21 (6.2.S) Utility Tunnels and Service Structures

21.1 Functions, Basic Configuration, and Interfaces

21.1.1 Functions

The ITER tokamak is located in a single large building. However, the auxiliary systems, power supplies, cooling systems, control, and a host of other support systems and facilities when taken together occupy several other buildings on the approximately 25 hectare site. The site utility tunnels and service structures provide space for interconnecting piping, wiring, and instrumentation. The site infrastructure provides: roads for transportation routes, paved areas for heavy load handling, foundations for equipment installed outdoors, fencing for security and safety, outdoor lighting, overhead bridges for carrying electrical power, and so on.

21.1.1.1 Provide Pathways for Communication and Integration of Plant Systems between Buildings

The utility tunnels and service structures provide support and space for the interconnecting facilities described above. They also provide space for maintenance. The tunnels and the structures bear the loads caused by facilities such as deadweight loads, vibration loads and so on. The tunnels and the structures also provide the resistance to the soil and water pressure load and seismic load. The magnitude of each load is determined by the site conditions and the classification of the specific tunnels.

The utility tunnels provide air quality sufficient to meet the requirements by using a ventilation system. The tunnels also provide for other services such as fire protection, drainage, lighting and low voltage electrical services where specified.

21.1.1.2 Provide Foundations and Supports for Outdoor Equipment

The site infrastructure provides foundations for equipment some of which are oil filled, such as transformers, to allow the oil to be caught in a gravel filled structure or basin in the event of a leak. In most cases, oil-filled equipment foundations will also incorporate a blast/fire wall structure to separate such equipment from other equipment or structures.

ITER has some systems which use large outdoor equipment, primarily tanks. The site infrastructure provides foundation pads for tanks

21.1.1.3 Provide Infrastructure for the Cooling Water System

The ITER cooling system is based on generic site conditions, which include the use of mechanical draft cooling towers. Since ITER is not a steady-state facility, the cooling system is optimized by providing separate basins for hot and cold water. The cold basin provides a foundation for the mechanical draft cooling towers. Pumps for the cooling water system needs protective structure to avoid direct exposure to rain.

21.1.1.4 Provide Infrastructure of Water Supply

The ITER site also provides a reinforced concrete potable water reserve tank with a capacity of 3 days' worth of potable water.

21.1.1.5 Provide Security, Access, Access Control

21.1.1.5.1 Site Security

The ITER site provides security appropriate to the regulatory approval conditions for its operation, to personal safety and to the nature of its activities.

21.1.1.5.2 Access and Access Control

The ITER site provides access and access control appropriate to the regulatory approval conditions for its operation, to personal safety and to the nature of its activities.

21.1.1.6 Provide Drainage and Aesthetics

The site infrastructure provides a yard drainage system, which will be suitable for rain and snow melt at the site. The site provides a landscape protected from erosion for a pleasant environment.

21.1.2 Basic Configuration

21.1.2.1 Utility Tunnels and Bridges

The underground utility tunnels form a network around the site between buildings, and are not exclusively reserved for electrical or water distribution. In many cases the tunnels provide access for several services, such as electrical power (also lighting), control and instrumentation wiring, water, some cryolines, steam, etc. These combination tunnels are segregated for protection of the services from each other in general. The tunnel spaces must have sumps and sump pumps which collect rain water and leakage and pump it to the site storm drain system.

21.1.2.1.1 Electrical Cables

Electrical power is distributed between buildings on the site in below-grade tunnel structures. These tunnels will link both the steady-state electrical power switchyard and the pulsed power switchyard on the west side of the site with electrical load distribution centers in various buildings. These tunnels form an electrical distribution system which covers the entire site. In some cases, electrical power feed is transferred on bridge structures where the required access to the building is above grade.

21.1.2.1.2 Cooling Water Pipes

Cooling systems for ITER are arranged such that secondary cooling water flows from the cold basin to the tokamak building. There are a number of large cooling pipes and many services for access to the tokamak. They are located in below-grade concrete structures or tunnels running from the south-east side of the tokamak complex.

21.1.2.1.3 Cryogenic Pipes

Cryogenic pipes outside buildings are connected from the cryoplant compressor building and the cryoplant coldbox building to the tokamak complex.

21.1.2.1.4 Other Pipes

Pipes for potable water, fire water, compressed air, and other liquids or gases are connected from the buildings which supply these fluids to client buildings.

21.1.2.2 Electrical Equipment Foundations and Outdoor Equipment Foundations

There are two separate switchyards, one for pulsed power serving magnet and plasma heating systems, and one for steady-state power, serving "house" loads, including the cryoplant, cooling systems, hot cell systems, HVAC, etc. These will both be outdoor switchyards, and the site infrastructure includes cast-in-place equipment foundations for transformers, circuit breakers, pylons, switchgear, and other switchyard equipment. No building structure is required to protect this equipment.

The site infrastructure includes foundation pads for large helium storage tanks used by the cryoplant, for fuel tanks used by the auxiliary boiler, and for fuel tanks associated with the emergency power supply.

