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Technical Specifications (In-Cash Procurement)

Technical Summary for CHWS-1B Air Cooled Chillers

This Technical Summary collects the main technical requirement for SIC qualified Air Cooled Chillers for system CHWS-1B.

It will be used for a market survey on available solutions for this equipment.

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1 Purpose

CHWS-1A/B systems provide cooling water at 6°C to safety related clients (see Appendix A). The heat is then transferred from clients to the environment via air-cooled refrigeration units.

CHWS-1 A/B design considers two completely independent and segregated subsystems which are inherently compliant with the equipment redundancy assured by the clients.

Cooling function is continuously required in plant normal operation operation (refer to section 4.1).

During Accidental Conditions, additional safety related clients will be cooled by the system.

Each train consists of three air cooled chillers, two horizontal centrifugal pumps (1 working and 1 in standby), a water polishing unit, a pressurizer, strainers, valves, together with a dedicated piping distribution as well as instrumentation for monitoring and operational purposes.

This Technical Summary will be used for a market survey on available solutions for the SIC qualified Refrigeration Units required for system CHWS-1B.

2 Scope of Supply

The scope of supply shall include one Complete Refrigeration Package. Composed by 3 Identical Air Cooled Chiller Units (Tags: 26CH1B-CHI-1001&1002&1003) installed in parallel (Refer to Appendix A).

The chilled water circulation pumps are supplied by others and excluded from this scope of this document.

Each Unit shall include all required Mechanical, Electrical and Instrumentation & Control equipment required for its safe and reliable operation under the duty conditions established in Section 4.

Each Unit shall be installed on one independent skid along with required seismic isolation devices (to be included in the scope of vendor).

Taking into account that pump run at fixed speed and that chilled water flow is equally divided among the 3 units, Supplier should propose as option any additional equipment required to coordinate the repartition of the duty among the 3 Units (e.g. additional control unit).

Refer to Appendix B for Detailed scope of supply.

3 Equipment Classification and Qualification

From Safety Classification point of view CHWS-1B Refrigeration Units are Protection Important Component (PIC) that falls in **SIC-2** category.

Applicable instrumentation and control Safety Classification is **SIC-2B**. If more convenient for the design of the system, supplier should propose a parallel safety control system based on hardwired technology, used to cover only basic functions when main control system is not available,

Equipment included in the scope of supply shall be **fully qualified** to demonstrate that it has been designed and manufacturer to perform the required function without experiencing failures before, during and after applicable events.

A qualification plan will be issued after order by vendor. It shall include but is not limited to:

<u>Seismic Qualification</u> : Seismic Qualification is SC-1 (SF) . The supplied equipment shall withstand a SL-2 category earthquake (Refer to Appendix D for applicable Floor Response Spectra, FRS) with no impact on system stability and functional capacity (see Note 1)
<u>Static Magnetic Field Qualification</u>
<u>Electromagnetic Compatibility Qualification</u>
<u>Material Traceability</u>
<u>Evaluation of the effects of Aging</u>
<u>Electrical and Instrumentation/Control Qualification</u> : equipment for safety operation shall be qualified as per RCC-E (category K3 , refer to section 4 for applicable environmental conditions)

Note 1: A Seismic Isolation Device has been included in the scope (refer to Appendix B) to reduce the accelerations to acceptable level for the equipment installed onskid. Taking into account applicable FRS, supplier to state in the proposal if this equipment is required. Qualification plan shall indicate how the seismic qualification of the assembly can be achieved (e.g. shaking table test of chiller unit installed on seismic isolation device).

