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Technical Specifications (In-Cash Procurement)

Market Survey - Technical Specifications for nuclear piezo-valve

The ITER organization is performing the present market survey in order to identify potential suppliers for hybrid pneumatic control-valve with piezoelectric-pilot (also called “piezo-valve” in the document), receive any feedback and optimize its procurement strategy.

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1 Purpose

The ITER organization is performing the present market survey in order to identify potential suppliers for hybrid pneumatic control-valve with piezoelectric-pilot (also called “piezo-valve” in the document), receive any feedback and optimize its procurement strategy. This market survey is not binding nor contractual. Following feedbacks from the industry, the procurement strategy presented in this document (e.g. scopes, sequences, requirements) may be refined and updated.

2 Definitions

ENF - Equivalent Neutron Fluence

HLG - Helium Leak in Gallery

IO - ITER Organization

LOCA - Loss of Coolant Accident

LOVA - Loss of Vacuum Accident

SMF - Static Magnetic Fields

TNF - Total Neutron Flux

3 Background

The ITER project is the experimental fusion reactor aiming at being the first fusion reactor producing net energy, maintaining fusion reaction over long periods.

Conventional solenoid valves have been found to be sensitive to Static Magnetic Field (SMF) of a few tens of mT. These values are exceeded in substantial parts of the Tokamak Complex. In order to address this issue, ITER is investigating the solution to use hybrid pneumatic control-valve with piezoelectric-pilots which are inherently less sensitive to SMF. These valves typically contain active electronics which are sensitive to radiation.

In order to meet the requirements for the first plasma and for the nuclear phase, the piezo-valve needs to be operated by passive electronics. The aim of the present Market Survey is to investigate for a solution to resist to the Static Magnetic Fields and Radiation environment.

4 Scope

The ITER Organization is planning to procure the following scope:

- Design of piezoelectric-pilots pneumatic control-valve with passive electronics
- Detailed analysis of the impact of the conditions indicated in ITER Requirements (radiation dose, thermal aging, seismic and LOCA) on the operability of the valve
- Prototyping of the piezoelectric-pilots pneumatic control-valve able to fulfil the ITER requirements
- Functional tests

- Manufacturing of the piezoelectric-pilots control-valve following the Quality Assurance to ensure the compliance of the series equipment with the model equipment to be qualified
- Qualification tests
- The completion of factory acceptance test and delivery

The aims is to provide the technology and the design optimised to fulfil the requirements of the ITER facility and qualification process.

5 Work Description

ITER Requirements

For the present Market Survey there are 2 groups of qualification requirements:

- Base Group - base requirements
- Harsh Group - harsh environments

2 different groups are provided because the conditions of the “Base Group” is the minimum requirement to meet to consider the piezo-valve as good candidate for the following qualification process.

The “Harsh Group” indicates the harsh conditions present in those areas of ITER buildings where the valves are planned to be used.

The following table shows the normal and accidental conditions to be evaluated in the Detailed Analysis. Please note that these values are provided only for the Detailed Analysis and they could change in the qualification phase to meet the specific requirements of each system.

Base Group	Normal Condition	Accident condition
Design Pressure [MPa-g]	0,7	1,1
Cycling [# cycles]	5000	
Ambient Room temperature	18 °C - 40°C	5 °C - 130°C
Ambient Room humidity	20% RH – 100% RH	0% RH – 100% RH
Ambient Room pressure	86 kPa – 106 kPa	100 kPa – 200 kPa
Static Magnetic field (Modulus) [mT]	126**	
End of Life Radiation Dose [MGy]	1.33 E-02	
Equivalent Neutron Fluence; Total Neutron Flux	ENF = 1E11 n/cm2; TNF = 1E5 n/cm2/s	
Vibration generated in the process pipes	≤ 13 mm/s, 10 Hz to 500 Hz ≤ 0.7 g, 10 Hz to 500 Hz	
Acceleration Reference for Seismic Qualification [g]		peak 6g on the floor level
LOCA - Δpmax ambient [Pa]; T[°C]	100000; 130°C for 2 hours	100000; Max 130°C - see LOCA profile.
Fire		410°C for 2 hours*

The following table indicates the harsh conditions:

Harsh Group	Normal Condition	Accident condition
Static Magnetic field (Modulus) [mT]	427**	
End of Life Radiation Dose [MGy]	3.35	3.35
Equivalent Neutron Fluence; Total Neutron Flux	ENF = 2E15 n.cm-2; TNF = 4.5E8 n/cm2/s	
Acceleration Reference for Seismic Qualification [g]		peak 6g on the floor level
LOCA - Δpmax ambient [Pa]; T[℃]		100000 ; Max 145℃ - see LOCA profile.
LOVA ΔP ; ΔPmax [Pa] / T min [℃]		-6000 ; 8000 / -15℃
HLG - Air T ; (T on the component) [℃]		-170 ; (11)
Fire		875°C for 2 hours*

