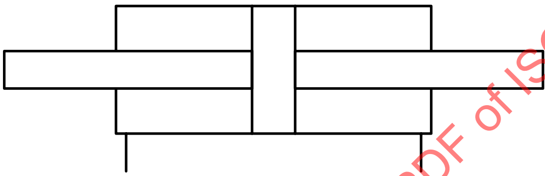

Figure 3 — Double ended utility actuator

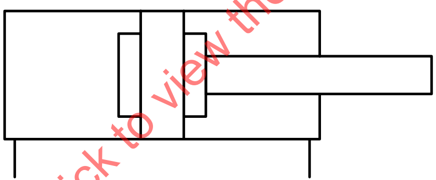

Figure 4 — Utility actuator with end of travel snubber (in extension and retraction)

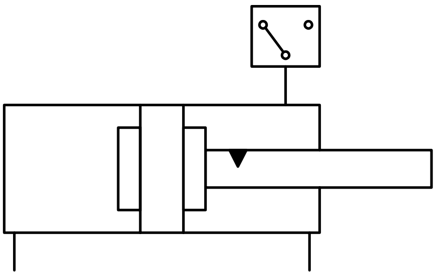

Figure 5 — Utility actuator with end of travel snubber (in extension and retraction), extend lock and lock indicator

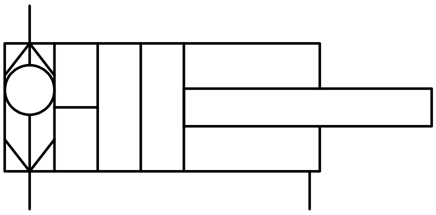

Figure 6 — Utility actuator with a shuttle valve for alternate supply power extend actuation

3.4
non-bottoming utility actuator
utility actuator (3.1) that does not rely on internal end stops for positioning as the extended and/or retracted positions of the utility actuator are dictated by external features such as mechanical stops on structure

Note 1 to entry: For non-bottoming utility actuators, the loads are generated by the internal pressures of the utility actuator only because the piston is floating.

3.5 Velocity damping and end of travel snubbing

3.5.1
velocity damping
incorporation of means to reduce the *utility actuator* (3.1) stroke velocity during extension and/or retraction

3.5.2
end of travel snubbing
incorporation of means to reduce the *utility actuator* (3.1) stroke velocity towards the extension and/or retraction end stop to reduce impact loads

3.5.3
end of travel velocity
rate of the *utility actuator* (3.1) upon reaching its mechanical end stop(s)

3.6 Design operating pressure (DOP)

3.6.1
system DOP
normal maximum steady pressure that is applied to the actuator from the hydraulic power generation system

Note 1 to entry: Excluded from this are:

— reasonable tolerances and transient pressure effects such as may arise from acceptable pump ripple, or

— reactions to system functioning or demands that may affect fatigue.

3.6.2
actuator DOP
sustained pressure that is generated within the actuator due to pressure intensification, such as end of stroke damping

3.7 Load

3.7.1
stall load
maximum load at which the external force applied to the *utility actuator* (3.1) in the opposing direction to that in which the utility actuator is operating, equals the internal hydraulic force generated by the utility actuator

Note 1 to entry: Beyond this point, the actuator may or may not be back-driven depending on the hydraulic circuit configuration.

Note 2 to entry: This load also corresponds to a static hydraulic chamber pressure (hydraulic load) that the actuator cylinder housing has to withstand.

3.7.2
limit structural load
maximum external load applied to the *utility actuator* (3.1) in either the extended or retracted position at the extent of the normal (nominal or worst case) operating conditions

Note 1 to entry: The limit structural load also takes into consideration the combined effects of both axial and bending loads, if applicable.

3.7.3
ultimate structural load
load that the *utility actuator* (3.1) withstands without buckling or structural failure, and normally associated with system single failure cases or flight outside the normal flight envelope

Note 1 to entry: The ultimate structural load also takes into consideration the combined effects of both axial and bending loads, if applicable.

3.7.4
break out seal and scraper friction load
load that the seals and the scraper(s) impose on the *utility actuator* (3.1) rod that has to be overcome before the actuator can start moving

3.8 Temperature

3.8.1 Ambient temperature

3.8.1.1
maximum rated temperature
<ambient> maximum continuous temperature of the air surrounding the *utility actuator* (3.1)

Note 1 to entry: This temperature is generally lower than the *survival temperature* (3.8.3).

Note 2 to entry: Temperatures are expressed in degrees Celsius.

3.8.1.2
minimum operating temperature
<ambient> minimum temperature of the air surrounding the *utility actuator* (3.1)

Note 1 to entry: This temperature is generally higher than the *survival temperature* (3.8.3).

Note 2 to entry: Temperatures are expressed in degrees Celsius.

3.8.2 Hydraulic fluid temperature

3.8.2.1
maximum rated temperature
<hydraulic fluid> maximum continuous temperature of the hydraulic fluid within the *utility actuator* (3.1)

Note 1 to entry: This temperature is generally lower than the *survival temperature* (3.8.3).

Note 2 to entry: Temperatures are expressed in degrees Celsius.

3.8.2.2
minimum operating temperature
<hydraulic fluid> minimum temperature of the hydraulic fluid within the *utility actuator* (3.1)

Note 1 to entry: This temperature is generally higher than the *survival temperature* (3.8.3).

Note 2 to entry: Temperatures are expressed in degrees Celsius.

3.8.3
survival temperature
minimum or maximum temperature of the fluid or air that the actuator will be exposed to without being required to function

Note 1 to entry: Temperatures are expressed in degrees Celsius.

3.9
purchaser
organization that has the engineering responsibility for the hydraulic system that includes the *utility actuator* (3.1)

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

Note 2 to entry: The purchaser is responsible for the compilation of the *detail specification* (3.11).

3.10
supplier
organization that provides the *utility actuator* (3.1)

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

3.11
detail specification
document compiled by the *purchaser* (3.9) that specifies the following:

— the technical requirements;

— the acceptance and qualification test requirements;

— the reliability requirements;

— the quality requirements;

— the packaging requirements;

— any other requirements

3.12
first article inspection
FAI
process that conducts the following:

— verifies that the parts of a component comply 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

3.13
service life
period from first installation of the *utility actuator* (3.1) to its last removal for scrapping

3.14
normal extension and retraction
extension and retraction of the *utility actuator* (3.1) under load conditions normally encountered by the actuator

3.15
maximum extension and retraction
extension and retraction of the *utility actuator* (3.1) under maximum load conditions, not *stall load* (3.7.1)

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 Hydraulic system characteristics

The utility actuator shall be designed for installation in hydraulic systems as specified in the detail specification. The specification shall include the characteristics of the hydraulic system in which the utility actuator is to be used.

The following information shall be provided in the detail specification to enable the supplier to ensure that the utility actuator is correctly integrated into the hydraulic system:

— the system DOP;

— the pressure/flow characteristic (P/Q curve) at the utility actuator interface(s);

— the operational loads;

— the operational and non-operational ambient and fluid temperatures;

— the fluid type;

— the fluid cleanliness limits according to ISO 11218;

— the selector valve characteristics;

— the predicted imported transient pressures.

4.3 Qualification

Utility actuators furnished in accordance with this document shall be products that have passed the qualification tests specified in the detail specification.

4.4 Airworthiness requirements

The utility actuator shall comply with the applicable airworthiness requirements.

