# 21 (6.2.E.01) Magnet Power Conversion Buildings

## 21.1 Functions, Basic Configuration, and Interfaces

### 21.1.1 Functions

The two (north and south) magnet power conversion buildings are used to house the rectifier and power smoothing equipment that convert 69 kV AC power coming from the pulsed power switchyard to DC power for the tokamak magnets. The following sections describe the functions of the building.

21.1.1.1 Accommodate Equipment

The magnet power conversion buildings are dedicated to magnet power supplies. The present building design requires space for AC/DC converter units, dummy loads, local control cubicle, inter-phase reactor, grounding switch, disconnectors, busbars and an area for a water cooling system. For electrical design reasons and to minimise the length of cabling and busbars, the rectifier sets are near the transformers, and the power conditioning equipment must likewise be located correctly relative to the rectifiers. Large busbars connect the rectifier sets to the magnet circuits, using busbar routing above the rectifier sets. Local control, operator workspace, maintenance areas, shops, and space for other system support facilities are located on the grade floor, at the west end of each magnet power conversion building.

21.1.1.2 Protect from External Hazards

Each building is designed for wind, snow, and other environmental loads, as well as seismic loads, consistent with protection of health and safety of workers (UBC requirements - see section 21.2.1.2).

21.1.1.3 Provide Building Services

The magnet power conversion buildings provide internal distribution of services including potable water, steam, cooling fluids, low and medium-voltage electricity for service and welding requirements, grounding (earthing) connections, compressed air for services and instruments, and fire fighting water. They also provide for the collection of rain water and floor drainage, which are discharged to site disposal systems. Self-contained building support systems include access control, lighting, fire detection, alarm and mitigation systems, and communications. Design requirements for each of these aspects are described in section 21.2.

21.1.1.4 Provide Heating, Ventilation, and Air Conditioning (HVAC)

The buildings provide air quality sufficient to meet the requirements set by the systems and functions located within the building. All of these systems and functions have no safety importance classification (non-SIC), therefore these requirements can be met by using conventional HVAC equipment. Most of the electrical equipment housed in these buildings will be served by cooling water systems. However, when the tokamak is operating, the

equipment will reject some heat to the building air volume. During these conditions, it is expected that ambient temperatures up to 40°C will occur in some areas. When the tokamak is not operating, these same areas may be cooler. Most areas shall therefore be served by exhaust fans to control high temperatures, and space heaters to prevent freezing. During maintenace activities, local areas may be temporarily served using portable equipment. The spaces, offices and other staff areas will be heated, cooled, and ventilated to meet worker comfort standards.

### 21.1.2 Basic Configuration

The two magnet power conversion buildings are both level structures approximately 120 m long x 30 m wide x 20 m high, with adequate indoor space for rectifier sets and related equipment, while also providing connections to transformers. The two-level structural design uses a concrete foundation and a steel frame building, with expansion joints as needed to accommodate thermal expansion. The foundation of the building shall be set below grade so that the finished floor level matches the grade level.

Rectifier and power conditioning equipment, located along the edge of each building, are floor-supported. Transformers for the various power supply circuits are located outdoors on foundation structures. Busbars are routed vertically from the rectifier sets to an upper level. Large doors at grade, and on an intermediate floor (at + 10 m) allow the installation and removal of equipment using portable equipment. Equipment located on the roof (+ 16 m) will be placed using road cranes from grade, although horizontal movement at all two levels will be accomplished using air pallets or similar devices. The roof is structurally flat, with built-up roofing to provide a slope to drain points. Roof level equipment is primarily HVAC.

Power is stepped-down from 69 kV to the voltage used by individual rectifier modules (from 1,000 to 2,000 V), using transformers located on foundations outside the magnet power conversion buildings, along the north and south sides of both buildings, including blast and fire walls to protect equipment in the buildings. Power is fed into the buildings near grade to the grade-level rectifier sets. In addition to rectifiers, reactors, and other power conditioning equipment, needed for each magnet power supply, are located in the these buildings. High current power supply output is collected in air-cooled bus bars, located on a second level above the converter sets in each building. Power delivered to coils is in a controlled DC waveform, with voltages up to 40,000 V, and currents up to 80,000 A. To make this power conversion, the system uses a large number of phase controlled rectifiers, which are connected in parallel and series to provide the needed parameters. The building provides some general services such as HVAC, lighting, power, drainage, fluids, and lifting capability. Office and restrooms are designated for personnel support.

