21 (6.2.B) Hot Cell Building

21.1 Functions, Basic Configuration, and Interfaces

21.1.1 Functions

The main functions of the hot cell building are the following;
1) House and support the systems, and provide space.
2) Provide a suitable environment for the systems, equipment, and personnel.
3) Provide confinement boundary of tritium, activated materials, and beryllium (Be).
4) Provide radiation shielding around removed in-vessel components and around all areas containing radiation hazards.

21.1.1.1 House and Support the Systems, and Provide Space

The building provides support and space for components and also provides space for access, processing, maintenance, equipment, and storage.

As the in-vessel components, both irradiated and contaminated with tritium, beryllium and activated dust are removed from the tokamak, the passageway and the cells where the components are handled must have shielding and confinement functions. In cells, the components are examined and processed. Waste from the components will be stored in a separate storage area. Another area provides storage for some in-vessel components, such as divertors, port plugs, and blankets.

An atmosphere detritiation system (ADS) and a ventilation detritiation system (VDS) provide a means of gathering tritium, and pipes transfer the tritiated water from the systems to the tritium building.

21.1.1.2 Provide a Suitable Environment

The hot cell building provides a suitable environment for the systems, equipment, and personnel, with the following systems;
- Materials handling
- Lighting, service power, and welding power
- Fire detection, alarm, and mitigation
- Service fluid distribution systems
- Drainage systems
- Electrical grounding
- Heating, air-conditioning, and ventilation (HVAC) system
- Access control and personnel escape system
- Communication system

The material handling system includes the overhead cranes, lifts, and hoists located in various cells and rooms that are potentially contaminated within the boundaries of the hot cells. Space and facilities must be provided for the retraction of cranes into separate rooms where they can be accessed for maintenance. As the building has radioactive materials inside, access control is necessary. The other building systems are similar to those used in large

industrial buildings.

21.1.1.3 Confinement Boundary

The components in the hot cells are sources of tritium, beryllium, and activated dust. The hot cells and hot cell building HVAC systems must provide confinement of these sources, to keep exposure to workers and the public within regulatory limits. The required confinement functions can be provided by assigning suitable leak tightness to hot cell boundaries, and maintaining HVAC pressure gradients and exhaust stream treatment. Thus, the portions of the building and the hot cells within the building have a confinement function. In order to reduce the amount of tritiated water in the atmosphere of the cells, and to recover the tritium in a cost effective manner, the hot cells are designed for minimum air inleakage as they operate in an environment of negative pressure. The rooms surrounding the hot cells, which are potentially contaminated, are under a negative pressure that is higher than the hot cells. The ADS detritiates the air inside the hot cells. The HVAC system handles the air in the rest of the building.

21.1.1.4 Radiation Shielding

Highly activated materials and components are moved from the tokamak building to the hot cell building using unshielded transfer casks. During the transit of in-vessel components and other radioactive devices, the tokamak complex and hot cell building must provide shielding to separate the transport pathway from other worker-occupied areas, and must provide systems to control access to the transportation pathway to prevent accidental exposure. The hot cell building provides shielding to adequately attenuate radiation doses from objects in storage, and processing cells, so that nearby areas can be occupied by operators who will control and supervise the remote handling operations. The hot cell building will be constructed of reinforced concrete, and building elements will be sized for structural loads or for shielding, whichever requires the thicker elements.

21.1.2 Basic Configuration

The major systems in the hot cell building are shown in the following table.

Table 21 (6.2.B) -1 Major Systems installed in the Hot Cell Building

Hot Cell Docking and Storage System	Docking Subsystem
	Dust Cleaning Subsystem
	Nitrogen Purge Subsystem
	Storage Subsystem
	Remote Handling Tool Storage/Repair Subsystem
	Control, Interlock and Monitoring Subsystem
Hot Cell Repair/Testing System	
Hot Cell Waste Processing and Storage System	
Hot Cell Radioactivity and Toxic Material Control System	ADS, VDS
Remote Handling Test Facility	Test Stand, Transfer Casks & RH Equipment Storage

The hot cell building provides space for the repair and storage of plasma-facing components at EL – 0.0 m level. The control room and other service rooms are provided at the EL + 5.38 m level. The lower RH test facility floor is also used as a cask storage area. Rooms for the ADS and VDS, and rooms for the HVAC are located at EL + 10.56 m level. The upper RH test facility, at EL +15.81 m, is also used for cask storage. The refurbishment area for remote handling (RH) casks, and the test stand for remote handling are also located in the building.