4 Package Design

4.1 Design Constraints

Design Life	30 years	
Duty	<p>Nominal Thermal Power for the Refrigeration package = 2500 kW.</p> <p>To be shared between the three Units. This is the maximum thermal power required in accidental conditions (with ~5% margin). Normal operation duty is lower. Refer Process Datasheet in Appendix C for all operating cases.</p>	
Chilled Water Flow	346 m ³ /h constant flow, equally divided among the 3 units (115m ³ /h per unit).	
Regulation	<p>In order to guarantee continuous availability of cooling function regulation range shall be 0-100%.</p> <p>The regulation target is to guarantee, in all operating conditions, a temperature of 6°C in the chilled water manifold downstream the refrigeration package (refer to Appendix A). If strictly required, slight deviation to the target temperature can be accepted and shall be indicated by supplier in the proposal.</p> <p>However, vendor could propose to reduce the number of continuously working units in normal operation, if this is considered the optimal configuration for the refrigeration units. In accidental case all units will be running.</p> <p>Vendor to indicate the methods of regulations required (e.g. hot gas bypass), taking into account that continuous start/stop regulation is not acceptable.</p>	
Chilled Water Design Conditions	Pressure (MPa absolute)	0.9
	Temperature (°C)	50
Chilled Water Quality	Liquid Handled	Demineralized Water (no glycol allowed)
	Operating Water Temperature Inlet / Outlet °C	12 / 6
	Sp. Gr.	1.0
	Conductivity @ 25 °C, µS/cm	≤ 1.0
	pH @ 25 °C	6.5 - 7.5
	Dissolved Oxygen conc. max. (ppb)	≤ 20
	Chloride, max. (ppb)	≤ 10
	Iron, max. (ppb)	≤ 10
	Copper, max. (ppb)	≤ 10
	Sodium, max. (ppb)	≤ 10
	TOC, max. (ppb)	≤ 100
Silica max. (ppb)	≤ 200	
Refrigerant Gas	Global Warming Potential (GWP)	<10
	Minimum pressure in the refrigerating circuit in all operating conditions shall be higher than atmospheric pressure	
	Low Flammability gas are preferred	
Available Footprint	<p>For Each unit: ~9150x2440 mm.</p> <p>with a clearance between chiller units of ~2050mm (refer to Appendix E)</p>	
Materials Of Construction	<p><u>Evaporator:</u> Austenitic Stainless Steel is the preferred material for the parts of evaporators in contact with chilled water.</p> <p>Supplier can propose other construction material taking into account the chilled water parameters (refer to 4.2), the given design conditions and the required qualifications</p> <p><u>Other Equipment:</u> Supplier can propose other construction material taking into account the chilled water parameters (refer to 4.2), the given design conditions and the required qualifications</p>	
Required Unit Availability	<p>Failure to Start < 9.21E-03/day</p> <p>Failure to Run < 6.93E-05/hour</p>	
Allowable Sound Pressure Level	<85 dBA at 1 meter of the skid	

4.2 Environmental Conditions

Units will be installed **outdoor**, on the roof of Diagnostic Building (B74-R1, Tokamak Complex).

Equipment of each unit (except condensers) shall be installed inside a **container/cabinet**.

Ambient Conditions	Maximum	Minimum
Temperature, °C	+ 45	- 25
Relative Humidity, % at 40 °C	60	
Annual Rainfall, mm	965	289
Daily Rainfall, mm	180	
Hourly Rainfall, mm	120	
Daily Snowfall, mm	230	
Wind Speed, m/s	25.22	
Static Magnetic Field	12mT*	
ATEX Area Classification	Safe**	
Radiation dose	Not Applicable	
Seismic Loads	Refer to Appendix D	

*a safety coefficient of 1.4 has to be applied to this value for the qualification to static magnetic field

**Adequate ATEX certification shall be included in the scope if required by the chiller configuration (type of gas, installation in closed container/cabinet)