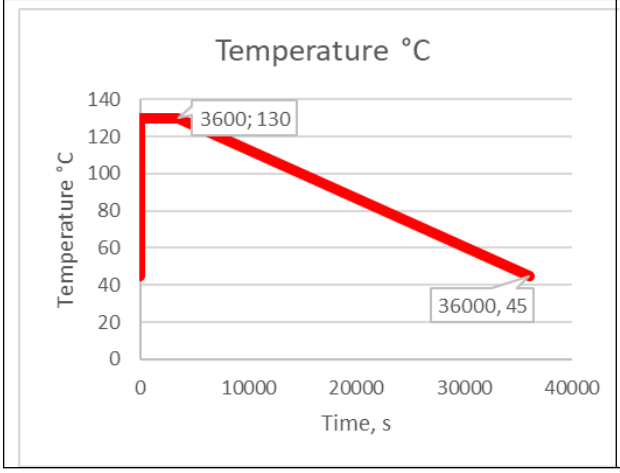
** In case of fire accident, the ambient temperature can exceed 400 °C. A fire protection insulation will be implemented to mitigate the effects. The supplier shall specify the maximal operating temperature without degradation of performance, as well as the maximal temperature to which the actuator valve can be subjected during fire accident for integrity purpose.*

*** The values of the Static Magnetic field include the margin of 3 dB*

The following LOCA profiles are applicable only for the Detailed analysis. The LOCA profiles for the qualification will be provided in a further stage.

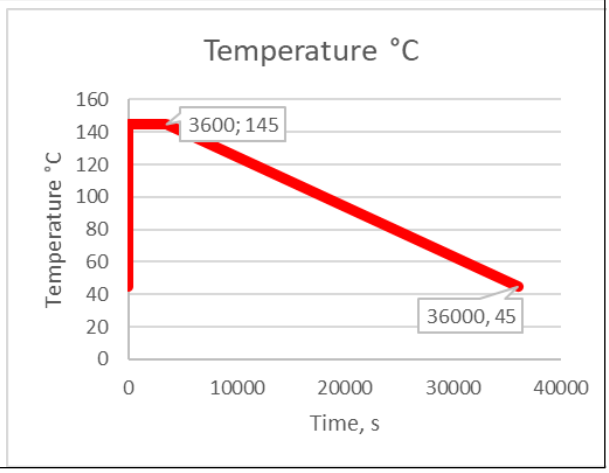
Base Group

Time, s	Time, h	Temperature °C
0.1	0.00	45
1	0.00	130
3600	1.00	130
36000	10.00	45



Harsh Group

Time, s	Time, h	Temperature °C
0.1	0.00	45
1	0.00	145
3600	1.00	145
36000	10.00	45



Design

The first activity aims to provide the technology and the design to fulfil the requirements of the qualification process.

The design shall demonstrate the ability to manufacture a series of piezoelectric-pilots pneumatic control-valves with passive electronics.

The design shall allow withstanding the qualification process for the conditions indicated in ITER requirements.

Detailed Analysis

The objective of the Detailed Analysis is to provide a report indicating if the piezo-valve is able to maintain the functionality in the conditions of the Base Group and Harsh Group.

The report shall include assessment of the safety margins resulting from the analysis and it shall specify which are the most sensitive parts.