21.1.3 Interfaces

The hot cell building has interfaces with the following WBS elements:

WBS	Title
2.3	Remote Handling Equipment
2.6.P	Chilled Water Systems
3.2.F	Atmosphere Detritiation
4.2.C	NB H&CD System Power Supplies
4.5	CODAC
4.6	Interlocks System
6.1.A	Site General Layout
6.2.A	Tokamak Buildings
6.2.G	Radwaste and Personnel Building
6.2.S	Utility Tunnels & Site Improvements
6.3	Hot Cell Processing and Waste Treatment
6.4	Radiological and Environmental Monitoring
6.5	Liquid Distribution, Including Water
6.6	Gas Distribution and Compressors

21.2 Design Requirements

21.2.1 General

The requirements for the hot cell building are derived from the DRG1 and section 21.1.1.

These requirements are not a complete list because equipment is still being developed and interface information will be revised. However, these requirements provide the input to control the overall configuration and general design concept of the building.

21.2.1.1 General

21.2.1.1.1 Docking

The building shall accommodate the docking system for receiving transfer casks from the tokamak building and provide space for the transfer components and RH tools.

21.2.1.1.2 Dust Cleaning

The building shall provide space for a dust cleaning system for the divertor cassettes and other components delivered by transfer casks.

21.2.1.1.3 Tritium Recovery

The building shall provide space for a tritium recovery system for segregated waste material if required, and provide space for its maintenance.

21.2.1.1.4 Hot Cell Storage

The building shall accommodate the hot cell waste processing and storage system and provide space for the components before repair/waste processing and after components are repaired.

21.2.1.1.5 Remote Handling Tools Storage/Repair

The building shall provide storage space, access, and facilities needed to store and maintain remote handling equipment used to effect remote handling operations in the tokamak. Space shall be provided for decontamination, testing, hands-on repair, and storage of remote handling equipment.

21.2.1.1.6 Hot Cell Component Repair/Testing

The building shall accommodate the component repair system which includes examination, preparation of service plans, preparation of samples for material evaluation, evaluation and segregation of parts into those which can be reused and those which must be replaced, disassembly, replacement of parts, re-assembly, and inspection/testing.

21.2.1.1.7 Waste Processing and Storage

The building shall provide dedicated hot cell space for processing activated waste materials and components, and provide the space for the operation of these hot cell systems. The operations to be carried out as part of waste processing include separation of beryllium from other materials, (if required), mechanical cutting and crushing, vacuum baking of high heat flux components and beryllium parts to recover tritium (if required), and packaging of residual materials for disposal.

21.2.1.1.8 Hot Cell Radioactivity and Toxic Material Control

The building shall provide the space for a hot cell radioactivity and toxic material control system.

21.2.1.1.9 Remote Handling Test Facility

The building shall provide the space for a remote handling test facility where the performance of RH is examined. The space is also used for the storage of transfer casks.

21.2.1.1.10 Introduction of New Parts and Equipment

The hot cell building shall provide facilities to allow for the introduction of new parts for plasma-facing objects and port-mounted systems. Although they may be completely free of radioactivity, if these parts and equipment are installed using the tokamak remote handling tooling and machinery, they will be delivered to the tokamak via the hot cell building. In addition, the building shall accommodate replacement equipment for hot cell systems. New parts and equipment located in the pit in the tokamak complex, but not using the remote handling systems for delivery to a tokamak port, will be introduced to the pit via the LA&RFH building or the hot cell building.