5 Regulatory Frame

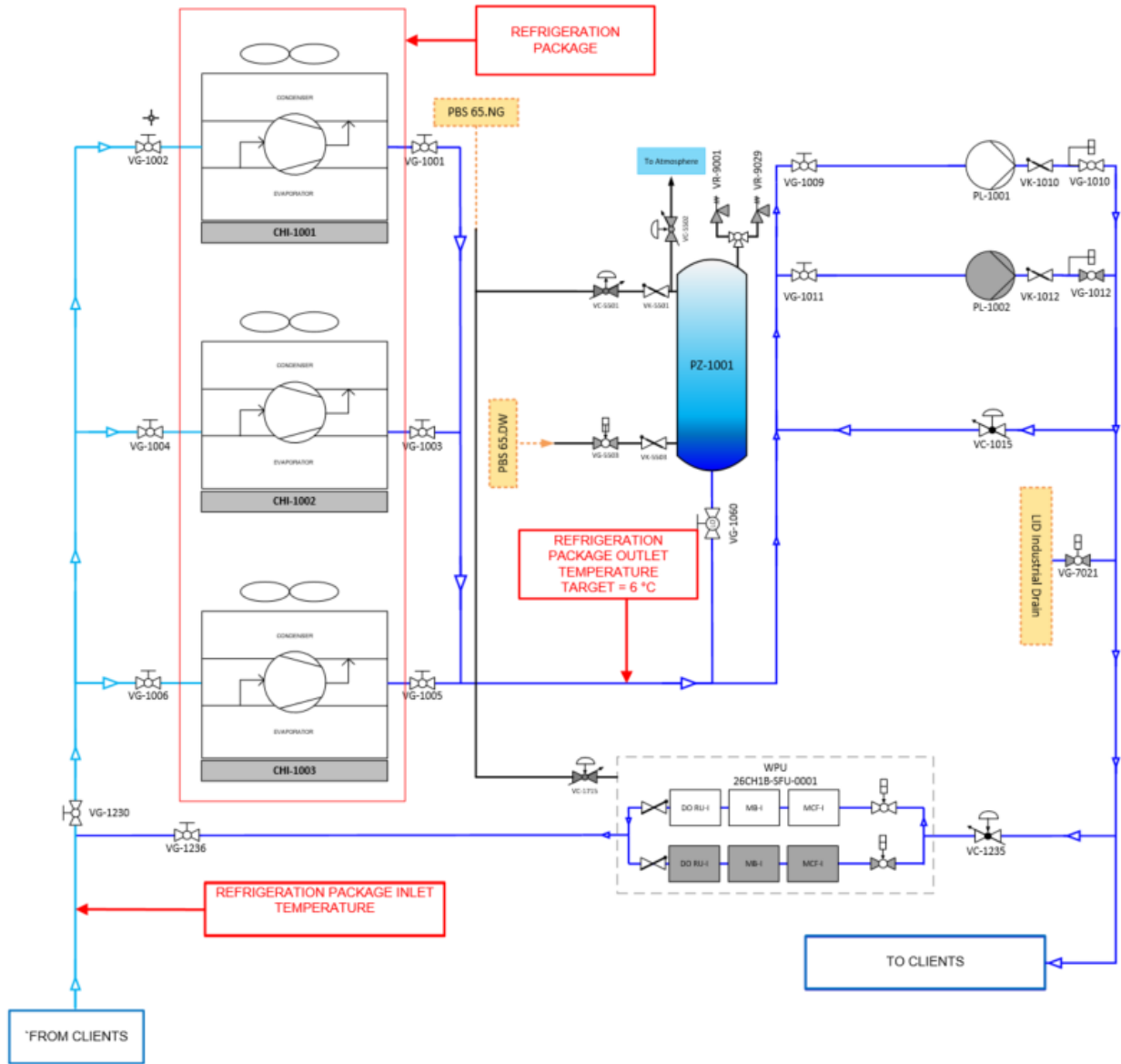
Offered package shall be in compliance with applicable French and European Regulation. This includes but is not limited to:

European Directive on machinery 2006/42/EC. Annex II, 1A to be applied for package certification
European Directive relative to pressure equipment 2014/68/UE
European Directive on Low Voltage Equipment 2014/35/UE
European Directive on Electromagnetic Compatibility 2014/30/UE
Cahier technique professionnel pour le suivi en service des systèmes frigorifiques sous pression” (CTP) du 23/07/2020
ASME Section VIII Division 1 (or equivalent)
RCC-E: Design and Construction rules for Electrical Equipment of Nuclear Island
AHRI Standard 551 591-2023 - Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle
IEC 60709 – 2018: Nuclear power plants - Instrumentation, control and electrical power systems important to safety - Separation
IEC/IEEE 60780 – 323 – 2016: Nuclear facilities - Electrical equipment important to safety - Qualification
IEC 60980 – Recommended Practices for Seismic Qualification of Electrical Equipment of the Safety System for nuclear generating stations
ASME-QME-1 2012-01-01 – Qualification of Active Mechanical Equipment Used in Nuclear Power Plants

6 Documentation to be provided with the Proposal

Minimum Set of Documentation
Technical Selection / Unit Datasheet
General arrangement drawing with overall dimensions (typical)
Technical Description of the package including Instrumentation and Control Arrangement
Unit/Package PID
Supplier Reference Lists for similar applications