5 Functional requirements

5.1 General

This clause refers to aircraft, helicopter or missile (henceforth called flight vehicle) requirements.

5.2 Actuator type

The detail specification shall state if the utility actuator is a single acting hydraulic utility actuator or a double acting hydraulic utility actuator.

If the utility actuator is a single acting type, the detail specification shall state if the means to return the utility actuator to its unpressurized position after actuation is by an internal spring or by an external force.

5.3 Features incorporated within the utility actuator

The detail specification shall state any specific features that are to be incorporated within the utility actuator, for example:

— extend and/or retract rate control (velocity damping);

— end of travel snubbing for the utility actuator extension/retraction;

— internal or external locks;

— single hydraulic supply or dual hydraulic supply (via a shuttle valve);

— filters.

5.4 Hydraulic fluid

The detail specification shall state the applicable hydraulic fluid(s).

5.5 Performance

5.5.1 General

The purchaser shall define the performance requirements to the supplier. The purchaser shall define the operating times under various conditions for no load, typical operating loads and limit loads.

The purchaser and the supplier shall work together to ensure that the utility actuator design is optimised to satisfy the performance requirements.

The utility actuator should be designed with a suitable performance margin at the commencement of the design phase as designing without a performance margin can cause redesign later in the flight vehicle programme as the loads loop definition develops.

The purchaser should assess how much margin is to be applied to the performance of the utility actuator dependant on the utility actuator function and based on previous flight vehicle programmes. As a general guide, a minimum positive performance margin of 10 % should be considered at the concept design stage.

5.5.2 Performance cases

5.5.2.1 General

The following performance cases are provided as a guide to the cases that should be considered for performance. The list of cases is not exhaustive and will vary dependant on the utility actuator function within the flight vehicle.

The supplier shall declare to the purchaser the utility actuator performance including the performance at the extremes of the temperature envelope.

5.5.2.2 Normal retraction and extension

For the normal operational case(s) the utility actuator shall meet the specified operational times using the following data:

— applicable utility actuator load vs. stroke profile;

— applicable hydraulic flow vs. pressure curve;

— applicable hydraulic fluid and ambient temperature (typically quoted as 20 °C).

Dependent upon the utility actuator function, there may be several normal operational cases to be considered for performance due to aerodynamic loading, etc. Each case shall be analysed by the supplier and the utility actuator shall meet the respective performance requirements for each normal operational case. These normal operational cases may include:

— the effects of high and low temperature on end of travel snubbing pressure where end of travel snubbing pressure and/or velocity damping dictates the stressing of sections of the utility actuator body, or

— temperature effects on operation time where operation time is a key performance requirement for the utility actuator e.g. landing gear retraction time.

5.5.2.3 Maximum retraction and extension

For these cases, the utility actuator shall meet the specified operational times without stalling using the following data:

— the applicable utility actuator load vs. stroke profile;

— the applicable hydraulic flow vs. pressure curve;

— the applicable hydraulic fluid and ambient temperature (typically quoted as 20 °C).

5.5.2.4 Alternate retraction or extension

If an alternative actuation supply is utilized, the appropriate interface parameters (for example, pressure/flow curves, fluid type) and performance requirements shall be specified in the detail specification.

5.5.3 Leakage

The detail specification shall state the maximum value of the internal leakage across the piston head and the seal(s) and the dynamic external leakage with the utility actuator at the retracted position, the extended positions and at mid-stroke.

NOTE 1 High and low fluid/ambient temperatures can have a major effect on the level of internal and external leakage.

NOTE 2 If there is no requirement, external leakage limits are typically:

— no static leakage, at ambient temperature;

— dynamic leakage of 1 drop of oil per 25 cycles.

NOTE 3 The detail specification could require a minimum level of piston head leakage to maintain fluid temperatures within the utility actuator.

These shall be stated at the following conditions:

a) new build:

  — when subjected to proof pressure at ambient temperature;

  — when the utility actuator has completed 50 full stroke cycles;

b) qualification testing:

  — over the expanded test envelope;

— on completion of the endurance test;

— when subjected to the proof pressure at rated temperature;

c) in-service:

— for maintenance reasons the maximum allowable limit for in-service external leakages (maximum number of drops per cycles) shall be defined and agreed between the supplier and the purchaser.

5.5.4 Seal and scraper friction

The supplier shall consider the effects of seal and scraper friction on the performance of the utility actuator especially that of the break out seal and scraper friction load. Allowances derived from simulation, calculation or test of seal and scraper friction force shall be incorporated into the utility actuator performance assessment.

The seal and scraper friction loads shall be agreed between the purchaser and the supplier.

5.5.5 End of travel snubbing

5.5.5.1 General

The purchaser shall define the following when end of travel snubbing is necessary within the design, i.e. when required to prevent structural damage to the airframe:

— the stroke position when end of travel snubbing starts;

— the load applied and the end of stroke velocity;

— the (equivalent) inertial load to allow the supplier to tune the end of travel snubbing characteristics.

The purchaser and the supplier shall jointly define and agree the means of verifying these requirements.

NOTE Depending on the application, it could be necessary to provide the (equivalent) inertial load to allow the supplier to tune the end of travel snubbing characteristics.

There shall be a smooth transition between the normal and the end of travel snubbing velocity to prevent large external loads and to limit internal pressure transients being generated within the utility actuator during its operation.

The supplier shall analyse the effects of the extremes of temperature on the end of travel velocity(s) with their corresponding pressures and report them to the purchaser to determine if a redesign or change of requirements is required.

5.5.5.2 End of travel snubbing pressures

The end of travel snubbing pressures shall be minimised to reduce the pressure cycling effects on the fatigue life of the utility actuator and to prevent excessive loading on the sealing configurations.

5.5.6 Utility actuator locking means

5.5.6.1 General

The purchaser shall define if either retract and/or extend locking of the utility actuator is required. The supplier shall propose the means of locking the utility actuator for agreement with the purchaser.

There shall be a smooth transition between the locked and unlocked positions to prevent large external loads and internal pressure transients being generated within the utility actuator during operation.

5.5.6.2 Locking loads and unlocking pressures

The purchaser shall define:

— the minimum unlocking pressure;

— the maximum unlocking pressure;

— the pressure rise rate of the unlock pressure or cylinder pressure if not a separate unlock pressure source;

— the maximum lock holding load (both directions if applicable);

— the minimum and maximum loads under which the lock needs to engage and disengage;

— the peak loads that could be applied when the lock is locked and the utility actuator is not operating;

— the position of the lock (stroke), and over-travel past the lock allowed;

— the acceptable tolerance of the locked position;

— the transient hydraulic system pressure at which the utility actuator shall remain locked. The time of the transients shall be also defined;

— if there is a separate hydraulic source for unlocking the utility actuator.

The detail specification shall specify the requirements for the unit after assembly [to pass the acceptance test procedure (ATP)] and for the unit at the end of its life (to pass the endurance test), noting that the lock positions and unlock pressures can change with wear.

5.5.6.3 Lock indications

5.5.6.3.1 General

If required, the purchaser should define the means for lock indication.

The indicator shall be operated by the lock mechanism.

The indicator shall only indicate (change state) when the lock is positively engaged.

The indicator should be designed such that it is resistant to the effects of prolonged exposure to hydraulic fluid at temperature especially for any plastic parts contained within the device, and the device should be subjected to a fluid immersion test to verify this.

Dependant on the application, the indication can be:

— visual if required for ground crew recognition;

— electrical if required for cockpit indication or for data required for system control sequencing;

— both visual and electrical.