21.2.1.2 Seismic

The hot cell building shall be safety importance class (SIC) and shall withstand SL-2 seismic conditions with peak horizontal and vertical accelerations as specified in the DRG1 annex “Load Specification and Combination”. Hot cell building HVAC systems which provide tritium control and confinement functions (i.e. maintain negative pressure in HVAC groups 1, 2, and 3) are classified SIC. The building will be considered to have withstood these conditions if no damage occurs to SIC components that would impair their safety function.

21.2.1.3 Structural

21.2.1.3.1 Dead Loads and Equipment Load

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

21.2.1.3.2 Live Loads supported by the Walls and Slabs

The structure shall support the weight and forces of all movable and active components,

systems, and structures supported by walls or slabs.

21.2.1.3.3 Lifting/Transporting Devices and their Loads carried on Support Structures

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 must 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.

21.2.1.4 Remote Handling

The intra-hot cell transportation system, and all overhead and lifting devices located within shielded cells shall be remotely operable. All such devices shall have a method of rescue in the event of failure and a method of withdrawal into a service area where radiation exposure is low enough to permit hands-on repair. If hot cell building lifting and handling devices are subject to excessive contamination, such that hands-on repair is precluded, they shall be designed for dry decontamination or remote repair.

21.2.1.5 Assembly

The hot cell building shall be used during the tokamak assembly stage for both the storage and the preparation for installation of the in-vessel components of the tokamak machine. To facilitate this, some of the building external structure will be delayed until after the assembly of these in-vessel components is complete, to allow for their handling with minimum restrictions by the otherwise confining spaces of the hot cell structure and walls.

21.2.1.6 Testing

The hot cell building shall be constructed to appropriate codes and standards (section 21.3), which will include requirements for the 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 hot cell building shall be designed to accommodate functional testing of building systems such as fire detection and mitigation systems.

21.2.1.7 Electrical

21.2.1.7.1 Building Lighting Service

The building shall provide appropriate permanently installed electrical lighting which includes normal and emergency lighting. Lighting for inaccessible areas (storage and processing cells) shall be designed for revamping and replacement of fixtures by withdrawal into an accessible area.

21.2.1.7.2 Building Electrical Service

The building shall distribute low voltage power for services and welding to all normally accessible rooms and spaces within the building.

21.2.1.7.3 Electrical Grounding

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

21.2.1.7.4 Lightning Protection System

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

21.2.1.8 Potable Water and Drainage

21.2.1.8.1 Potable Water

There shall be no potable water supply or sanitary drainage facilities from potentially contaminated zones. This restriction is designed to avoid the potential of worker ingestion of contaminated potable water and the potential radioactive contamination of sanitary drains. Portable facilities including drinking water containers and self-contained decontamination showers will be permitted under the supervision of the plant health physics procedures. These rules exclude the supply of potable water to the hot cell building.

21.2.1.8.2 Roof Drains

The hot cell building shall have roof drains that connect to the yard drain system.

21.2.1.8.3 Floor Drains

Floor drains within contamination control areas (i.e. all of the hot cell building) shall always connect to the low level radwaste systems. However, because there should be no water used within the hot cells, nor other liquids, the floor drains shall be isolated unless a specific need arises.

21.2.1.9 HVAC

21.2.1.9.1 Heating, Ventilation and Air Conditioning (HVAC) for Tritium Control

All areas except red and amber zones within the hot cell building shall be equipped with HVAC systems. The tritium handling areas (red zone) and possible potential tritium contamination areas (amber zone) shall be equipped with tritium confinement (emergency HVAC isolation valves) and detritiation capability.

21.2.1.9.2 HVAC Pressure Gradients

The building shall be constructed such that HVAC pressure gradients in the airflow system are in the opposite direction of the contamination gradients of the areas associated with the building. The hot cell ventilation shall consist of the systems shown in Table 21 (6.2.B) -2.