Appendix A – Simplified System Diagram



Appendix B – Scope of Supply and Battery Limits

SCOPE OF SUPPLY OF EACH REFRIGERATION UNIT (Total Qty 3)	
1. Refrigeration gas compressor(s):	
	<ul style="list-style-type: none"> • Hermetic construction is preferred. • Semi-hermetic construction can be accepted or can be proposed by vendor as option, • Compressor electric motor(s) designed as per Manufacturer Standard, integral to compressors body, • Screw compressor technology has been considered as the base case. Other Technologies can be proposed by vendor based on his reference and his technical expertise. Reciprocating compressors are forbidden. • Compressors complete lube oil systems with oil separator and oil cooler (if required),
2. Evaporator, shell & tubes type,	
3. Forced Air Cooled condensers with AC type Fan motors,	
4. Economizer (Optional). To be included by vendor if required to cope with required operating conditions,	
5. Variable Frequency Drive (Optional). To be included by vendor to cope with required regulation range	
6. Hot gas bypass (Optional). To be included by vendor to cope with required regulation range	
7. On-skid set of safety and control instrumentations:	
	<ul style="list-style-type: none"> • High and Low Pressure switches/sensors for compressor inlet/discharge(1 set for each compressor), • Temperature Sensors for Evaporator Inlet And Outlet, • Flow transmitter on Evaporator Inlet to detect risk of freezing, • All other required safety and control instrumentation for safe and reliable operation of the package, • Instrumentation Junction Boxes, • Supplier to consider requirements on Separation for instrumentation important to safety.
8. All required pressure safety valves dual, fitted on three ways isolating valves	
9. Piping, Valves and fitting inside the skid	
10. Refrigerant gas receiver, flanged, valved, sized for complete refrigerant circuit drain	
11. First Charge of Refrigerant Gas	
12. Electrical Cabinet(s):	
	<ul style="list-style-type: none"> • Installed on skid to manage Electrical Motors and power distribution for any other equipment on skid (auxiliary equipment, PLC, HMI, valves...) • VFD (if required for regulation) or Softstarter for main AC motors shall be included in same cabinet or in a separated cabinet installed on skid • DOL start method for main motors is not accepted • One common entry for power supply in each refrigeration unit at the interface point along with required cable glands
13. PLC with local HMI panel installed in a dedicated control cubicle	
	<ul style="list-style-type: none"> • Preferred installation area is on skid • Supply to a centralized PLC able to control the duty and power repartition among the three chiller units is Optional, to be proposed by vendor • Units Control Parameters will be deported in control room. Required interface connections (hardwired and Modbus) to be provided by Vendor at battery limits • Units shall be designed to be operated either locally or remotely via control interface signals.
14. Cabinet/Container	
	<ul style="list-style-type: none"> • To protect from extreme environmental conditions all equipment included in the scope of supply, except condenser. Condenser will be installed on the top of the cabinet • Cabinet/Container configuration shall guarantee full accessibility and maintainability of components

<ul style="list-style-type: none"> Required HVAC, fire protection, noise insulation and leakage detection devices shall be included in the scope
15. Metallic Cable Glands at battery limits
16. Anti-freezing system, heat insulation/tracing, if required by the design of the equipment
17. Baseplate, with its anchor bolts and stainless steel shimming,
18. Seismic isolation structure/devices to cope with applicable seismic Floor Response Spectra (Refer to Appendix D):
<ul style="list-style-type: none"> It shall include all devices required to reduce accelerations to acceptable levels for the unit (e.g. dampers, springs) It shall include all structural elements required for the interface with unit baseplate and civil works. A secondary baseplate is required at the interface with foundation
19. All additional item to be supplied to cover the complete qualification of the chillers, including, if required, full scale test equipment
20. Testing (required quality class : QC-1):
<ul style="list-style-type: none"> Full Scale Performance Testing All Other Required Testing required by the applicable Quality Class as well as by Applicable Standards and Codes (3.1 Material Certificates, NDTs, etc.) All Testing Required in the Qualification plan, including full scale shaking table test for seismic qualification
21. All Required Surface protection and coating suitable for Outdoor installation
22. All Required Spares for Commissioning and Start-up
23. Quality documentation specific to material and components of each unit
24. All power and Instrumentation and Control cabling inside the skid battery limits.
25. UPS equipment (including accumulators) when required by Vendor to reach the safe state of the units after complete loss of main power supply
COMMON SCOPE OF SUPPLY FOR ALL REFRIGERATION UNITS
26. Additional centralized PLC (Optional) for the load repartition/regulation of the three chiller units, Including required interconnection cabling and communication with the individual PLCs of each refrigeration unit.
27. All Drawings, Calculation Notes, Common Qualification documentation as per agreed Vendor Document List (to be discussed later)