5.5.6.3.2 Visual lock indication

If a visual indication of the utility actuator lock position is required, it shall be achieved by a pop out indicator. The indicator shall be positively retained in position. A transparent cover should be used to protect the indicator against the accumulation of dirt and ice preventing it correctly indicating.

The indicator shall be positioned on the utility actuator and sized such that it can be easily visible to ground crew. The size and position of the indicator shall be agreed between the purchaser and the Supplier.

The indicator should be coloured as follows:

— a red indication signifies that the utility actuator is in an unsafe position;

— a green indication or no indication signifies that the utility actuator is in a safe position.

5.5.6.3.3 Electrical lock indication

Electrical indication of the utility actuator position can be achieved typically by the use of micro switches or by proximity sensors.

The electrical interface, signal type and signal conditioning shall be agreed between the purchaser and the supplier.

There shall be a sealing arrangement that prevents the indication device from being exposed to hydraulic pressure or moisture ingress.

5.6 Endurance

5.6.1 General

The utility actuator shall be designed so that it can withstand the duty cycle as detailed in 5.6.2 such that it will be able to meet the leakage requirements of 16.3.5 at the end of its service life.

5.6.2 Duty cycle

The detail specification shall define the duty cycle for the utility actuator and ensure that all operational aspects of the utility actuator in service are considered, including:

— the number of cycles, including maintenance and training operations;

— the loads that the utility actuator shall operate against, including aerodynamic, gravitational, inertial loads;

— any limit load cases and the associated number of cycles;

— the ambient and hydraulic fluid temperatures at which the cycles shall be performed.

The duty cycle shall also include:

— any hydraulic system pressure transients generated by other users during the flight phases in which the utility actuator is connected to the hydraulic system;

— any pressure transients generated by external loading of the utility actuator.

5.6.3 Endurance test

The detail specification shall specify the duration and the conditions of the endurance test.

5.7 Fluid and ambient temperature

The detail specification shall provide the following hydraulic fluid and ambient temperature requirements:

— the normal operating temperature range;

— the extreme operating temperature range;

— the survival temperature range;

— the minimum temperature where normal performance of the utility actuator is achieved;

— the maximum temperature where normal performance of the utility actuator is achieved (if applicable).

5.8 Fluid cleanliness

5.8.1 Operation

The equipment shall operate at the nominal standard of fluid cleanliness ISO 11218, class 8 or better.

5.8.2 Malfunction

The utility actuator shall not malfunction when supplied with a hydraulic fluid cleanliness up to ISO 11218, class 9.

5.8.3 Equipment delivery

The fluid in the delivered equipment shall have a cleanliness of at least ISO 11218, class 7.

5.9 Environmental requirements

The utility actuator shall be designed so that it can withstand the environmental requirements as defined below.

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

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

— temperature shock (in accordance with ISO 7137);

— humidity (in accordance with ISO 7137);

— fluid susceptibility (in accordance with ISO 7137);

— vibration (in accordance with ISO 7137);

— acoustic vibrations (in accordance with ISO 2671);

— gunfire vibration (in accordance with MIL-STD-810);

— vibration due to engine imbalance (to be specified by the purchaser);

— vibration due to tyre burst (to be specified by the purchaser);

— transportation vibration (in accordance with MIL-STD-810);

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

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

— salt spray (in accordance with ISO 7137);

— water resistance (in accordance with ISO 7137);

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

— shock (in accordance with ISO 7137);

— ice formation (in accordance with ISO 7137).

NOTE 1 There could be circumstances where combined environmental requirements are meant to be tested simultaneously, for example, combined humidity, pressure and temperature if there are moisture sensitive cavities.

NOTE 2 RTCA/DO-160 and MIL-STD-810 are alternative standards that can be used in place of ISO 7137.

For utility actuators containing electrical or electronic equipment, the utility actuator shall be compliant with the following additional operating environmental conditions:

— magnetic effect (in accordance with ISO 7137);

— power input (in accordance with ISO 7137);

— voltage spike (in accordance with ISO 7137);

— audio frequency conducted susceptibility - power inputs (in accordance with ISO 7137);

— induced signal susceptibility (in accordance with ISO 7137);

— radio frequency susceptibility (radiated and conducted) (in accordance with ISO 7137);

— emission of radio frequency energy (in accordance with ISO 7137);

— lightning induced transient susceptibility (in accordance with ISO 7137);

— electrostatic discharge (ESD) (in accordance with ISO 7137);

— explosion proofness (in accordance with ISO 7137).

For utility actuators that are installed in designated fire zones the following additional environmental condition shall be considered:

— fire resistance (in accordance with ISO 7137).

6 Detail design requirements

6.1 General

The utility actuator shall be designed in accordance with the detail specification; however the purchaser and supplier shall consider any appropriate certification requirements and general hydraulic design guidelines.

6.2 Prevention of incorrect assembly

The design of the utility actuator shall ensure that it is not possible to incorrectly install components together and to minimise damage to components (such as seals) as the utility actuator is being assembled.

In addition, components that are not functionally interchangeable shall not be physically interchangeable.

If the utility actuator requires fasteners of different lengths to be used for its assembly, then there shall be provisions to avoid installation errors.

6.3 Standard parts

Standard parts shall be used wherever possible.

6.4 Maintainability features

The following design requirements for maintainability shall be considered in the design of the utility actuator:

— 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.

6.5 Seals and scrapers

6.5.1 General

All seal cross sections shall be the largest possible that can be reasonably accommodated within the design.

Elastomeric seal cross sections smaller than 2,62 mm (0.103 inch) nominal should not be used as external seals except in port seal installations where they are used as secondary seals for example on ring locked fittings.

Seal materials shall be compatible with the hydraulic fluid in which they are operating. For seals operating in phosphate ester based hydraulic fluid compatibility shall be considered for the specific fluid type (Type IV or Type V) or mixtures of permissible fluid types.

If redundant seals are used, the inside seal shall be capable of preventing a pressure differential between the inside and outside seal.

If redundant dynamic seals are used, a contamination collection groove shall be placed between the inside and outside seals.

The supplier may use non-standard or proprietary seals in specific areas where compliance with wear, internal, or external leakage requirements cannot be achieved using standard seal designs. The use of non-standard seals shall be agreed between the purchaser and supplier.

NOTE For piston seals, the cylinder bore for sizes -001 to -007 and -104 to -113 in accordance with AS5857 are smaller than for piston seals in accordance with AS4716, i.e. for any of these inclusive sizes a piston in accordance with AS4716 will not fit into a cylinder bore in accordance with AS5857.

The maximum hydraulic fluid leakage from both static and dynamic seals for the specified temperature range shall be defined and agreed between the purchaser and the supplier.

6.5.2 Gland surface finishes

Gland surface finishes shall be designed to meet the leakage requirements of the detail specification at the new build and at the end of the utility actuator's service life.

6.5.3 Static seals

Static seal loads should be applied in one direction only.

External static seals shall be installed in AS5857 or equivalent standard glands.

Internal static seals shall be installed in AS4716 or equivalent standard glands.

NOTE Where necessary loads can be both applied axially and radially such as in a port boss seal application.

6.5.4 Dynamic seals

Surface finishes on which dynamic seals run shall be defined and agreed between the supplier and the seal manufacturer dependant on the coating to be applied to the running surface.

NOTE 1 The surface coatings used to replace the use of chromium such as Tungsten Nickel Carbide or other High Velocity Oxygen Fuel (HVOF) applied surfaces can damage seals during installation if the plating run-out is not properly controlled and a sharp edge is left.