Table 21 (6.2.B) -2 Classification of HVAC

Ventilation	**ADS VDS**	**ADS VDS**	**HVAC VDS**	**Local air cooler**
Tritium contamination zone	Red	Amber	Green White	Red (*1)
Exposure zone	D	C	B	
ADS/VDS operation	Normal	Normal	Backup	
Pressure, mbar gauge	-3	-2	-1	

*1 Heat load in the red zone is removed by internal circulation local air cooler to maintain room temperature < 35°C

21.2.1.9.3 Temperature, Humidity, Particulates, Gaseous Contaminants

The hot cell building HVAC systems shall provide air quality (temperature, humidity, purity, freshness) sufficient to meet the requirements of the personnel and equipment located in the building. HVAC systems also provide heat removal for the equipment and lighting. The hot cell storage and processing areas should have temperatures at 35°C or less. Relative humidity in the amber and green zones will be maintained less than 40% at 25°C to minimise tritiated water generation during ADS/VDS normal operation for red and amber zones. Pathways of moisture in-leakage into the red and amber zones will be from green zones and the surrounding building wall exposed to the external atmosphere. The HVAC systems shall be designed to meet the humidity requirement in the green zones. The rooms and spaces which are assigned a containment or confinement function shall be equipped with instrumentation and controls to detect and identify off-normal pressurisation conditions. Signals from these instruments will be used by the building HVAC or the CODAC system to initiate mitigating actions where appropriate.

21.2.1.9.4 HVAC Subsystem Independence

The hot cell building HVAC systems shall be designed as independent subsystems for each of the major process areas, to limit the possibility of transfer of contamination between areas.

21.2.1.9.5 Leak Tightness

The rooms and cells classified into contamination zone red or amber shall have a maximum in-leakage of 20 vol.%/day under negative pressure design conditions.

21.2.1.10 Fire Protection

21.2.1.10.1 Passive Protection

All areas within the hot cell building shall have separate fire-rated zones for identified

hazards and protected exit routes.

21.2.1.10.2 Detection System

All areas within the hot cell building shall have an automatic fire detection and alarm system installed throughout the building, including audio-visual alarms and manual activation stations. The system shall be sensible to flame, smoke or combustible gas.

21.2.1.10.3 Mitigation Systems

All areas within the hot cell building shall be equipped with appropriate fire mitigation (including suppression) systems, consistent with the building occupancy and anticipated fire hazard loading. No wet standpipes or other fire suppression systems will be permanently installed inside of storage, examination or processing cells. Dry chemical or inert gas fire suppression systems may be installed for specific hot cell machinery or functions if the hazards they represent are considered sufficient.

21.2.1.11 Internal Communication

The building shall provide communications networks such as telephones, a public address system, local area computer network, CCTV, etc.

21.2.1.12 Access Control

The hot cell building shall provide a system to control access to all rooms and spaces within the building. The building shall be equipped with physical restrictions to unauthorized personnel for entrance to or between the four access control zones, A, B, C & D. The system must be capable of allowing and recording single person ingress and egress with discrete signals to the central control. The access control shall include an audiovisual alarm to warn of potential hazards or the need for evacuation. The alarm shall be activated automatically by zone breach, or manually by push-button. Personnel monitoring and radiation protection procedures shall be used whenever workers cross zone designation boundaries. In addition, worker entry and exit from areas within normal accessible areas (A and B zones) will be monitored to assure appropriate responses to building evacuation events. The access control system must confirm that no workers are anywhere along the pathway used to transport plasma-facing objects from the tokamak to the hot cell building when such transport operations can occur. The access control system must interface with the area radiation monitoring system to prevent re-entry into any area where alarms have been actuated by high radiation. The access control shall be provided with the necessary equipment to control worker access and to interface with the plant access control system.

21.2.1.13 Materials

21.2.1.13.1 Structural

There are no special requirements for materials of construction, however many hot cell building systems shall be constructed using materials that are not sensitive to gamma radiation. Because tritium easily exchanges with hydrogen, the hot cell building and its support systems should avoid the use of exposed hydrocarbons such as rubber, plastic, etc.

However, this does not preclude the use of epoxy, or fibreglass reinforced epoxy, for the liner. Fibreglass reinforced epoxy is preferred, not for its increased strength, but for the fact that it contains a smaller fraction of hydrogen-containing materials, and thus will absorb somewhat less tritium by tritium-hydrogen exchange reactions. Thus, the use of epoxy materials for the hot cell lining, with suitable radiation resistance, is acceptable.