21.1.2.3 Hot/Cold Basins

Water drawn from the cold basin is used to cool the tokamak systems, is returned to a hot basin. Flow between the basins and the rate at which water is pumped from the hot basin to the cooling towers are used to control the temperatures of the two basins. These basins incorporate a spillway which will allow excess hot water to overflow into the cold basin. A major part of the basins is located below grade level.

21.1.2.4 Potable Water Reserve Tank and Industrial Sewage Holding Tank

A reinforced concrete potable water reserve tank will have a capacity of 1,250 m^3 to provide several days (up to 3) makeup for demineralized water and potable water storage systems.

When the sewage streams have become contaminated, sewage can be held in a holding tank while corrective action and procedures for processing are established. The ITER site also provides a industrial sewage holding tank with a capacity of 2,000 m^3.

21.1.2.5 Fences, Miscellaneous Buildings, Roads and Outdoor Lighting

21.1.2.5.1 Fences and Gatehouses

The ITER site will be enclosed by two fence systems. The outer perimeter will encompass all the land area under the control of the ITER operating entity.

The inner perimeter will encompass the high security region of the ITER site, under strict access control through a gatehouse. The ITER plant systems and structures which involve nuclear materials or safety-related functions which are subject to regulatory approval will be within this area, as will all other ITER buildings and structures except the cooling basins and structures, the laboratory office building, and the pulsed and steady-state switchyards.

The fencing system for the high security area shall have two rows of fence, spaced approximately 5 m apart. This fence system shall be instrumented to detect any breach by unauthorized persons, and equipped with passive features to impede unauthorized vehicle penetration. There will be a gate house for pedestrians and vehicles to facilitate control over authorized entry.

Other, single fences will be used to delineate the switchyards, the cooling basins, gas storage area, and any other structures or areas either inside the high security boundary or outside of it, which require controlled access for reasons of worker safety or protection of property.

21.1.2.5.2 Pumping Station

The site infrastructure provides a structure for the pumps of the heat removal system. This structure supports one low flow pump and four high flow pumps (which are used to move water from the hot basin to the cooling tower) and miscellaneous equipment including motor controls, corrosion and biological inhibition equipment, and basin blowdown pumps and valves.

21.1.2.5.3 Roads

The assembly of the ITER tokamak will involve the receipt and on-site handling of numerous large, heavy objects. Site-fabricated PF coils, off-site shop-fabricated TF coils, vacuum vessel segments, and other tokamak parts must be delivered to the tokamak buildings. For this there will be wide paved areas to the south of the tokamak building. There will also be a wide, heavy duty transport path able to move the site-fabricated coils from the east end of the coil fabrication buildings to the south entrance of the tokamak hall. The pathway will be smooth enough for heavy haul vehicles, and will have appropriate surface drainage.

The site infrastructure also includes additional on-site paved roads which connect various buildings and provide access to all parts of the inner perimeter fence.

21.1.2.5.4 Outdoor Lighting

Each of the ITER buildings will include appropriate outdoor lighting. In addition, the site infrastructure shall include outdoor overhead lights. Lighting shall cover the switchyards, cooling towers, security fence, perimeter road, personnel and vehicle gate areas, and parking areas.

21.1.3 Interfaces

The utility tunnels and service structures have interfaces with the following WBS elements:

WBS	Title
2.6	Cooling Water System
3.4	Cryoplant and Cryodistribution
4.1	Coil Power Supply and Distribution
4.2	Heating and Current Drive Power Supplies
4.3	Steady State (SS) Electrical Power Network
4.5	Command Control and Data Acquisition (CODAC)
4.6	Interlocks System
5.5	Diagnostics
6.1.A	Site General Layout
6.2.A	Tokamak Buildings
6.2.B	Hot Cell Building
6.2.E	Auxiliary Buildings
6.2.G	Radwaste and Personal Buildings
6.2.H	Laboratory Office Building
6.2.J	Cryoplant Buildings
6.2.K	Control Building
6.2.L	Emergency Power Supply Building
6.2.M	Site Services Building
6.5	Liquid Distribution, Including Water
6.6	Gas Distribution and Compressors

21.2 Requirements

The requirements for the utility tunnels and service structures are derived from the DGR1 and from the functions of the structures.

21.2.1 Utility Tunnels

21.2.1.1 Configuration and Essential Features

The tunnel structures for the cooling system shall be integrated with other services which provide support and routing space for cryogenic piping, electrical power and other services. Expansion joints shall be provided, where appropriate, for protection of the internal piping, cabling, and other components. Intermediate walls shall be provided within these structures to reduce the required span of the roof.

A lot of pipes and cables will be located inside utility tunnels. The layout and section of the tunnels shall be decided in consideration of reasonable pipe/cable routing.

21.2.1.2 Structural

The utility tunnels shall support their own weight as well as the weight of all installed equipment in (or on) the structures. The utility tunnels shall support the weight and forces of all movable and active components and systems in (or on) the structures. The utility tunnels, if located under buildings, shall be routed to avoid interference with the footings of the buildings.

