

## **21 (6.2.A.04) Laydown, Assembly & RF Heating Building**

### **21.1 Functions, Basic Configuration and System Boundaries**

#### **21.1.1 Functions**

The main functions of the laydown, assembly, and RF heating (LA&RFH) building are the following;

- House and support the systems, and provide space.
- Provide a suitable environment for the systems and workers inside.
- Provide space for pre-assembly of the tokamak, and subsequent maintenance.

##### **21.1.1.1 House and Support the Systems, and Provide Space**

The LA&RFH building has space for the systems located within, and enough strength to support itself and the systems. The LA&RFH building protects against external hazards, including seismic events, extreme weather (hurricanes, tornadoes, rainfall, snow, etc. as specified in the PDS) in order to prevent failure of the systems. For the maintenance of the tokamak, an area of the LA&RFH hall is set aside with sufficient space to accommodate the cryostat lid and other major components.

Each system requires services, such as power supply, cooling water, etc. Thus, cables and pipes have to be installed in the LA&RFH building, to be connected to the site infrastructure.

##### **21.1.1.2 Provide a Suitable Environment**

For a suitable environment, the LA & RFH building provides the following systems;

- Lighting, service power
- Fire detection, alarm, and suppression
- Service fluid distribution system
- Drainage systems
- Grounding system
- Heating, ventilation, and air conditioning (HVAC) system
- Communication system

Many of these systems are commonly found in large industrial buildings, but there are some special features of the tokamak and its complex that generate some uncommon requirements;

- a very robust grounding system
- an access control system

##### **21.1.1.3 Provide Space for Pre-assembly of the Tokamak**

During assembly, the building is used for the assembly of the tokamak sector as a temporary fabrication facility. In this period, no internal structures above grade are provided. Thus, the internal structure to support the RF equipment shall be constructed after the assembly of the tokamak. The tokamak building heavy lift crane will be used to transport the cryostat components, the assembled vacuum vessel sectors, and other major tokamak components, into the pit in the tokamak complex. Thus, the rails for the heavy crane shall continue into the LA&RFH building.

### 21.1.2 Basic Configuration

The LA&RFH building is a 60 m high one-story building with a partial mezzanine floor. Power supply equipment for the heating and current drive (H&CD) systems is located on the basemat in the northern two thirds of the building, and H&CD generators are located on the mezzanine floor above the power supplies. The building is a steel reinforced concrete building. Steel frames are adopted as the support for the H&CD systems, and for the trusses for the roof and the south wall.

The main systems accommodated in the LA&RFH building are the ion cyclotron (IC), electron cyclotron (EC), and lower hybrid (LH) H&CD systems with their power supply equipment. As more H&CD equipment and power supply equipment may be added after the start of operations, the design of the building shall accommodate such expansion.

After the construction of the building enclosure, the LA&RFH building will be dedicated to support the assembly of the tokamak. Once the assembly is complete, the internal structure that will support the RF H&CD systems will be constructed, and those systems installed.

The major systems to be installed in the LA&RFH building are shown in the Table 21 (6.2.A.04) -1.

**Table 21 (6.2.A.04) -1 Major Systems installed in the LA&RFH Building**

Heating and Current Drive Power Supply	IC power supply, EC power supply, and extra power supplies
RF Generator	IC generators, EC gyrotrons, extra H&CD equipment
Laydown Area	An open area for general assembly, maintenance and equipment laydown

### 21.1.3 Interfaces

The building interfaces with the following WBS elements:

WBS	Title
2.2	Tokamak Assembly & Tooling
2.6.O	Component Cooling System
2.6.P	Chilled Water Systems
4.3.C	Steady State Electrical Power Distribution
4.5	CODAC
4.6.C	Access Control
5.1	IC H&CD System
5.2	EC H&CD System
5.4	Lower Hybrid Heating & Current Drive System
6.1.A	Site General Layout
6.2.A	Tokamak Buildings
6.2.S	Utility Tunnels & Site Improvements
6.5	Liquid Distribution

## 21.2 Requirements

### 21.2.1 Design

The requirements for the LA&RFH building are derived from the PDS, DRG1, and section 21.1.1. The requirements identified below are not complete as some equipment is still being designed. However, all the requirements necessary for the overall configuration and general conceptual design of the building have been identified.