### 21.1.3 Interfaces

The magnet power conversion buildings interface with the following WBS elements:

| WBS | Title |
|---|---|
| 2.6.O | Component cooling system |
| 2.6.P | Chilled water systems |
| 4.1 | Coil power supply and distribution |
| 4.3.A | Steady state HV substation |
| 4.3.C | Steady state electrical power system distribution |

4.5 CODAC
4.6.C Access control system
6.1.A Site general layout
6.5.C Potable & fire systems water
6.5.D Sewage (sanitary and industrial)
6.5.E Steam/condensate/demineralized water
6.6.A Compressed air

## 21.2 Requirements

### 21.2.1 Design

The requirements for the magnet power conversion buildings are derived from the DRG1 and the functions of the building. The requirements below are not complete because equipment designers continue to provide new information. However, the information is sufficient to identify all the requirements which control the overall configuration and general design concept of the building.

21.2.1.1 General

21.2.1.1.1 Rectifiers

The buildings shall accommodate the equipment for rectifying an alternating current to a direct current. The transformers should be located outside but close to the buildings. Each rectifier module set is accompanied by one or more inductors, circuit breakers, and other power conditioning equipment. This is an arrangement which permits short distances between rectifier modules and outdoor transformers.

21.2.1.1.2 Steady-State Power Supply Load Center

The south magnet power conversion building shall accommodate the steady-state power supply load centre LC-2.

21.2.1.1.3 Power Supply Local Control Room

The buildings shall provide space for a power supply instrumentation room.

21.2.1.1.4 HVAC and Building Service Space

The buildings shall provide space for HVAC system and other building services.

21.2.1.1.5 Component Cooling Water Station

The buildings shall provide space for component cooling water stations.

21.2.1.1.6 Chilled Water Station

The south magnet power conversion building shall provide space for a chilled water station.

#### 21.2.1.1.7 Access and Maintenance Space

The buildings shall provide space for normal maintenance and good access to all equipment within the building. The buildings shall have large aisles and doors to accommodate the handling of large pieces of equipment.

### 21.2.1.2 Seismic

The buildings shall not be of safety importance class (non-SIC) and shall withstand SL-0 seismic conditions with peak horizontal and vertical accelerations as specified in the PDS, or UBC.

### 21.2.1.3 Structural

#### 21.2.1.3.1 Component Support

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

The structures shall support the weight and forces of all movable and active equipment, systems, and structures located on the slabs.

#### 21.2.1.3.3 Lifting and Materials Handling Devices

The buildings shall support the weight and forces of all lifted loads, including the lifting devices over the full range of their travel, and those from materials handling equipment such as fork lifts, trolleys, etc. Structural deflection under such loading must be consistent with the required precision of the lifting devices.

#### 21.2.1.3.4 Thermal Loads

The structures shall either resist stress induced by expansion and contraction due to changes between the as-built temperature and the maximum expected structure temperature excursions, or allow movement through the use of expansion joints.

#### 21.2.1.3.5 Wind Loads

The buildings shall withstand horizontal wind conditions of up to 140 km/h defined at 10 m above grade.

#### 21.2.1.3.6 Snow Loads

The buildings shall withstand snow loading conditions of up to 300 $kg/m^2$.

21.2.1.4 Electrical

21.2.1.4.1 Lighting

The buildings shall be equipped with normal and emergency lighting. Lighting standards to be applied will be similar to those used for industrial process plants.

21.2.1.4.2 Electrical Service

The buildings shall provide low-voltage (~ 100 - 230 V and ~ 400 V welding power) electrical service to all areas of the building where needs for this service are anticipated.

21.2.1.4.3 Grounding

The magnet power conversion buildings shall have an electrical grounding grid placed around the basements with connections to the grounding grids from the plant-wide grounding network and with robust grounding terminals at electrical service power outlet locations inside the building.

21.2.1.4.4 Lightning Protection

The buildings shall have lightning protection with connection to specified grounding terminals.

21.2.1.5 Potable Water and Drainage

The buildings shall provide potable water and drainage systems for lavatories and drinking fountains.

21.2.1.6 HVAC Systems

21.2.1.6.1 Electrical Equipment Areas

The large electrical bays in the magnet power conversion buildings shall be provided with HVAC equipment to protect water-cooled equipment and busbars from freezing, and to limit peak air temperatures to less than 40°C. The entire level of each building is enclosed by a lightweight cover, able to resist wind, snow loads and protect equipment from dirt and condensation. Conventional requirements are placed on the air change rate, dust, and humidity conditions.