The supplier and the seal manufacturer shall jointly define a suitable dynamic sealing configuration for the utility actuator dependant on the application for both static and dynamic operations. The sealing configuration shall consider the effects of the:

— hydraulic fluid type;

— operating temperature range;

— operating pressure;

— break-out friction;

— endurance life.

Dynamic seals shall be installed in AS4716 or equivalent standard glands.

NOTE 2 AIR1244 provides information on slipper sealing devices when used as piston rod seals.

6.5.5 Scraper rings

A scraper ring shall be incorporated to protect the primary dynamic seal(s) and therefore the internal components of the utility actuator from the effects of external contaminants such as sand, dust, general flight vehicle lubricants. It shall be capable of shedding any ice formation built up on the piston rod in accordance with the requirements of the detail specification.

The scraper ring should be a continuous ring "non-scarf cut" design and should be loaded by a single piece elastomer or metallic spring that is a continuous ring that allows constant contact with both of its radial sides throughout the temperature range specified in the detail specification.

The scraper gland design shall be according to AS4088.

6.5.6 Back-up rings

Back-up rings shall be used to reinforce the seal against the effects of pressure loading extruding the seal into the gap between the piston and the gland (or housing); hence protecting the seal from subsequent nibbling damage. Where seals are exposed to pressure loading in both directions a back-up ring shall be used to support the seal on both sides.

If scarf cut back-up rings are used, they should be adequately designed to avoid the seal extruding through the split especially in higher pressure applications. If solid backup rings are used on dynamic piston applications, friction due to pressure entrapment between the backup rings shall be considered in the design of the device.

Back-up rings for AS4716 glands shall conform to AS5781 or AS5782 or equivalent back-up rings.

Back-up rings for AS5857 glands shall conform to AS5860 or AS5861 or equivalent back-up rings.

Back-up rings may not be required in low pressure environments. The omission of the back-up rings shall be agreed between the purchaser and the supplier.

6.5.7 Lead in chamfers

Components shall be designed such that sufficient clearance (lead in chamfer) exists to permit assembly of the sealing elements without damage to sealing elements where they pass threaded parts or sharp corners.

Lead in chamfers shall be designed according to AS4716.

Care should be taken to ensure that the lead-in chamfers are not stress concentration points for the substrate.

It should be noted that there could be a potential change in surface finish where the lead in chamfer is the boundary between one surface finish and another. This will need to be taken into consideration during the design and qualification of the utility actuator.

Installation tooling may be used in lieu of chamfers.

6.6 Fluid porting through interfacing surfaces

Fluid porting through interfacing surfaces which deflect under structural loading or pressure conditions should utilise transfer tubes with seals installed in two backup ring grooves on both ends, unless the fluid porting is machined as an integral part of one component to prevent leakage under deflections due to structural loading.

6.7 Lubrication of hydraulic elements

The internal portions of the utility actuator shall be self-lubricating using the flight vehicle hydraulic fluid.

6.8 Orifices

Orifices larger than 0,30 mm (0.012 inch) but smaller than 1,78 mm (0.070 inch) in diameter shall be protected by adjacent strainer elements having screened openings 0,20 mm to 0,30 mm (0.008 inch to 0.012 inch) in diameter.

Smaller orifices shall be protected by adjacent elements. These elements shall have openings smaller than the orifices.

Larger orifices shall be self-cleaning.

Orifices and strainer elements shall be strong enough to absorb the maximum flow through them that is consistent with their operational parameters.

Orifices and strainer elements shall also be strong enough to withstand the differential ultimate (burst) pressure without rupture.

Care should be taken in the location of the orifice within the utility actuator to ensure the outlet from the orifice does not directly impinge on any surface as impingement can cause internal erosion of the utility actuator internal surfaces and lead to premature fatigue failure of the utility actuator.

6.9 Retainer (snap) rings

Retainer or snap rings shall not be used in hydraulic system components in any location where failure of the ring will allow "blow apart" of the equipment caused by internal hydraulic pressure except where they are positively retained from being dislodged.

Retainer or snap rings shall not be used in locations where the build-up of clearances and manufacturing tolerances will allow the destructive end play in the assembly contributing towards the failure of packings or gaskets, brinelling or fatigue of parts.

6.10 Spring rings

Un-restrained spring rings shall not be used in fluid cavities to prevent spring rings from migrating into the hydraulic system and causing functional failures in the event that the spring rings breaks up.

6.11 Secondary locking

If required for safety reasons, a positive locking arrangement shall be used to maintain the thread preload and/or secure the washer, such as:

— lock wire;

— deformable lock or cup washers;

— oval threads;

— locking inserts;

— cotter pinning.

The means of secondary locking shall be agreed between the purchaser and the supplier.

6.12 Drainage

Where the possibility of the build-up of water or ice on or in the utility actuator can affect its function, suitable drainage provisions shall be included. These provisions shall be agreed between the purchaser and the supplier.

The design shall avoid any accumulation of water, moisture or ice in any cavities, considering the installation situation and movement in the flight vehicle.

Consideration should be given to the orientation of the utility actuator in the flight vehicle to optimise the drainage and prevent any accumulation of water.

If drain holes are incorporated in the utility actuator, the diameter of the hole(s) should be at least 6 mm.

In addition, care shall be taken to avoid the possibility of hydraulic leakage into cavities that could lead to hydraulic lock.

6.13 Drillings

All passages entering the cylindrical surface of pressure chambers should be inclined at an angle not less than 75° in relation to the chamber centreline to avoid any stress concentration at intersections leading to premature fatigue failure.

Angled drillings less than 75° in relation to the chamber centreline should be agreed between the purchaser and the supplier.

6.14 Fillet radii

Unless otherwise specified in the detail specification, the intersection of highly stressed thin wall cylinder barrels with heavy bulkhead areas shall incorporate generous radii to improve the fatigue life characteristics of the utility actuator.

6.15 Rod ends

The rod ends shall be designed to minimise high stress concentration areas. Special care shall be taken with the following:

— The definition of a suitable thread root radii and undercuts to prevent premature fatigue failures.

— The blend between the rod eye end and the thread and where there are significant changes in cross sectional area of those components that form the load bearing path within the utility actuator.

— For applications where the rod ends are equipped with bearings:

  — the installation of the bearing shall not provide any high stress concentration within the rod end assembly;

  — drillings for grease paths should be designed in a way to ensure that there are no stress concentrations in the eye-end.

6.16 Bearings

6.16.1 General

Self-aligning spherical bearings or universal joints should be used in the end connections to permit correct alignment of the utility actuator and hence remove excessive bending loads.

Plain bearings may be used where design limitations preclude the use of spherical bearings.

The method of bearing retention shall follow a standard that shall be submitted to the purchaser by the supplier for approval.

If cartridge type spherical bearings are used, these bearings shall be fitted in housings with sufficient interference to eliminate the “soft centring” characteristics, thus minimizing backlash in the assembly.

The detail specification shall specify the backlash limits to prevent the possibility of flutter and abnormal wear. For the definition of backlash limits, the wear over lifetime shall be considered.

Limits for the bearing breakout torque shall be defined to avoid stick-slip effects during operation.

The purchaser shall specify the pin diameter and associated limits and fits to the supplier to ensure the correct interface with the attachment bearing is achieved. The purchaser shall also specify to the supplier the bearing width based on the attachment lug and bush dimensions.

