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ITER Institute Letter of Intent to the CNSC

Attachment 1

Iter Project Description – Objectives, Schedule and Technical Description

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1.1 Iter Objectives and Mission

The Iter International Fusion Energy Institute, (referred to hereafter as the Iter Institute), intends to site, construct, commission, operate and decommission a pre-commercial R&D facility aimed at demonstrating the feasibility of fusion energy. The Iter Institute will base the project on the work done by the Iter Parties[1] under the Iter Engineering Design Activities (EDA) International Agreement of July 21, 1992, and the subsequent extension in 1998. Under this agreement, the Iter Parties agreed to take the next step in the advancement of fusion science through the design of a tokamak device to be known as "Iter". Provisions for continuing authority for the design are described in Attachment 5.

The Iter mission is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes and to demonstrate the safety and environmental potential of fusion energy. The goal is to develop a prototype aimed at achieving the technical breakthroughs necessary to demonstrate that large-scale energy output can be consistently generated through the process of magnetic fusion. To do this, Iter will demonstrate extended pulse operation and perform integrated testing of key elements required in the future use of fusion as a practical energy source. Iter will be the final step before a demonstration fusion power facility is constructed. While achieving this, Iter will have

[1] The European Union (EURATOM), Japan, the Russian Federation and the United States of America were the original 4 Iter Parties, the current EDA extension continues without the participation of the USA.

minimal environmental impact and will adhere to the highest standards of industrial and personal safety.

1.2 Regulatory Applications

Applicability of the Nuclear Safety and Control Act and the Canadian Environmental Assessment Act

As per the Nuclear Safety Control Act (NSCA) and the Class I Nuclear Facility Regulations (Class I Regs.), Iter will be classified as a Class I A Nuclear Facility [NSCA Section 2; Class I Regs. 1(a)]. In order to obtain a Licence under NSCA Section 26(e), the Iter Institute will have to comply with the requirements of the NSCA, including its regulations, and of the Canadian Environmental Assessment Act (CEAA), including its regulations.

This submission is intended to both notify the CNSC of the Iter Institute's intention to site and construct the project, and to provide sufficient information to enable a determination of the application of the CEAA to the project.

Under the NSCA, separate licences are required for "site preparation", "construction", and "operation" of a nuclear facility. However, due to the nature of the Iter project, this Letter of Intent is for both a site preparation licence and a construction licence. The site is described and plotted in the two following attachments. The site is part of a parcel of land that has already been designated for a nuclear facility.

Application of Other Federal Regulations and Provincial or Municipal Regulations

The Iter Institute will comply with all applicable Municipal, Provincial and Federal regulations.

1.3 Project Phases and Schedule

Design (ongoing)

The facility design proposed herein is a combination of the generic design produced by the Iter Parties and the modifications proposed by Iter Canada to adapt the generic design to the Clarington site. In general these proposed modifications do not alter the design of the main components of the Iter facility.

Currently, the design parameters are largely fixed, although there are continuing detailed design activities. These activities may continue beyond the start of construction for any items procured late in the schedule.

Siting and Construction (year –2.5 to year 8+)

In advance of the start of construction, a licence to construct pursuant to the NSCA must be obtained. Prior to issuing such a licence, the CNSC will have to ensure that all obligations and requirements under the CEAA are met. The timeline described in Figure 1.3-1 considers that the construction licence is issued at time T=0. The efforts for siting and construction begin approximately 2.5 years prior to obtaining a construction licence.

During this time, the Joint Implementation Agreement for the production, manufacture and/or assembly of components and systems will be negotiated by the governments involved. The construction phase will include the preparation and execution of the procurement for various components.

The construction of the facility will be phased according to need. The facilities for handling the activated components for refurbishment will be completed during the initial construction phase. The facilities for handling and storing the activated components resulting from the decommissioning phase will be scoped and planned, but will not be licensed or constructed until the De-activation or the Decommissioning phase, as required. A proposed schedule for the construction phase is given in Figure 1.3-1. Installation of some systems required only after the hydrogen testing phase (see below) may be deferred beyond the initial 8-year construction period.