#### 21.2.1.1 General

The crane hall in the tokamak complex continues into the LA&RFH building, with no wall or door between them. Thus, the expansion joint between these buildings shall be robust and able to withstand weathering and provide a reliable seal against air leakage.

Large tokamak components will be transported into the LA&RFH building through the southern access door. This door shall be capable of handling the widest and the tallest component which is the cryostat.

After the assembly of the tokamak is complete, the LA&RFH building shall provide space for the RF H&CD systems with their power supplies, and will also provide a laydown area for any large components that may be removed for maintenance, such as sectors of the tokamak and the cryostat lid.

The systems in the LA&RFH building are identified below.

##### 21.2.1.1.1 Ion Cyclotron IC H&CD System

The building shall accommodate the initial IC H&CD system, which includes generators and coaxial transmission lines. The system shall be placed to minimise the number of bending points of these transmission lines. The layout shall accommodate future expansion of the system.

##### 21.2.1.1.2 Electron Cyclotron EC H&CD System

The building shall accommodate the initial EC H&CD system including gyrotrons and waveguides. The system shall be placed to minimise the number of bending points of waveguides. The layout shall accommodate future expansion of the system.

##### 21.2.1.1.3 Lower Hybrid LH H&CD System

There is no plan for a LH H&CD system to be placed in the building at the time of first operation. However, a LH H&CD system may be added. The building shall accommodate the generators and waveguides of the LH H&CD system, if and when required.

#### 21.2.1.1.4 Power Supply Equipment for H&CD Systems

The building shall accommodate the power supply equipment for H&CD systems. The number and type of equipment may be increased after construction, and the building shall allow for these changes.

#### 21.2.1.1.5 Laydown Area

The building shall incorporate a flat area as a laydown area for the cryostat lid and other tokamak components that may be removed during maintenance.

#### 21.2.1.1.6 Building Cranes

The building shall accommodate the tokamak crane with a lifting capacity of up to 1,500 t. This capacity is supplied from two (2) 750 t capacity cranes, each with 2 hooks, and able to operate in conjunction with one another. Crane rails of the LA&RFH building shall match with those in the tokamak crane hall.

#### 21.2.1.2 Seismic

The LA&RFH building is not safety importance class (SIC) but shall withstand SL-2 seismic conditions with peak horizontal and vertical accelerations as specified in the PDS and DRG1.

#### 21.2.1.3 Structural

##### 21.2.1.3.1 Dead Loads and Equipment Loads

The building shall support its own weight as well as the weight of all installed equipment.

##### 21.2.1.3.2 Live Loads

The building shall support the weight and forces of all movable and active components, systems, and structures located on the slabs or walls of the building.

##### 21.2.1.3.3 Lifting and Materials Handling Devices

The structure shall support the weight and forces of all lifted loads, including the lifting devices over the full range of their travel. Structural deflection under such loading shall be consistent with the required precision of the lifting devices.

##### 21.2.1.3.4 External Hazard Loads

The structure shall resist the force exerted by seismic activity, wind, snow and soil and ground water pressure, as defined in the PDS.

#### 21.2.1.4 Electromagnetic

To avoid disruption in operation, ferromagnetic material shall not be placed within 2 m of the core parts of gyrotrons or generators. Structural steel supporting these components shall be

non-ferromagnetic.

#### 21.2.1.5 Construction

The internal structure of LA&RFH building shall be constructed after tokamak assembly is completed. The building shall be designed to accommodate the additional steel structural floors required for the RF H&CD systems.

#### 21.2.1.6 Assembly

##### 21.2.1.6.1 Area for Tokamak Assembly

The entire building internal area shall be dedicated as an assembly area for the tokamak and the cryostat during the assembly phase. The area shall be flat at grade level. The area shall be designed to support loads of the tokamak components to be assembled.

##### 21.2.1.6.2 Crane Hall Cleanliness

The space to be used for tokamak assembly shall meet air quality requirements that include the maintenance of temperature in the range  $20^{\circ}\text{C}$  to  $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$  up to an elevation of + 5 m, relative humidity below 70%, and dust shall be minimised. These conditions shall be maintained until the cryostat top is installed except for periods when the large access doors are opened and/or large numbers of workers are present.