6.16.2 Lubrication

If the bearings are self-lubricating, the purchaser and supplier shall consider the loading effects as these bearings typically use polytetrafluoroethylene (PTFE) as the bearing surface, which is not capable of withstanding higher load applications without permanent deformation.

The supplier shall consider whether a derating factor shall be applied for self-lubricating bushes that are supplied as a standard catalogue item.

If the bearings are not of the self-lubricating type, then the detail specification shall define:

— the lubrication fitting standard to be used;

— the grease specification;

— the maximum pressure at which the grease shall be applied;

— the periodicity for greasing.

The purchaser shall define the lubrication interval as part of the system maintenance philosophy.

The supplier shall ensure that:

— the bearing can be adequately lubricated throughout its service life;

— it shall be possible to easily witness the purging of old grease from the bearing as the bearing is lubricated with new grease.

Greased bearings should not be used if the loads do not reverse. If all loads are either tensile or compressive the grease will migrate to the unloaded surface of the ball, thus starving the loaded surface of grease and cause rapid wear. If the loads reverse the grease is pumped from one side to the other.

6.16.3 Anti-roll feature

An integral anti-rotation feature should be installed at each attachment point of the utility actuator to prevent the bearing to move within its seat. This is in order to prevent excessive attachment fitting wear and binding.

Each anti-rotation device should be incorporated into the same component (for example, the rod end) in which the spherical bearing is attached.

6.17 Threaded components

The internal thread root radius should be the maximum permissible for any specific thread size and it should be called out on the detail drawing.

All threaded holes in non-ferrous parts, to be used for mounting screws or bolts, should incorporate Corrosion Resistant Steel (CRES) self-locking inserts to prevent the threads being stripped in the non-ferrous part.

For highly stressed components, cold rolled thread should be considered for use as this reduces stress concentrations in highly stressed areas such as the piston rod thread.

6.18 Electro-conductive bonding

If required, the utility actuator shall have the facility to enable it to be effectively bonded to the airframe. The detail specification shall define the overall electrical bonding requirements and means of bonding.

6.19 Marking

6.19.1 Nameplate

The utility actuator shall contain a nameplate to allow the maintainer to identify the utility actuator, its associated maintenance instructions and, if required, the point of return to the supplier for third line repairs.

The nameplate should be positioned such that it is always visible when the equipment is installed on the flight vehicle without the need to remove any associated equipment.

The minimum nameplate nomenclature shall be as follows:

— manufacturer's name and Commercial And Government Entity (CAGE) code;

— equipment title;

— manufacturer's part number;

— equipment serial number;

— date of manufacture;

— fluid type;

— modification standard.

NOTE This can be the revision letter/amendment strike-off standard.

6.19.2 Fluid identification

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

7 Strength requirements

7.1 Hydraulic

7.1.1 DOP definition

The purchaser shall state the system and utility actuator DOP's as detailed in 3.6.

The supplier shall define the DOP for any internally generated pressures including end of travel snubbing and pressure intensification effects.

7.1.2 Proof pressure

The utility actuator shall not permanently deform to an extent that would prevent it from functioning correctly when subjected to a proof pressure of not less than 1,5 times the DOP for a minimum of 2 min.

7.1.3 Ultimate (burst) pressure

For commercial flight vehicles, the utility actuator shall not rupture, but can permanently deform when subjected to the ultimate (burst) pressure of twice the DOP for a minimum of 1 min.

For military flight vehicles, the utility actuator shall not rupture, but can permanently deform when subjected to the ultimate (burst) pressure of 2,5 times the DOP for a minimum of 2 min.

7.1.4 Impulse fatigue

The detail specification should stipulate the number of cycles and the pressure levels, using the guidelines of ARP1383, Category II. This shall include details of any pressure transients, including:

— the magnitude of the pressure transients;

— the number of pressure transients per flight.

If the number of cycles is not provided in the detail specification, then the number of cycles should be specified using the guidelines of ARP1383, Category I.

For utility actuators where internal areas are subjected to a higher nominal pressure than the general utility actuator DOP, then this pressure shall be applied whenever possible to those areas for impulse fatigue. If this is not possible, then these areas shall be cleared by analysis.

7.1.5 Operation at full flow relief pressure

The utility actuator shall be capable of performing a normal extension and retraction operation without sustaining any damage whilst operating at the hydraulic system full flow relief pressure.

7.2 Loads

7.2.1 Buckling load

The utility actuator shall be capable of withstanding 1,5 times the buckling load applied to the piston rod with the utility actuator in the extended position, and the extend side pressurised to 1,5 times the DOP. The buckling load shall include any bending moment due to bearing friction and any loads if the utility actuator is offset from the centre line.

7.2.2 Locking load (if applicable)

The utility actuator shall remain locked with the application of limit load. The locks shall not fracture up to ultimate load.

7.2.3 Limit load

The limit load can be derived by two means:

— by applying a factor of 1,5 to the normal operating conditions, or

— using a normal maximum operating condition not considering failure cases without an additional factor being applied.

The limit load shall be defined from whichever derivation provides the highest load case.

After being subjected to this load, the utility actuator shall not have any permanent deformation that would prevent it from complying with the performance criteria defined in the detail specification.

7.2.4 Limit retraction and extension

For the limit extension and retraction cases, the utility actuator shall withstand any load within the specified load profile without damage and shall perform normally within the specified performance envelope when the limit load is removed.

7.2.5 Ultimate load

The ultimate load can be derived by two means:

— by applying a factor of 1,5 to the limit load condition, or

— using a failure case without an additional factor being applied.

The ultimate load shall be defined from whichever derivation provides the highest load case.

The utility actuator shall be capable of withstanding this load when applied once and does not need to function within the detail specification performance limits after this load has been applied.

7.2.6 Bottoming loads

If the piston bottoms in the utility actuator as part of its intended function, the utility actuator should be designed to cater for bottoming loads that incorporate inertia loads, etc.

A non-bottoming utility actuator should be designed to cater for bottoming loads, which could occur due to, for example:

— a mis-rigged mechanism;

— pressure testing the utility actuator when it is not attached to the flight vehicle.

7.2.7 Stall load

Following a stall condition, i.e. when the performance conditions exceed the maximum retraction or extension conditions of 5.5.2.3, the utility actuator shall then continue to operate normally when the applied load decreases to that below the stall load of the utility actuator providing the limit load conditions of 7.2.4 have not been exceeded.

7.2.8 Bench handling loads

The utility actuator shall be designed to withstand any damage caused by mishandling when the utility actuator is tested on a bench. 17.2.11.12 provides the test method to be used to verify compliance with this statement.

The design of the utility actuator should ensure that, if possible, any items that will be sensitive to damage if the utility actuator is dropped (for example, pressure sensors, external switches) are shielded by other parts of the utility actuator assembly.

7.3 Combined hydraulic pressure and structural loading

7.3.1 General

These requirements listed below only apply to utility actuators that bottom (where the piston rod uses the internal cylinder bore as the end stop for extension/retraction or both) or for utility actuators that contain a locking mechanism where external loads can be transmitted into the utility actuator and internal hydraulic pressures can both be applied simultaneously.

7.3.2 Design operating pressure and limit structural load

The utility actuator shall not permanently deform that would prevent it from functioning correctly when subjected to the DOP in combination with the limit structural load that may be imposed on it.