Commissioning (up to year 11)

This phase includes commissioning of individual systems and integrated testing through the hydrogen (HH) plasma testing phase. During commissioning, a License to Operate must be acquired to allow for operation with deuterium (DD phase) and for the reference operation phase with tritium (DT phase).

The HH phase is planned to test the tokamak systems in a non-radioactive environment, when full remote handling is not required. Full reference operations can be partially developed or simulated in this phase, allowing some parameters to be checked.

Characteristics of electromagnetic loads due to disruptions or vertical displacement events (VDE’s), and various heat loads, will be basically the same during the HH phase as those during the reference operation phase. Studies of the design-basis physics will reduce the uncertainties of the reference operation. Mitigation of severe disruptions and VDEs, or better control of these events, will become possible in later phases, leading to a more efficient operational phase.

The actual length of the hydrogen phase will depend on the merit of this phase with regard to its impact on the reference operation, in particular on the ability to achieve good plasma confinement with large enough plasma density.

Operating (year 11 to year 27)

During the operating period, tests will be performed with DD phase and DT phase operation to further develop the knowledge base needed to design and operate successfully a demonstration fusion power plant. It is important to note that Iter is not intended to produce electricity.

DD Phase

In the DD phase, neutrons and tritium will be produced from DD reactions and part of this tritium will react in subsequent DT reactions. Although the fusion power is low, the activation level inside the vacuum vessel will not allow human access after several deuterium discharges with powerful heating. The demand for the heat transfer system (except for the divertor and heating devices) and for the tritium processing system to support this phase would be minimal.

Characteristics of DD plasma behaviour are very similar to those of DT plasma except for the amount of heating by alpha particles in the DT reaction. Therefore, the reference DT operation scenarios can be simulated. Since tritium already exists in the plasma, fusion power production at a significant power level for a short period of time could also be demonstrated without fully implementing cooling and tritium-recycle systems, which would be required in the subsequent full DT phase. By using limited amounts of tritium in a deuterium plasma, the final integrated testing of the device is possible. Importantly, the shielding performance can be checked.

DT Phase (reference operation)

During the first phase of DT operation the fusion power and pulse length will be gradually increased until the inductive operational goal is reached. Non-inductive, steady-state operation will also be developed. Test blanket modules relevant for a future demonstration facility (DEMO) will also be tested whenever significant neutron fluxes are available, and a reference mode of operation for that testing will be established.

The second phase of full DT operation, beginning after a total of about ten years of HH plasma testing, plus DD and DT operation, will emphasise improvement of the overall performance and the testing of components and materials with higher neutron fluences. This phase should address the issues of higher availability of operation and further improved modes of plasma operation. The programme and its implementation will be decided following a review of the results of the preceding operational and commissioning phases, and the assessment of the merits and priorities of programmatic proposals.

In all operating phases, Iter will provide facilities for the receipt, storage, processing/recycling and utilization of hydrogen isotopes for the tokamak. Apart from the HH phase, this will include tritium, and the recycling capability shall include the possibility to recover tritium from plasma-facing materials.

De-activation

After the last plasma pulse has been performed, the facility will enter a phase for de-activation. This phase will last approximately 6 years and will include all activities required for the preparation of removal and storage of active and contaminated components from the Tokamak Building.

The activities in this phase will include: removal of in-vessel components by remote handling; removal of mobilizable tritium and activated dust from components; coolant decontamination; classification and packaging of active, contaminated and hazardous materials. It is anticipated that activities will largely cease for a time to allow for decay of radioactivity on large structural components to facilitate handling and processing for size reduction, recycling and/or disposal.

Decommissioning

Funds will be set aside during the earlier phases and will be made available for the decommissioning period. These funds will be used to realize the plan for decommissioning in accordance with regulatory requirements. Currently, the decommissioning phase is intended to include the segregation of structural materials and components with a view to facilitate the recycling and minimize the disposal of material. Decommissioning will be further addressed in the application for construction.