21.2.1.6.2 HVAC for Personnel Areas

Spaces at the south ends of the buildings, which are normally worker occupied (office, lavatory, shop, etc.), shall be served with a ducted recirculating system capable of providing two to three air changes per hour, and maintaining temperature and humidity within human comfort zones. Fresh air will be added to recirculation systems at a rate equal to about 30% of the recirculation rate to maintain a positive relative pressure. Fresh air will be filtered and heated or cooled to match zone conditions.

#### 21.2.1.7 Fire Protection

The buildings shall provide fire detection, alarm, and mitigation systems commensurate with the occupancy and fire risk loading of the building.

#### 21.2.1.8 Internal Communication

The buildings shall provide an internal communication system, including distribution of telephone connections, a public address system, and appropriate warning systems (plant emergency, crane movement, fire, etc.). Telephone access points will be provided with noise shields where necessary.

#### 21.2.1.9 Access Control

The buildings shall provide access control to prevent unauthorised entry and to prevent worker exposure to electrical power hazards. Access control will be accomplished with badges, or other identification, which must be read by installed equipment to allow doors to be opened. The system will provide for automatic tracking of the individuals and total number of workers within each controlled space.

#### 21.2.1.10 Materials

##### 21.2.1.10.1 Structural

There are no special requirements for construction materials. The buildings foundations will be cast-in-place reinforced concrete mats, locally thickened to provide stiffness and point load bearing, and the superstructure will be prefabricated structural steel. Siding and roofing will be metallic, with integral insulation where appropriate. The building roof structure will be flat, with built-up insulation material to provide local slopes to drainage points.

##### 21.2.1.10.2 Electrical

All cables will be made with copper and should have appropriate insulation level according to the 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.E.1) -1 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 |

21.2.1.11 Cranes, Lifts and Material Handling

The magnet power conversion buildings will not be provided with bridge cranes. Floor-supported moving aids (e.g. air cushion pallets) and temporary rigging will accomplish installation and maintenance relocation of heavy equipment in these buildings. The buildings shall provide one electrical travelling hoist with a hook capacity of 5 t, for lifting the equipment to the 2$^{nd}$ floor. Grade access at the building must be suitable for the entry and operation of mobile equipment. The buildings doors must provide 4.2 m vertical clearance.

21.2.1.12 Instrumentation and Control

Buildings systems, including HVAC access control 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. However, these systems shall not be controlled from the control building.

### 21.2.2 Operation and Maintenance

The operations and maintenance (O&M) requirements for the magnet power conversion buildings are derived from the DRG1, from the systems which occupy the buildings, and from the functions of the buildings.

21.2.2.1 Operation and Control of Building Services

Buildings systems shall incorporate instrumentation and control to manage system operation. Manual control over lighting, power distribution, large doors, and fluid supply is expected to be adequate. Manual control with safety interlocks will be provided for building cranes and lifting devices. Automatic controls with manual override capability will be installed for the operation of HVAC and fire suppression systems. Operation and control of building support systems will be centralized in building control panels located within the building. Status of building support systems will be provided to the CODAC system. However, no building support systems will be directly controlled from the ITER main control room.

21.2.2.2 Maintenance of Building Services

There are no specific buildings 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.

### 21.2.3 Surveillance and In-Service Inspection

There are no surveillance and in-service inspection requirements for the buildings apart from usual, annual, visual inspections of the buildings 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 service equipment such as lifts, and the fire detection, alarm, and mitigation systems.

### 21.2.4 Corrosion Protection and Control

The buildings will be painted and provided with passive corrosion protection features (galvanising) where appropriate to assure that the design life of the structure is at least 30 years, the expected combination of ITER construction and operating periods.

### 21.2.5 Quality Assurance (QA)

There are no quality assurance requirements for the magnet power conversion buildings beyond those established by the uniform building code (or equivalent) and the ITER QA manual.

### 21.2.6 Reliability Assurance

There are no special reliability requirements for the magnet power conversion buildings structures. Buildings support systems shall be designed to meet all functional requirements with the lowest overall lifetime cost, including effects of unavailability and cost of maintenance and repair.

#### 21.2.6.1 HVAC

HVAC components and equipment shall be designed, procured, and installed in accordance with industrial codes and standards. No additional reliability requirements are applied.

#### 21.2.6.2 Lifting Equipment

Cranes, hoists, and other lifting devices shall comply with the classification system, design practices, and safety factors established by the crane manufacturers associations of America (CMAA), or equivalent.

## 21.3 Codes and Standards

The magnet power conversion buildings shall be designed in accordance with the 1994 uniform building code (or equivalent). Good engineering practice, as expressed in the "Ninth Edition of the American institute of steel construction (AISC) Manual of Steel Construction", shall also be employed.