7.3.3 Proof pressure and ultimate structural load

The utility actuator shall be permitted to permanently deform, but shall not rupture or mechanically fail when subjected to the proof pressure of 1,5 times the DOP in combination with the ultimate structural load that may be simultaneously imposed on it.

7.4 Mechanical fatigue

Mechanical fatigue shall be considered for the structural sections of the utility actuator, such as the rod, cylinder and its airframe attachments.

The detail specification shall state the variation in loads that are applied to the utility actuator:

— over a typical flight throughout the different flight phases;

— during an alternate operation (if appropriate, for example, emergency landing gear operation);

— ground operations, including maintenance.

The scatter factor to be applied shall be agreed between the purchaser and the supplier.

If the utility actuator is non-bottoming, then it is permissible to combine the mechanical fatigue test with the impulse fatigue test as the fatigue loads are generated by utility actuator internal hydraulic pressures and not by the application of external mechanical loads to the utility actuator structure.

7.5 Port strength

Each utility hydraulic port shall be capable of withstanding a factor of 2,5 (unless otherwise specified) times the maximum wrench torque load associated with that port size without any permanent deformation.

7.6 Vibration

When designing the utility actuator to take into consideration the vibration effects, consideration should be given for the modal shapes of the utility actuator for different frequencies. The detail specification should state a minimum first mode of vibration frequency that the utility actuator should exceed.

8 Construction

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 utility actuator shall:

— be of aerospace quality;

— be suitable for the purpose;

— comply with regulations in terms of environmental requirements;

— comply with the applicable 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

The properties of the materials that are used in the utility actuator should be in accordance with internationally published design data such as that provided in the Metallic Materials Properties Development and Standardization (MMPDS) Handbook, etc. Where strength is important, material certification is required from the supplier approved aerospace material suppliers.

For the allowable ultimate stresses for metals, the supplier shall use either the ultimate allowable stress specified in MMPDS or 1,5 times the yield stress as described in MMPDS whichever is lower. For metals that are not listed in MMPDS, the supplier uses the limit and ultimate allowable stresses developed by methods agreed with the purchaser.

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 utility actuator are likely to be jeopardised 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 Zinc and tin plating

Zinc and Tin plating shall not be used for internal parts or for internal surfaces in contact with the hydraulic fluid or exposed to its vapours as the zinc plating can detach from the parent material surface and contaminate the utility actuator and hydraulic systems.

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 sub-clauses, to resist corrosion that may result from conditions such as:

— dissimilar metal combinations;

— moisture (as defined by the purchaser in the detail specification);

— salt spray (as defined by the purchaser in the detail specification);

— high temperature deterioration.

The applicable government environmental regulations are considered in the selection of processes for corrosion protection.

The supplier shall seal the edges of all joints, fastener heads and nuts which are not protected against the effects of galvanic corrosion or in contact with hydraulic fluid with a bead of appropriate corrosion prevention sealant.

8.2.2 Ferrous and copper alloys

Ferrous alloys and all copper alloys, except for parts with bearing surfaces, shall have surface plating applied if required to provide adequate corrosion protection. Exceptions shall be submitted to the purchaser for approval. Where not indicated, the class and type of plating are at the supplier's discretion. Acceptable forms of plating are electrolytic nickel plating, electrolytic silver plating and electrolytic tin plating. These types of plating shall be in accordance with ISO 2093.

8.2.3 Aluminium alloys

Aluminium alloys shall be anodised in accordance with ISO 8078 and ISO 8079 (except that in the absence of abrasive conditions they may be coated with chemical film in accordance with ISO 8081), unless otherwise authorised. Exceptions shall be submitted to the purchaser for approval.

8.3 Forgings

The design of forged components shall consider the grain flow direction of the forging to optimize the strength of the utility actuator.

9 Mass

The dry mass of the utility actuator shall be agreed between the purchaser and the supplier.

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

The supplier shall provide an appropriate safety label on the utility actuator if its mass exceeds 25 kg (55 lbs).

10 Installation requirements

10.1 Space envelope

The purchaser shall define the space envelope for the utility actuator. The space envelope shall allow sufficient clearances between the utility actuator and all adjacent systems and structure throughout the utility actuators stroke.

The clearance allowances shall be as defined in the flight vehicle hydraulic system installation guidelines. The space envelope shall provide the maximum envelope available for the utility actuator.

The supplier shall consider the maximum tolerance conditions whilst maintaining the design within the space envelope dimensions.

10.2 Overtravel

If the purchaser has determined that the flight vehicle structural deflections will occur that will affect the installation length of the utility actuator during flight, then the purchaser shall consider incorporating overtravel in the utility actuator design. This is achieved by provisioning an additional stroke length in the utility actuator such that the stroke length can accommodate the structural deflections encountered by the flight vehicle during flight.

The purchaser should determine whether these structural deflections occur with the utility actuator retracted and/or extended and incorporate sufficient overtravel in the "extend" and "retraction" chambers to cater for these structural deflections. The purchaser should ensure that sufficient overtravel is incorporated such that the utility actuator does not bottom during these structural deflections (unless the utility actuator and attachment structure is designed to accommodate these loads).

The overtravel stroke should be kept to the minimum possible in order to optimise the utility actuator mass.

10.3 Adjustment

If overtravel is not to be included in the utility actuator as described in 10.2, then the purchaser shall define to the supplier the amount of adjustment required in the utility actuator length to ensure its correct installation.

The length adjustment shall consider all reasonable tolerances that can occur on the flight vehicle airframe and utility actuator attachment structure.

The supplier shall propose a suitable means of adjustment to cater for these tolerances in the design of the utility actuator. Typically, this is achieved by adjustment of the length using the piston rod to eye end thread.

10.4 Dimensions

10.4.1 Retracted length

The purchaser shall specify the utility actuator retracted length. The retracted length shall quote an applicable tolerance on the nominal retracted length to cater for installation tolerances.

10.4.2 Extended length

The purchaser shall specify the utility actuator extended length. The extended length shall quote an applicable tolerance on the nominal extended length to cater for installation tolerances.

10.5 Interface document

The interface document for the utility actuator shall be configuration-controlled and agreed between the supplier and the purchaser.

The interface document shall include:

— the material interfaces at the pin attachments;

— the material surface finishes at the pin attachments.

10.6 Installation drawing

The suppliers' installation drawing shall include (but not be limited to) the following information:

- the bearing details including type, material, width, bearing bore diameter (including limits and fits);
- the anti-roll feature(s);
- the retracted length;
- the extended length;
- the length adjustment (if applicable);
- the lubrication fittings (location and size);
- the electrical bonding points;
- the hydraulic ports (location and size);
- the electrical connections (if applicable);
- the general space envelope (maximum);
- the hydraulic schematic;
- the wiring diagram (If applicable);
- the nominal supply pressure (with tolerances);
- the nominal return pressure (with tolerances);
- the part number;
- the dry mass;
- the centre of gravity;
- the applicable specification.

10.7 Mounting of the actuator to structure

The purchaser shall specify:

- the mounting pins' diameters and their associated limits and fits to the supplier to ensure the correct interfaces with the attachment bearings for the installation of the utility actuator are achieved. The responsibility for the definition of the attachment pins shall be agreed between the supplier and the purchaser;
- the bearings' widths based on the attachment lug and bush dimensions;
- the material and surface finish of the pins and any adjacent bushes/bearings.

The supplier and the purchaser shall agree on suitable lifting and slinging points for utility actuator installation.

The supplier shall identify and provide suitable areas of the utility actuator for lifting and slinging (if required) that prevent damage to the external features of the utility actuator, such as pipes, electrical connections and valves.