1.4 Description of Tokamak Systems

Iter is a long pulse tokamak with an elongated plasma and a single null poloidal divertor (Figures 1.4-1, 1.4-2, 1.4-3). Nominal inductive operation produces a fusion power of 500 MW for a fusion pulse length of 400 s.

The major components of the tokamak are the superconducting toroidal and poloidal field coils which magnetically confine, shape and control the plasma inside a toroidal vacuum vessel. The magnet system comprises toroidal field (TF) coils, a central solenoid, external poloidal field (PF) coils, and correction coils. The centering force on toroidal magnets is reacted by the central solenoid. The TF coil cases are used to support the external PF coils. The vacuum vessel is a double-walled structure supported on the toroidal field coil. The magnet system together with the vacuum vessel and internals are supported by gravity supports, one beneath each sector.

Inside the vacuum vessel the internal, removable components, including blanket modules, divertor cassettes, port plugs such as the limiter, heating antennae, test blanket modules, and diagnostics sensors, absorb most of the radiated heat from the plasma and protect the vessel and magnet coils from excessive nuclear radiation. The divertor exhausts the helium (a product of the fusion reaction) and limits the concentration of impurities in the plasma. The other vessel internals are chosen so they do not contribute unacceptably to the concentration of impurities in the plasma. The shielding blanket design does not preclude its later replacement on the outboard side by a breeding blanket.

The heat deposited in the internal components and the vessel is rejected to the environment via the tokamak cooling water system (comprising individual heat transfer systems), which is designed to preclude releases of tritium and activated corrosion products to the environment. Some parts of these heat transfer systems are also used to bake and hence clean the plasma-facing surfaces inside the vessel by releasing impurities. The tokamak is housed in a cryostat, with thermal shields between the hot parts and the magnets and support structures which are at cryogenic temperature.

The tokamak fuelling system is capable of gas and solid hydrogen pellet injection. Low-density gaseous fuel (hydrogen isotopes) will be introduced into the vacuum vessel chamber by a gas injection system. The heating and current drive systems include electron cyclotron heating and current drive (ECH&CD), ion cyclotron (ICH&CD) and Neutral Beam Heating.

The production and fusion of a plasma is initiated with ECH, where the plasma progresses from a circular configuration touching the limiter to an elongated divertor configuration as the plasma current is ramped up. After the current maximum is reached (nominally 15 MA for inductive operation), subsequent plasma fuelling (gas or pellet) together with additional heating (ion cyclotron or neutral beam injection) for ~ 100 s leads to a high Q (where Q is the ratio of energy out over energy in) DT plasma fusion pulse at 500 MW. With non-inductive current drive from the heating systems, the plasma pulse duration can be extended to ~ 3600 s, or longer. In inductive scenarios, before the inductive flux available is consumed, fusion is terminated by reducing the fuelling to rampdown the fusion power, followed by current rampdown and plasma termination. The inductively driven pulse has a total duration of 400 s, and the pulse repetition period may be as short as 1800 s. Plasma control is provided by the poloidal field system, and the pumping, fuelling (D, T and impurities such as N_2, Ar) and heating systems, based on feedback from diagnostic sensors.

Successive barriers are provided for tritium (and activated dust). These include the vacuum vessel, the cryostat, active air conditioning systems, with detritiation and filtering capability in the building. Confinement and effluents, normal as well as accidental, are filtered and detritiated, in such a way that their release to the environment is as low as reasonably achievable (ALARA).

1.5 Building Descriptions

Iter buildings house, support, protect, control access to, provide suitable environmental conditions for, and provide services to the components, systems, and operations that are selected to be located within them. The Iter buildings have been optimised to meet the mission requirements, the standards for public and worker health and safety, as well as requirements for investment protection. The layout of the buildings can be found in Iter Canada drawing 008311-01-00-L102, and in Figure 2.1-1.

The Iter buildings can be grouped in two main classes:

- the radiologically controlled buildings;
- the conventional buildings.

The next section describes the radiologically significant aspects of the radiologically controlled buildings. The subsequent sections identify the key buildings and their contents.