##### 21.2.1.6.3 Construction Schedule

The installation of systems in LA&RFH building, such as the tokamak crane, shall be coordinated with the tokamak assembly schedule.

#### 21.2.1.7 Testing

##### 21.2.1.7.1 General

The LA & RFH building shall be constructed to appropriate codes and standards, which will include requirements for construction and commissioning testing of materials, welding, piping systems, electrical systems, and other active building components. In addition to construction-related inspection and testing, the LA & RFH building shall be designed to accommodate functional testing of building systems such as fire detection, alarm, and mitigation systems. Specific testing requirements will be imposed on the building features listed below.

##### 21.2.1.7.2 Crane Testing Capability

The tokamak building cranes, which have a combined lifting capacity of 1,500 t, shall be tested periodically to confirm the crane's performance capability. The LA&RFH building shall provide permanently installed hook points at grade which are capable of withstanding the structural load associated with attaching the cranes and lifting until the desired crane test load is induced in the crane structures. The size and spacing of the hook points shall be suitable for attachment with the dual crane lifting beam.

### 21.2.1.8 Electrical

#### 21.2.1.8.1 Lighting

The building shall be provided with appropriate permanently installed electrical lighting which shall include an emergency lighting circuit.

#### 21.2.1.8.2 Electrical Services

The buildings shall distribute low voltage power for services and welding to points within the buildings.

#### 21.2.1.8.3 Grounding

The building shall have an electrical grounding grid with connections to the plant-wide grounding grid network, and shall have robust grounding terminals at specified locations inside the building.

#### 21.2.1.8.4 Lightning Protection

The building shall have lightning protection systems with connections to specified grounding grid terminals.

### 21.2.1.9 Potable Water and Drainage

There will be no potable water supply or sanitary drainage facilities in the building. The LA&RFH building shall have roof drains that connect to the yard drain system, and shall have floor drains that connect to the plant industrial sewer system.

### 21.2.1.10 HVAC

#### 21.2.1.10.1 Temperature, Humidity, Particulates, Gaseous Contaminants

The tokamak assembly requires that the HVAC system in this building shall maintain a uniform temperature distribution,  $\pm 2^{\circ}\text{C}$ . Air quality for the workers shall also be maintained at acceptable levels. Use of local air coolers and up to 95% re-circulation of the HVAC air flow shall be considered to minimise the HVAC equipment size and heating and cooling loads.

#### 21.2.1.10.2 Reliability

The HVAC system shall have sufficient redundant capability including pre-filters, cooling and re-heating coils and high-speed fans.



- under short circuit conditions      250°C;
- acid gas content                              zero halogen, according to IEC-754;
- fire retardancy                                according to IEC-332-3

**Table 21 (6.2.A.04) -2 IEC Relevant Material**

IEC #	Technical Committee	Title
332 -1 to 3	SC 20C	Test on electric cables under fire conditions
728	SC 12G	Cable distribution systems
754	SC 20C	Tests on gases involved during combustion of electric cables
840	SC 20A	Test on electric cables 30 kV to 150 kV

#### 21.2.1.15 Cranes, Lifts and Material Handling

##### 21.2.1.15.1 Cranes

The crane hall, which is approximately 49 m wide, 37 m high, and 175 m long from the north end of tokamak complex to the south end of the LA&RFH building, shall be served by two independent 750 t bridge cranes, each equipped with two 375 t main hoists and two 100 t auxiliary hoists. The maximum load with the four main hoists synchronised shall be 1,500 t. The crane rails shall span 45 m and the maximum vertical load travel shall be about 40 m.

##### 21.2.1.16 Decommissioning

The laydown area of the LA&RFH building shall be available for decommissioning activities, which is to accommodate the large components removed from the tokamak pit, in a similar manner to tokamak assembly and maintenance.

##### 21.2.1.17 Instrumentation and Control

Building support systems which have actively controlled components shall comply with ITER plant standards for control and communication protocols, and shall provide appropriate interfaces to the CODAC system.

## 21.2.2 **Operation and Maintenance**

The operations and maintenance (O&M) requirements for the LA&RFH building are derived from DRG1 and the PDS, and the functions of the building (as given in section 2.1.1).