BATTERY LIMITS	
Process	Flanged Connection at Skid Edge for Evaporator Inlet and Outlet
Electrical	1 Single Electrical Connection at Skid Edge, 400 VAC 50 Hz, 3P+N+PE. The rest of voltage levels to be generated internally inside the electrical cabinet of each skid by the vendor.
Instrumentation	Junction Boxes at battery limits. Modbus (signal related to non-safety functions) and Hardwired (signals related to safety functions). Separation to be applied between safety and non-safety classified instrumentation
Civil/Structure	Chillers will be anchored on plinths equipped with embedded plates (Refer to Appendix E)

Appendix C - Process Datasheet

REFRIGERATION PACKAGE DATASHEET PROCESS DATA												
REFRIGERATION PACKAGE CONFIGURATION												
1	Package vendor :						System : CHWS-1B				Rev	
2	Package manufacturer :						Service : Chilled Water				Rev	
3	N. of refrigeration Units included the package : 3						Units TAGs : 26CH1B-CHI-1001/1002/1003					
4	Unit model :						Compressors items TAGs :					
5	Units process sparing : 3x33%						Evaporators items TAGs :					
6							Condensers items TAGs :					
7							Other :					
8							Other :					
9												
10												
11	Quantity of elements per unit :						Refrigeration Package Control:					
12	Compressor : <input type="radio"/> Serial <input type="radio"/> Parallel						Control system of each package:					
13	Condenser : <input type="radio"/> Serial <input type="radio"/> Parallel						<input checked="" type="radio"/> Local PLC <input type="radio"/> Centralized Control System Centralized Control System for the Refrigeration Unit (3)					
14	Evaporator : <input type="radio"/> Serial <input type="radio"/> Parallel						<input checked="" type="radio"/> Local PLC <input type="radio"/> Centralized Control System					
15	Other : <input type="radio"/> Serial <input type="radio"/> Parallel											
16	Other : <input type="radio"/> Serial <input type="radio"/> Parallel											
17	Other : <input type="radio"/> Serial <input type="radio"/> Parallel											
18												
19												
20	Package service description : Normal Operation: Package is continuously operated. Duty can vary from Minimal to Maximal Thermal Load											
21	Operation during accidents: Additional safety related clients will be cooled by the package.											
22	Duty can vary during the operation and can go down to low thermal power. In order to insure prompt availability of the cooling function, 0-100% regulation range has been considered. Start/stop regulation is forbidden											
23	Cooling water flowrate is constant et equally divided between the three units. No water flow regulation device is taken into account											
24	Inlet and Outlet temperature is referred to the mixing point downstream to chillers											
25	Target Temperature to clients is 6 °C. Vendor to indicate if this value can be guaranteed in all operating cases.											
26	PROCESS CONDITIONS IN OPERATING CASES											
27												
28		Design (Accidental Conditions)		Maximal Normal Operation		Minimal Normal Operation		Case 4		Case 5		
29		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
30												
31	Temperature (4) :	6	12.0	6	9.1	6	6.9					°C
32	Pressure :											bar a
33	Total process flowrate :	346		346		346						m ³ /h
34	Latent heat :											J/kg
35	Density:	1000		1000		1000						kg/m ³
36	Viscosity:											cP
37	Thermal Conductivity:											W/mk
38	Solidification Temperature :											°C
39	Specific Heat	4186		4186		4186						J/kgK
40												
41												
42	Package Duty											
43	Total Duty Required :	2400		1230		350						kW
44	N. of Units in operation (7):	3		2		2						
45	Duty of each chiller unit :	800		615		175						kW
46	Electrical Power for each chiller :											kW
47	Total Electrical Power :											kW
48	Energy Efficiency Ratio :											
49	Duration :											days/year
50												
51	Design Refrigeration Power	2400										kW
52	Required Margin on Refrigeration power	4.5										%
53	Total Refrigeration Power Required	2508										kW
54	Refrigeration power required for each chiller unit :	836										kW (1)
55	Refrigeration power provided for each chiller unit :											kW (5)
56	Control / regulation :	<input type="radio"/> By compressor slide control valve		<input type="radio"/> By speed variation		<input type="radio"/> By Hot gas by-pass (5)						
57	Regulation Range :	from 0 %	to 100 %									(2)
58												
59	REMARKS											
60	(1) Refrigeration power required for each chiller unit shall cover power required in maximum case											
61	(2) Regulation Range takes into account the Refrigeration Margin.											
62	(3) Need for a centralized PLC to be discussed with Vendor taking into account the different load cases											
63	(4) Outlet temperature is calculated from required thermal load. Refer to table at page 3 for allowable process values											
64	(5) Method of regulation to be defined by vendor.											