1.5.1 Design Aspects of the Radiologically Controlled Buildings

The radiologically controlled buildings include the tokamak complex (tokamak building (11), tritium, vacuum, fuelling and services building (14), and laydown and radiofrequency (RF) heating building (13)) hot cell building (21), low level radwaste building (23), and personnel access control building (24).

These are the core of the Iter Facility and, beyond their specific functional requirements, have been designed consistent with the requirements for:

- protection of personnel from exposure to radiation and contamination;
- confinement barriers that limit the spread of contamination to the external environment in accidental conditions.

As a consequence, the radiologically controlled buildings have been designed to provide appropriate radiation shielding, ventilation, drainage, and access control.

Radiation shielding

The general philosophy in the design of the Iter buildings that are potentially radioactive, or may become contaminated by radioactive species, is to provide shielding using the building structure itself to keep radiation exposure to the workers as low as reasonably achievable (ALARA).

The radiation sources are of three main types:

- radiation deriving directly from tokamak operation (mainly during DT pulsing);
- radiation deriving from activated components and structures within the bioshield and activated components removed from the vacuum vessel during maintenance;
- radiation deriving from inventory of radioactive materials directly (e.g. tritium) or indirectly (activated corrosion products and dust) connected with tokamak operation, but present also when the tokamak is not in operation.

The radiation deriving directly from tokamak operation is relevant only for the tokamak building. During tokamak operation, the radiation sources include gamma and neutron radiation from neutral beam injectors, gamma and neutron radiation from inside the vacuum vessel (VV), and gamma and beta (tritium) radiation from short-live activated coolant. The radiation fields which will exist during DT pulsing have been estimated throughout the tokamak building. The shielding in this case is mainly required to limit gamma ray fields from activated materials in the volumes where human access is required. These fields are constituted by the emissions from a few isotopes. The field strength decreases rapidly as short-lived isotopes decay, then remains fairly constant as longer-lived isotopes dominate. Shielding thickness is, in general, sufficient to reduce the dose rate in the tokamak galleries and in the tokamak crane hall below 10 µSv/h, within

24 hours of a DT pulse, allowing personnel access without special supervision or requirements.

The shielding for this source of radiation is primarily provided by the bioshield, a hollow cylindrical concrete structure that is located around the cryostat. Bioshield plugs installed in front of each of the ports, designed for removal in pieces, provide access for remote maintenance activities within. The tokamak crane hall is shielded from radiation effects by a 2 m thick bioshield lid on the top of the cryostat.

During maintenance, gamma and beta radiation comes from the plasma-facing components that have been removed from inside the VV. These components are handled in casks, which move on floor-supported air-bearing vehicles. The buildings and structures, through which the casks pass, provide the shielding function. The destination for most radioactive components and materials is either the hot cell building or the low-level radwaste building. Objects will exit the tokamak building via a lift shaft located in the gallery space and be delivered to the hot cell complex. Shielding is provided, along this path, by the structural elements of the building. A concrete thickness of 1 m is provided in the floor slabs; in some locations, a wall thickness of 500 mm is used where it provides both adequate strength and adequate shielding.

All the other radioactive materials inventories are located in the tokamak complex (see below), the hot cell, or the radwaste buildings. For these sources of radiation the shielding is provided by the thickness of the building structures complemented as necessary by local shielding.

Radioactive contamination control

The Iter plant is designed to limit releases of radioactive material to the environment, and radioactive exposure to workers and the public. Buildings where tritium or tritium-bearing components/materials or activated components/materials are handled have been designed accordingly, as described below.

The heating, ventilation, and air conditioning (HVAC) systems are designed to provide suitable air change rates to remove heat rejected to air in the building, to maintain acceptable levels of airborne radioactive contamination within the buildings, and to prevent contamination spread to the external environment.