10.8 Hydraulic interfaces

The detail specification shall define the hydraulic port locations, types and sizes. All interface fluid connections to the utility actuator shall be made through threaded bosses.

The spacing of hydraulic port locations shall ensure that suitable access is provisioned to allow for standard spanners access to the port fitting nuts and tubing nuts for installation of the utility actuator.

It shall not be possible to cross connect any hydraulic connections on the utility actuator.

The hydraulic fittings on the utility actuator should be aligned such that the hydraulic hoses or coiled tubes are able to articulate in a single plane.

10.9 Electrical interfaces (if applicable)

The detail specification shall define the electrical connector locations, types and sizes.

All interface electrical connections to the utility actuator shall be made through sealed connectors capable of satisfying the environmental requirements of the detail specification.

It shall not be possible to cross-connect any electrical connections on the utility actuator.

11 Instrumented utility actuator

If the supplier requires a utility actuator that incorporates instrumentation for rig test and/or flight test purposes, then the test utility actuator shall include the appropriate provisions as required, such as pressure transducers in the end of travel snubbing chambers.

If the utility actuator is to be used for rig testing, it shall undergo a dedicated acceptance test programme to demonstrate that the instrumentation functions correctly and does not affect its integrity.

If the utility actuator is to be used on a flight vehicle, it shall undergo a dedicated qualification test programme appropriate for flight test usage to demonstrate that the instrumentation does not affect its integrity.

12 Maintainability requirements

12.1 General

The supplier and the purchaser should work together to ensure that access can be easily achieved to all the required maintenance points on the utility actuator when it is installed on to the flight vehicle.

NOTE For example, the greasing of bearings.

The utility actuator should be designed with provisions for maintenance tools such as door actuator gags.

12.2 Maintenance concept

The detail specification shall state the specified maintenance concept, e.g. "On Condition".

The design shall permit the line replacement of the unit or a module of the unit, using standard tools only as defined in the detail specification.

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

12.3 Service life limitations and storage specifications

The detail specification shall state:

— the time between overhauls (if applicable);

— the storage life;

— the storage conditions;

— the service life limit.

For storage life and storage conditions, consideration shall be given to the effects of long-term storage on the life of elastomeric components.

12.4 Reparability

The supplier shall identify those areas of the utility actuator that can be repaired following damage to it together with the definition of the appropriate limits.

13 Reliability requirements

13.1 Requirements

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

— the defect rate;

— the failure rate;

— the safety rate (if applicable);

— the failure mode and effect analysis (FMEA).

13.2 Equipment compliance

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

14 Quality assurance provisions

14.1 Responsibility for inspection

Unless otherwise specified in the contract or the purchase order, the supplier:

— shall be responsible for the performance of all inspection requirements as specified herein;

— may use its facilities or the services of any industrial laboratory that has the necessary approvals.

The purchaser reserves the right to perform any of the inspections contained in this document or the detail specification, where such inspections are deemed necessary to ensure that the supplies and services conform to the stipulated requirements.

14.2 First article inspection (FAI)

14.2.1 General

The first article inspection shall consist of the examinations and the tests specified in 16.3.

14.2.2 First article samples

The supplier shall make available at least one utility actuator for review by the purchaser's quality organisation.

The FAI utility actuator for review shall be totally representative of the design and construction, workmanship, integral components and materials to be used during production.

14.2.3 First article inspection report

Upon completion of the first article inspection, the supplier's quality organisation shall submit to the purchaser the following:

— results of the inspection and the test programmes;

— recommendations if the qualification test programme can commence or not.

14.2.4 Rejection

The failure of any FAI utility actuator to successfully comply with any of the requirements of the first article inspection or quality conformance inspection shall be the cause for rejection of that utility actuator design.

14.3 Classification of tests

For the purpose of demonstrating compliance of the utility actuator with this document and the applicable detail specification, two distinct test programs shall be conducted, hereinafter referred to as follows:

— acceptance tests (refer to Clause 16);

— qualification tests (refer to Clause 17).

14.4 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 purchaser and the supplier.

— Low pressure: ±2 % of low pressure, but not more than ±35 kPa (±5 psi).

— High pressure: ±2 % of high pressure, but not more than ±200 kPa (±30 psi).

— Low temperature: −57 °C (−71 °F) to +43 °C (109 °F), within ±3 °C (±5,5 °F).

— High temperature: +43 °C (109 °F) to +107 °C (225 °F), within ±6 °C (±11 °F).

— Flow: within ±2 % of maximum predicted flow demand.

The accuracy of the instrumentation shall be consistent with the measurement tolerances required.

Test stands shall use sufficient filtration so as to maintain the cleanliness of the hydraulic fluid to ISO 11218, Class 5B or better, except for qualification endurance testing, as referred to in 17.2.10.

The hydraulic fluid in the test stand shall be the same type as that specified for the utility actuator application, as defined in 5.4.

The test stand shall have the representative stiffness of the attachments.

15 Development tests

The purchaser and the supplier should agree on the scope of development testing to be performed on features of the utility actuator where a level of technical risk has been identified. These can include:

— fretting;

— dissimilar materials;

— velocity damping;

— end of travel snubbing;

— internal or external locks;

— sealing;

— seal friction;

— structural strength;

— novel design features.

16 Acceptance tests

16.1 General

Each utility actuator to be delivered as a production unit or for qualification testing shall be subjected to the following acceptance test requirements:

— visual examinations (16.2);

— an acceptance test programme (16.3) to determine design quality and check whether the utility actuators conform to the performance requirements of this document and the purchaser's detail specification.

16.2 Examination of the product

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

Any defective components found during the inspection shall be cause for rejection of the utility actuator.

Special attention should be given to the condition of the locking devices, check for signs of damage, corrosion, deformation, scratches, marks and complete name plate and log card (if applicable).

A dimensional inspection of all relevant interface dimensions shall be performed. The periodicity of the dimensional inspection shall be agreed between the supplier and the purchaser for production units.

16.3 Test programme and inspection methods

16.3.1 General

The supplier shall repeat the applicable parts of the acceptance test procedure if, at any phase of testing, components require replacement. The run-in portion may be omitted if the dynamic seals were not affected.

16.3.2 Mass

The utility actuator shall be weighed with the following conditions:

— the utility actuator after assembly, before being filled with hydraulic fluid;

— no nameplates installed;

— no wire locking applied.

The mass of the utility actuator shall be recorded on the acceptance test results sheet for onward shipment to the customer.

16.3.3 Run-in

Prior to starting the proof pressure, leakage and functional tests, the utility actuator shall be subjected to a run-in test of a minimum of 50 run-in cycles where the utility actuator is fully stroked from the fully retracted to the fully extended position and back again.

16.3.4 Proof pressure

With the utility actuator fully extended, apply the proof pressure to the extend port and maintain the pressure to a value of 1,5 times the DOP for a minimum of 2 min. For double chamber utility actuators, repeat the test with the utility actuator in the fully retracted position with the pressure applied to the retract port.

There shall be no evidence of damage, permanent deformation that would prevent it from functioning correctly, or external leakage (apart from gland seal leakage) during the proof pressure test.

16.3.5 Leakage

16.3.5.1 External leakage

Other than at the gland, no external leakage of sufficient magnitude to form a drop within 5 min shall be permitted.

16.3.5.2 Internal leakage

With the piston bottomed in either position and with the DOP applied to the utility actuator, the measured leakage across the piston shall not exceed that specified by the detail specification.