21.2.1.3 Load-Bearing Capability

The utility tunnel roof members for the cooling system shall be designed to support some power supply equipment and site roadways. The utility tunnel design will also permit the use of cranes and other heavy maintenance equipment above the tunnel spaces. When the electrical power, cooling water and steam distribution structures cross roadways, the top earth cover height will be available to locally reinforce the structure roof as needed. The load of the heaviest transportation component must be considered for the design of crossing utility tunnel.

21.2.1.4 Conformance with Site Plan and Building Arrangement

Utility tunnels shall be located and arranged so that the function of all buildings and structures can be accomplished. They shall also be arranged to facilitate interfaces with external facilities such as roadways, power grid, water supply, etc. provided by the ITER host.

21.2.2 Service Structures

21.2.2.1 Switchyard Structures

The switchyard structures shall support the power supply equipment in both the steady-state and pulsed power supplies. These structures include concrete pads, pedestals, towers for overhead services and any civil works which are defined by interface data.

21.2.2.2 Cryoplant Structures

Cryoplant structures shall include concrete pads, pedestals, dikes and other civil works which are defined by interface data.

21.2.2.3 Emergency Power Supply Structures

Emergency power supply structures shall include concrete pads, pedestals, dikes and other civil works which are defined by interface data.

21.2.2.4 Site Services Structures

Site services structures, including bridges for overhead support and routing of power connections, shall include concrete pads, basins, pedestals, dikes and other civil works which are defined by interface data.

21.2.3 General

21.2.3.1 Instrumentation and Electrical Services
Some of the utility tunnels and service structures shall provide space for instrumentation and electrical services. They shall also provide space for normal maintenance.

21.2.3.2 Ventilation and Other Services

Some of the utility tunnels and service structures shall provide space for ventilation system and other services.

21.2.3.3 <u>Structural</u>

21.2.3.3.1 Components Supported by the Structures

The utility tunnels and service structures shall support their own weight as well as the weight of all installed equipment in (or on) the structures.

21.2.3.3.2 Live Loads Supported by the Structures

The utility tunnels and service structures shall support the weight and forces of all movable and active components and systems in (or on) the structures.

21.2.3.4 <u>Electrical</u>

21.2.3.4.1 Lighting Service

The utility tunnels and service structures shall provide permanently installed electrical lighting and emergency lighting. Each of the ITER buildings shall provide appropriate outdoor lighting. In addition, the site infrastructure shall provide outdoor overhead lights mounted on poles or standards.

21.2.3.4.2 Electrical Service

The utility tunnels and service structures shall provide low-voltage (100 - 200 V) electrical service to all areas of the tunnels where needs for this service are anticipated.

21.2.3.5 <u>Seismic</u>

Some of the utility tunnels and service structures are not safety importance class (SIC) components, but house SIC components and shall withstand SL-2 seismic conditions as specified in the PDS. The other structures shall withstand SL-0 seismic conditions as specified in the PDS, which provide for a minimum of 0.05 g horizontal seismic force.

21.2.3.6 <u>Grounding/Insulation</u>

21.2.3.6.1 Grounding

The utility tunnels and service structures shall have electrical grounding grids embedded below their basemat with connections to the grounding grids of the plant-wide grounding network and with robust grounding terminals at electrical service power outlet locations inside the tunnels and structures.

21.2.3.6.2 Insulation

All cables will be made with copper and should have the 15 kV, 6 kV and 0.6 kV rated insulation voltage for 11 kV. 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.S) – 2 IEC Relevant Material

IEC #	Technical Committee	Title
332 -1…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

21.2.3.7 Materials

No special requirements except as noted above for cable insulation.

21.2.3.8 HVAC Systems

The utility tunnel spaces housing hot pipes and components must be equipped with grated vents at appropriate locations to allow natural air cooling. The utility tunnels shall provide air quality (temperature, humidity, purity, freshness) sufficient to meet the requirements of the equipment located in the tunnels. Maintenance work may be served by temporary and portable HVAC systems.

21.2.3.9 Fire Protection

The utility tunnels shall provide fire protection systems commensurate with the occupancy and fire risk loading of the tunnels.

21.2.3.10 Internal Communications

Some of the utility tunnels 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.).

21.2.3.11 Landscaping

Appropriate landscaping including the replanting of native trees and shrubs, and planting of lawns and other appropriate ground cover shall be provided to control erosion and maintain a pleasant environment.

21.2.4 Quality Assurance (QA)

The utility tunnels and service structures shall be designed and constructed in compliance with the ITER QA program. The utility tunnels which contain SIC components and seismic class (SC) components shall be designed and constructed in accordance with the 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. The utility tunnels which comprise only non-SIC and non-SC components shall be designed and constructed in accordance with ACI - 318 (or equivalent) and subject to all the quality assurance and inspection requirements contained therein, plus any additional requirements specified by the ITER QA program.

21.3 Codes and Standards

The site-specific design shall be in accordance with codes and standards acceptable to the regulatory agencies which approve the construction and operation of the facility.

Engineering and constructions shall be done in compliance with ASTM Codes, ACI Codes, AISC Code, AWS Codes, UBC Codes, and other related US codes, or their equivalent.

All materials, procedures, and works will be subject to the QA tests that are indicated in these codes.