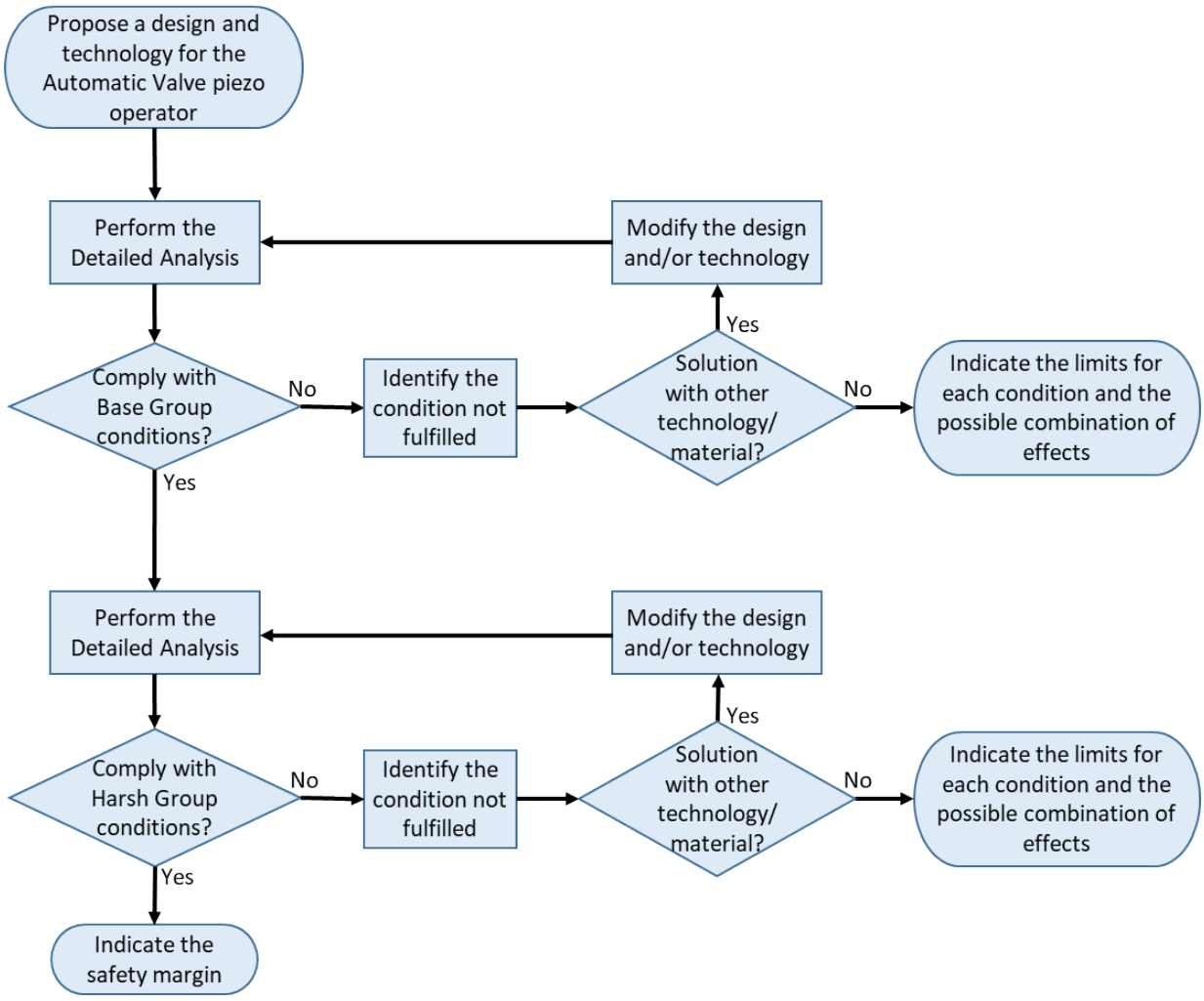
Based on the materials and their functions in the piezo electric valve and other electromechanical components, the Contractor shall evaluate the capability to perform the function in normal operating condition and shall assess the component aging.

The report will determine the radiation, thermal, seismic and accidental tolerance of the materials used to make the components.

If the piezo-valve is not able to withstand the conditions of the Base Group and/or Harsh Group, the Contractor shall identify the possible solutions to meet the criteria. If the piezo-valve, after the implementation of the identified solutions, is not able to withstand the specified

conditions, in this case the report shall include the allowable limit for each condition (e.g. radiation, magnetic field, etc.) and the possible combination of effects (e.g. radiation + temperature).

The Detailed Analysis shall take into account the effects of the qualification process.



Prototype

After having demonstrated via the Detailed Analysis that the piezo-valve is able to meet the ITER requirements, a prototype shall be manufactured, implementing the any technological solution identified in the Detailed Analysis.

The prototype shall demonstrate the ability to manufacture a series of piezoelectric-pilots pneumatic control-valves with passive electronics.

The prototype will be submitted to the functional test and could be submitted to some specific test of the qualification process to demonstrate that it is able to fulfil the ITER requirements before performing the complete qualification test sequence.

Functional tests

The functional test will provide the characteristics of the piezo-valve.

This test comprises the following:

- Electrical interface characteristic tests, for example:
  - dielectric strength test (RCC-E MC 3100 or other nuclear applicable standard shall be applied);
  - insulation resistance test (RCC-E MC 3200 or other nuclear applicable standard shall be applied);
- Measurement of the functional characteristics specific to each type of equipment:
  - as a minimum, these shall include the characteristics required to perform the safety function assigned to the equipment.

Manufacturing

This activity consists in the manufacturing of the piezoelectric-pilots control-valve following the Quality Assurance and monitoring the manufacturing process to ensure the compliance of the series equipment with the model equipment to be qualified.

The model that will be qualified must be manufactured using the same materials and the same process of the series equipment.

If the prototype is in conformance with the series production and it is already built following the Quality Assurance and monitoring of the manufacturing process, in this case, the prototype can be used as model for the qualification.

Qualification Process

The qualification process allows to demonstrate that the model complies with the ITER requirements, acknowledging its ability to provide the required service under all of the environmental conditions to which it might be subjected.

The same model needs to be submitted to the complete sequence (the accidental conditions could be applied on the same model or on different models in relation to the specific needs of the systems).

The following sequence of test is provided for indication and it could vary in relation to the specific needs of the systems.

- Reference tests
  - Electrical interface characteristic tests (dielectric strength, measurement of insulation resistance)
  - Measurement of functional characteristics
- Assessment of behaviour at the limits of functional use:
  - at the limits of the nominal operating ranges of the equipment
  - at the limits of the equipment's installation conditions (pressure and ambient temperature, electromagnetic environment, static magnetic field, etc.)
- Assessment of behaviour over time
  - Thermal, mechanical and humidity ageing
  - Prolonged operation ageing
- Cumulative radiation during normal operation
- Assessment of behaviour due to earthquakes and accident ambient conditions
  - Seismic resistance
  - Cumulative radiation during an accident
  - Resistance to thermodynamic conditions