The radiologically controlled buildings are divided into areas based on their potential contamination ranging from "white" (uncontaminated) through "green" and "amber" to "red" (with different degrees of airborne and surface contamination). The design of HVAC systems ensures appropriate pressure and flow gradients within the buildings so that air flows from areas of lowest probability of contamination towards areas of higher probability of contamination. Potentially contaminated air is treated by filters, detritiation systems, and is then directed to the plant exhaust. Areas where the release of elemental tritium or tritiated water is possible are equipped so that the exhaust flow is continuously monitored as part of compliance monitoring of effluents and it can be passed through a vent detritiation system (VDS), as required.

Floor drainage from radiologically controlled areas is collected in tanks where it can be monitored and, if necessary, treated before it is released to the environment.

1.5.2 Tokamak Complex

The tokamak complex includes the tokamak building (11), the laydown, assembly, and RF heating building (13) and the tritium, vacuum, fuelling and services building (14). The tokamak building and the tritium, vacuum, fuelling and services building are integrated into a large reinforced concrete structure with dimensions of approximately 79 m in the east-west direction, and 90 m in the north-south direction.

Tokamak Building (11)

The tokamak building houses the vacuum vessel and the in-vessel components, the magnet system (including the central solenoid, the poloidal field coils and the toroidal field coils), the cryostat and its thermal shields. As well, there are the systems required for heat transport, HVAC, services, etc. The key systems are described in Section 1.4 above.

The tokamak building is designed to permit assembly and operation of a tokamak with 18 sectors with radial ports at three vertical levels. The general architecture is arranged around the cryostat. A three-dimensional view of the key systems inside the tokamak building is provided in Figure 1.4-2. The floor levels, radial walls and pillar positions are generally symmetrical and are directly related to port access and the remote handling cask docking/transport system. An irregularity exists on the east side, where the layout accommodates the requirements of the Neutral Beam Heating and Current Drive (NB H&CD) system. A plan (at the equatorial level) and an elevation view (east-west section) of the tokamak building are shown in Figure 1.5-1 and 1.4-3, respectively.

The tokamak building is arranged in three major volumes:

- the pit
- the galleries
- the crane hall.

The tokamak pit comprises the volume of the building within the cylindrical bioshield wall, that houses the cryostat, the vacuum vessel, the magnets, and all the other in-cryostat and in-vessel components. The tokamak pit is configured to support the replacement of the central solenoid, the replacement or repair in situ of any PF coil, and any 40° machine sector (which consists of a 40° VV sector, associated thermal shields, and 2 TF coils), without the need to dismount the other TF coils and to cut leads and pipes pertaining to other TF coils or machine sectors. The cryostat is supported on the tokamak building basemat, and there is sufficient access through the bioshield at the basemat level, via temporary removable blocks, so that the in-situ rewinding of a faulted lower PF coil (PF5 or PF6) is possible if required.

The tokamak galleries are all the rooms and access areas under the crane hall floor and outside the bioshield, plus the TCWS vault and the VV pressure suppression tank vault; they are organised in several levels:

- basement level;
- divertor level;
- equatorial level;
- upper port level;
- upper magnet level;
- crane hall and TCWS level.

The tokamak crane hall is connected to the laydown, assembly and RF heating building to form a contiguous crane hall, about 175 m in length, with the crane rails being approximately 47 m apart. The south end of the crane hall (actually in the laydown, assembly and RF heating building) is designed to allow for possible future expansion.

The architecture and dimensions of the tokamak building are largely determined as a complex trade-off among various functional and structural constraints:

- equipment sizes;
- service routing;
- internal trasport;
- shielding and structural elements;
- initial assembly and maintenance requirements.

Tritium, Vacuum Pumping and Fuelling Building (14)

The tritium, vacuum, fuelling and services building (the tritium building) is located immediately adjacent to the tokamak building to minimise the length of vacuum and tritium lines and is built on the same basemat as the tokamak building. It is approximately 21 m in the north-south direction, and about 79 m in the east-west direction. The bottom floor of the tritium building is at the same elevation as the tokamak building, but has six additional floors up to 34 m above the basemat. The roof is contiguous with the east side of the tokamak building roof.