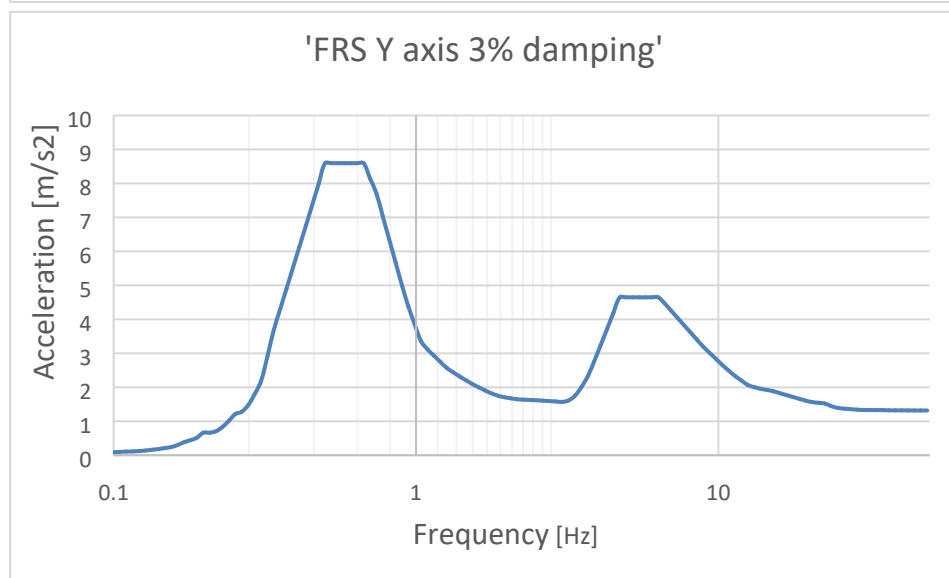
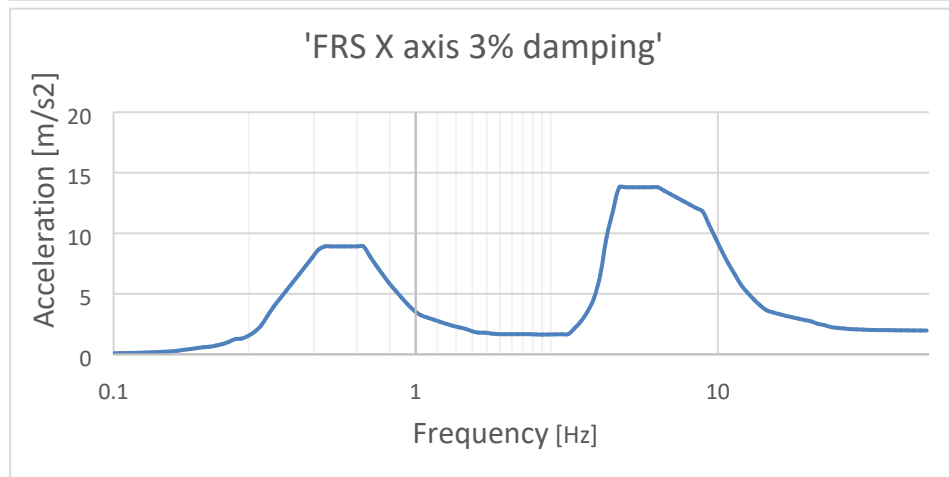
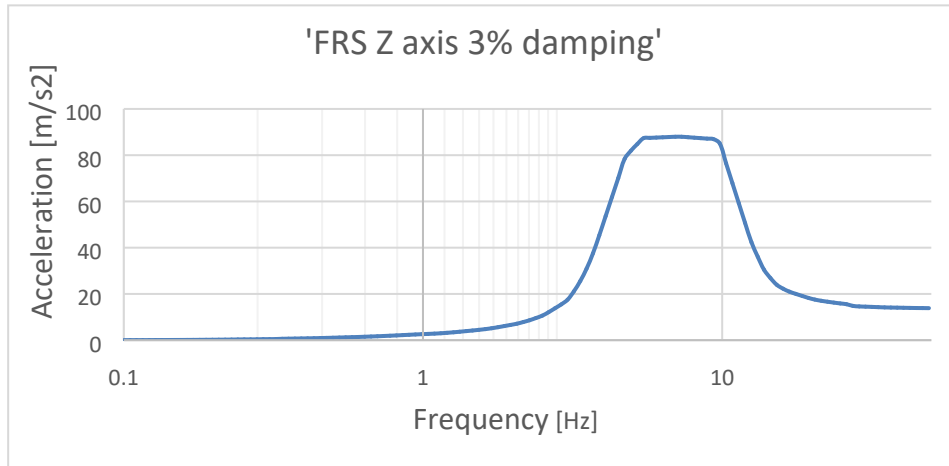
Appendix D – Floor Response Spectra