The actual recorded leakage of the utility actuator shall be recorded on the acceptance test results sheet for onward shipment to the customer.

NOTE This test cannot be conducted on a single acting utility actuator.

16.3.5.3 Dynamic leakage

During acceptance testing, the utility actuator permissible dynamic leak rate shall not exceed the values specified for new build conditions as defined in 5.5.3.

16.3.5.4 Low pressure leakage

A low-pressure test shall be applied to the utility actuator dynamic seals for a period of at least 12 h. The test pressure and test time shall be agreed between the purchaser and the supplier.

There shall be no evidence of external leakage during the test apart from at the gland seal, the value of which shall be agreed between the purchaser and the supplier. A pass/fail indication of the utility actuator external leakage test shall be recorded on the acceptance test results sheet for onward shipment to the customer.

NOTE This test represents the leakage that could be experienced due to seals within the utility actuator not being fully energised with an unpressurised hydraulic system.

16.3.6 Performance tests

The following performance tests (where applicable) shall be included in the acceptance test procedure:

— the extend operating time;

— the retract operating time;

— the extend velocity damping characteristics;

— the retract velocity damping characteristics;

— the extend end of travel snubbing characteristics;

— the retract end of travel snubbing characteristics;

— the extend lock load;

— the retract lock load;

— the shuttle valve operation;

— the correct operation of switches, indicators, etc.

16.3.7 Electro-conductive bonding

If required by the procurement specification, measure the electrical resistance at the applicable parts of the utility actuator. It shall not be greater than the value specified in the detail specification.

16.3.8 Storage and packaging

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

The purchaser shall agree with the supplier if the utility actuator is to be delivered in an extended or retracted position for shipping. The shipped condition may be required to suit the system condition for the utility actuator replacement.

The packaging used for the shipment of the utility actuator shall consider the normal handling damage that may occur during transportation. Hydraulic ports, electrical connectors, mechanical and structural interface attachment parts such as bearing and rod ends shall be protected in an adequate manner for shipment.

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 utility actuator relies on the hydraulic fluid internal to the unit for corrosion protection, then the hydraulic plugs shall form a leak-free seal.

17 Qualification

17.1 Purpose

Qualification tests with the purpose of verifying whether the utility actuator design complies with the requirements of this document and the detail specification shall consist of the tests specified in 17.2.5.

17.2 Qualification procedure

17.2.1 Qualification programme plan

The supplier shall provide to the purchaser a qualification programme detailing the requirements from the detail specification and how they are to be verified either by analysis/design statement/similarity or test.

17.2.2 Qualification test procedure

For those requirements from the detail specification that are to be verified by test, the supplier shall provide to the purchaser a qualification test procedure detailing how each individual test is to be performed providing detail of the test set-up, measurements to be recorded, etc.

17.2.3 Similarity and analysis report

For those requirements from the detail specification that are to be verified by similarity or analysis, the supplier shall provide to the purchaser a similarity and analysis report detailing written evidences of how the requirement can be adequately cleared either by a test performed on similar equipment or by theoretical analysis.

The written evidence shall be provided to the purchaser for review as early as possible in the utility actuator development programme in order to minimise the risk of rejecting the claim and additional qualification testing having to be performed.

17.2.4 Qualification test report

A qualification test report detailing the tests carried out on the utility actuator and the results shall be compiled.

The qualification test report shall include a full assessment of the extent to which the utility actuator tested complies with the detail specification and a detailed account of the way in which the tests were carried out.

The qualification test report shall 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, and test set-ups shall be described including all the details for each test. Assembly and installation drawings defining the configuration of the test article shall be appended to the qualification test report.

Any test anomalies shall be highlighted in the qualification test report.

17.2.5 Samples and programme of qualification tests

Qualification tests should be conducted on four sample utility actuators (specimens 1, 2, 3 and 4). It is essential that the utility actuators that are tested are identical to those that are manufactured using a serial process and that any deviations are approved by the purchaser prior to the commencement of testing. The qualification tests to be carried out are listed in Table 1.

The dynamic seal leakage may degrade to the limit specified in the detail specification as defined in 5.5.3.

Table 1 — List and sequence of qualification tests

Tests	Test specimen				Corresponding subclause
	1	2	3	4	
Acceptance	X	X	X	X	17.2.6
Dimensional check	X	X	X	X	17.2.7
Performance/wear					
Expanded envelope test	X				17.2.8
Performance	X				17.2.9
Endurance	X				17.2.10
Strength requirements					
Proof pressure			X		17.2.11.2
Ultimate pressure[a]			X		17.2.11.3
Limit load			X		17.2.11.4
Ultimate load[a]				X	17.2.11.5
Design operating pressure and limit load[b]		X			17.2.11.6
Proof pressure and ultimate load[a]		X			17.2.11.7
Buckling load			X		17.2.11.8
Locking loads[c]		X			17.2.11.9
Impulse fatigue			X		17.2.11.10
Mechanical fatigue				X	17.2.11.11
Bench handling loads		X			17.2.11.12
Wrench loads		X			17.2.11.13
Vibration		X			17.2.11.14
Operational shocks		X			17.2.11.15

[a] These tests can be conducted with either the same test unit that has completed the fatigue testing or use dedicated test units.

[b] Only applicable if the utility actuator bottoms.

[c] Only applicable if the utility actuator incorporates internal or external locks.

[d] To be specified by the purchaser.

[e] Only applicable if the utility contains electrical or electronic equipment.

[f] Only applicable if the utility actuator is installed in a designated fire zone.

Table 1 *(continued)*

Tests	Test specimen				Corresponding subclause
	1	2	3	4	
Environmental requirements					
Temperature and altitude		X			17.2.12
Temperature shock		X			17.2.12
Humidity		X			17.2.12
Fluid susceptibility		X			17.2.12
Resistance to fungus and mould		X			17.2.12
Salt spray		X			17.2.12
Water resistance		X			17.2.12
Sand and dust		X			17.2.12
Ice formation		X			17.2.12
Vibration		X			17.2.12
Acoustic vibrations		X			17.2.12
Gunfire vibrations		X			17.2.12
Vibration due to engine imbalance[d]		X			17.2.12
Vibration due to tyre burst[d]		X			17.2.12
Transportation vibration		X			17.2.12
Steady state acceleration		X			17.2.12
Magnetic effect[e]		X			17.2.12
Power input[e]		X			17.2.12
Voltage spike[e]		X			17.2.12
Audio frequency conducted susceptibility – power inputs[e]		X			17.2.12
Induced signal susceptibility[e]		X			17.2.12
Radio frequency susceptibility[e]		X			17.2.12
Emission of radio frequency energy[e]		X			17.2.12
Lightning induced transient susceptibility[e]		X			17.2.12
Electrostatic discharge (ESD)[e]		X			17.2.12
Explosion proofness[e]		X			17.2.12
Fire resistance[f]		X			17.2.12

[a] These tests can be conducted with either the same test unit that has completed the fatigue testing or use dedicated test units.

[b] Only applicable if the utility actuator bottoms.

[c] Only applicable if the utility actuator incorporates internal or external locks.

[d] To be specified by the purchaser.

[e] Only applicable if the utility contains electrical or electronic equipment.

[f] Only applicable if the utility actuator is installed in a designated fire zone.

17.2.6 Acceptance tests

Acceptance tests, as part of the design approval test programme, shall be performed exactly as specified in 16.3.