### 21.2.2.1 Operation and Control of Building Services

Building services shall incorporate appropriate instrumentation and control subsystems to manage system operation. Manual control over lighting, power distribution, and fluid supply will be adequate. Manual control with safety interlocks are provided for the crane. Building

systems with no safety or radiation control function (compressed air distribution, industrial drainage, grounding, etc.) will be equipped with appropriate instrumentation and control to operate in a stand-alone mode. Operation and control of these building systems will be centralised in building control panels located within the building. The status of these building systems will be provided to the CODAC system. However, the LA&RFH building systems shall not be directly controlled from the main control room.

Fire protections systems in the LA&RFH building will be equipped with automatic controls with manual override capability. These systems will initiate alarms and signals which will initiate appropriate reactions, and will report their status to the CODAC system, but these systems will not be controlled directly from the main control room.

Access control, floor drainage, and HVAC systems perform functions that are directly related to worker safety and release of radioactive material to the environment. These systems will be equipped with instrumentation and control to enable active control from the main control room. When authorised, devices will also be operable from field control panels at building control panels in the LA&RFH building. Door status indicators will be provided, and integrated with the control system for HVAC, so that different HVAC operating modes can be accommodated dynamically.

#### 21.2.2.2 Maintenance of Building Services

There are no specific building system maintenance requirements apart from periodic inspection and repair or system correction during or after these inspection periods. Operation of most systems may be interrupted for maintenance activities. However, HVAC systems will include sufficient installed redundancy so that adequate service can be maintained while one unit is removed from service for maintenance.

#### 21.2.2.3 Structural Maintenance

##### 21.2.2.3.1 Expansion Joints

The building design shall provide access and methods for maintaining expansion joint seal quality.

##### 21.2.2.3.2 Corrosion Prevention and Control

The building materials which may be degraded by corrosion shall have prevention and control measures which may be maintained over the life of the project including decommissioning and dismantling.

### 21.2.3 **Surveillance and In-Service Inspection**

#### 21.2.3.1 Fiducial Reference Marks

The LA&RFH building shall contain primary and secondary fiducial reference marks permanently installed for initial assembly, maintenance and rechecking of critical dimensions.

### 21.2.3.2 Periodic Inspection and Testing of Safety Functions

All safety related functions shall be implemented in a way to allow periodic inspection and testing. The access control system must be testable to assure the integrity of door status indicators and other features.

### 21.2.4 **Quality Assurance (QA)**

The LA&RFH building shall be designed and constructed in compliance with the ITER QA program. The building shall be designed and constructed in accordance with American concrete institute (ACI) - 349 (or equivalent) and all the quality assurance and inspections contained therein, plus any additional requirements specified by the ITER QA manual.

### 21.2.5 **Reliability Assurance**

There are no special reliability assurance requirements for the LA&RFH building, except where those structures form part of a safety related building subsystem. By choosing appropriate codes and quality assurance requirements, the primary structures of the LA&RFH building can reasonably be assured to meet the failure expectancy assumed in safety evaluations (on the order of  $10^{-6}$  per year). Other measures taken to assure that building support systems meet or exceed the reliability assumed in safety analyses shall include continuous monitoring with instrumentation, periodic functional testing, and suitable preventative maintenance programs.

#### 21.2.5.1 HVAC Components and Equipment

HVAC systems shall be designed with sufficiently redundant installed components (filters, air handling units, and depression fans) to achieve all safety requirements. Reliability of these systems will be assured by continuous monitoring, control panel alarm response and a program of preventative maintenance.

#### 21.2.5.2 Lifting Equipment

The LA&RFH building overhead cranes are not redundant, and their reliability will be assured by specification, good design practice, proper operation, and adequate testing. Cranes shall be rated for continuous duty and will be subject to continuous preventative maintenance programs. Lifting beams, slings, and other lifting aids shall be subject to industry rules for periodic inspection, testing, and certification, similar to rules for instrument calibration.

## 21.3 **Codes and Standards**

The building shall be designed and constructed in accordance with American concrete institute (ACI) - 349 (or equivalent). Structural steel elements within the LA&RFH building, such as the building roof trusses, shall be designed in accordance with American institute of steel construction (AISC) - "Allowable Stress Design Manual of Steel Construction" (or the load and resistance factor design manual of steel construction ) or equivalent.