The values curves here below represent the SL-2 FRS in the installation area of the equipment.

Damping value considered for mechanical and electrical equipment in ITER standards is 3%.

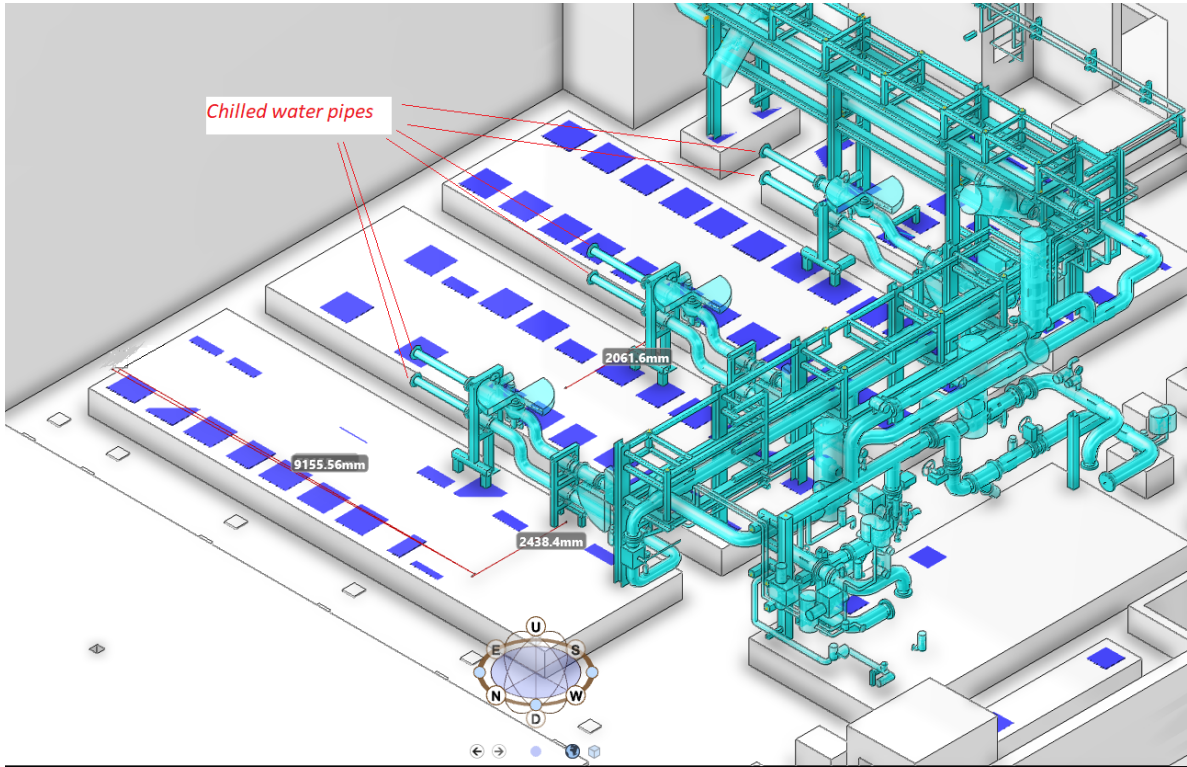
This is taken from U.S. Nuclear Regulatory Commission - REGULATORY GUIDE 1.61-DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS - Washington, DC 20555-0001 - March 2007

Vendor to check and validate the damping factor to be applied.



Appendix E –Installation Area on B74 – R1

Overall View of the installation Area (3 adjacent Plinths with embedded plates)



Location of embedded plates on chillers plinths