21.2.1.13.2 Electrical

All cables will be made with copper and should have appropriate insulation level according to nominal voltage of equipment to be supplied. Cable insulation should meet the following requirements:

- insulation material XLPE preferred, PVC not accepted;
- max. permissible temperature of conductor:
  - continuous 90°C,
  - 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.B) -3 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

21.2.1.14 Cranes, Lifts and Material Handling

The building must be consistent with and provide part of the air-pad transportation system that connects the tokamak with the hot cell. The storage, processing and repair cells shall have overhead bridge cranes with manipulators that retrieve hot cell processing equipment for maintenance. These cranes can also act as backup systems for the floor-supported intra-cell transportation system. The hot cell building must also provide a rescue capability for all overhead cranes.

21.2.1.15 Instrumentation and Control

Building support systems, including HVAC and any other subsystems 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.

21.2.1.15.1 Access Control

The building shall be provided with the necessary instrumentation and control equipment to control worker access and to interface it to the plant CODAC system.

21.2.1.15.2 Communications Networks

The building shall be provided with the necessary cabling and equipment to link specified locations in the building with plant communications networks such as telephones, computers, CCTV, etc.

21.2.1.15.3 Confinement Systems

The rooms and spaces, which are assigned a containment or confinement function shall be equipped with instrumentation and controls to detect and identify off-normal pressurisation conditions. Signals from these instruments will be used by the building HVAC or CODAC system to initiated mitigating actions where appropriate.

21.2.2 Operation and Maintenance

The operations and maintenance (O&M) requirements for the hot cell building are derived from DRG1 and the functions of the building (section 21.1.1).

21.2.2.1 Operation and Control of Building Services

Building service systems shall incorporate manual control over lighting, power distribution, large doors, and fluid supply. Manual control with safety interlocks shall be provided for building cranes and lifting devices located in green zones. Remote control with safety interlocks and control interfaces to hot cell systems shall be provided for building cranes and lifting devices located in amber and red zones. 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 centralized in building control panels located within the building. The status of these building support systems will be provided to the CODAC system. However, none of these hot cell building support systems will be directly controlled from the ITER main control room.

Fire protection systems shall be equipped with automatic controls with manual override capability. These systems will initiate alarms and signals, and will report status to the CODAC system, but these systems will not be controlled directly from the ITER 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 it is authorized, devices will also be operable from building control panels in the hot cell 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. The access control system will interface with remote handling transport

systems, to assure that no workers are in unsafe locations when hazardous operations are initiated.

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.

21.2.2.3 Maintenance of Structures

The buildings 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

There are no surveillance and in-service inspection requirements for the building apart from usual, annual, visual inspections of the building for noting the status of the overall condition, and for monitoring for any deterioration. In addition, there may be legal inspections for some of the building equipment such as lifts, and the fire detection, alarm, and suppression systems. Leak rates for various rooms and cells will be continuously monitored and evaluated through the development and analysis of HVAC performance data.

21.2.4 Quality Assurance (QA)

The hot cell building shall be designed and constructed in compliance with ITER QA program. The building is SIC and seismic class, and shall be designed and constructed in accordance with American concrete institute (ACI) - 349 (or equivalent) and all the QA and inspections contained therein, plus any additional requirements specified by the ITER QA program.

21.2.5 Reliability Assurance

21.2.5.1 Confinement Boundary Components and Equipment

Confinement boundary components shall be designed to permit continuous status monitoring regarding pressure, temperature, and radiation levels. Status of all boundary closure devices shall be instrumented. The hot cell building shall be designed to also support periodic functional testing at full or partial design pressure of confinement boundaries, per ASME section 11 (or equivalent). Functional testing shall include time to achieve closure, leak rate at pressure, and other parameters important to safety analyses.

21.2.5.2 HVAC Components and Equipment

HVAC systems shall be designed with sufficiently redundant active 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.

21.2.5.3 Lifting Equipment

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

21.3 Codes and Standards

The hot cell building, and all seismic class reinforced concrete structures will be built in accordance with the American concrete institute (ACI) - 349 code (or equivalent).