Laydown, Assembly and RF Heating Building (13)

This is a large rectangular, reinforced concrete building of about 47 m width, as set by the distance between the crane rails, and of height dictated by the height of the crane rails (25 m above the top of the tokamak building roof). It includes the westward extension of the tokamak crane hall, and houses several vital functions.

During the machine assembly phase, the building will be used for the assembly of the Iter machine. At this time, the building will consist only of the shell: the walls, the roof, the interface with the adjacent tokamak building, and the east wall with a 30 m wide door.

The floor will be at grade, to allow for easy access of material and components into the area, and the pre-assembly of the 2 TF coils with a 40º vacuum vessel sector and its thermal shields, and the large pre-assembly tools that are used for handling these heavy and large components. The 2 x 750 tonne main cranes will be used extensively during this period, and the crane rails are designed to allow smooth transition from the tokamak building to the laydown, assembly, and RF heating building, even after a design basis earthquake.

1.5.3 Diagnostic and TF Fast Discharge Resistors and Capacitors Building (74)

The diagnostic and TF fast discharge resistors and capacitors building is a reinforced concrete building with five floors, the lowest at approximately the divertor level. This building is adjacent to the tokamak building on the north side. The number of floors and the floor-to-floor heights are determined by the relation between the tokamak complex and the diagnostic building, because many diagnostic cables or waveguides cannot accept many changes in directions. The main systems accommodated in the diagnostic hall are the diagnostic systems and related equipment. This includes the following diagnostic equipment:

- shielded neutron test area;
- cubicles;
- spectrometers;
- reflectrometry;
- toroidal interferometer and polarimeter;
- LIDAR.

In addition, the building houses the TF coil fast discharge resistors and capacitors, and the power supply bus bars to the magnet coils.

1.5.4 Hot Cell Building (21)

The hot cell building is located adjacent to the tokamak building to facilitate the transportation of objects moved to and from the tokamak. It is a rectangular reinforced concrete building with a footprint approximately 52 m by 44 m. It is organised on two main levels. Lower level functions include in-vessel component docking, dust cleaning, storage, repair/testing, remote handling (RH) tools exchange and maintenance, activated materials processing, storage and shipping, and new parts and components receiving and storage. The upper level functions include RH equipment test, transfer casks storage, atmosphere confinement control and atmosphere detritiation equipment.

The Iter hot cell facility provides space and handling facilities for receiving, dispatching, decontaminating, storing, repairing, refurbishing and testing radioactive and/or contaminated tokamak components. Facilities are also provided for the maintenance of remote handling tools and for radioactive materials processing and storage. The following are the key hot cell areas by function:

- Dust cleaning area, where components withdrawn from the Vacuum Vessel (VV) are received and offloaded into a component receiving cell to remove activated dust. After refurbishment and testing, the components can be brought back into the receiving cell, loaded into transfer casks, and returned to the tokamak.
- Refurbishment area.
- Storage area, where components are stored prior to and after repair.
- Radwaste processing and storage area, where tritium is recovered, if required, and radioactive components are segmented for packaging and storage or disposal.
- Port plug equipment testing area, where the ex-vessel side of port plugs is accessible for hands-on maintenance and testing, whereas the plasma facing side is accessible with remote handling equipment from within the hot cell.
- Remote handling (RH) equipment test stand, for the maintenance and repair of RH equipment followed by commissioning, operation training and commissioning of equipment before maintenance or rescue interventions in the vessel.

General Functions

- Hot Cell Docking has to receive transfer casks with radioactive components through an Air Lock from Tokamak Building. Activated dust from delivered components and RH tools is removed in the Dust Cleaning area. Components before repair/waste processing and after repair are stored in the Storage Cell.
- Hot Cell Component Repair System performs disassembly, replacement of parts, re-assembly, and inspection/testing. The processing function includes evaluation and segregation of parts into those which must be replaced.
- Hot Cell Waste Processing and Storage System stores solid radioactive materials which have been removed from the tokamak and which will be discarded or refurbished for reuse.
- Waste processing includes cutting, preparation of samples for material evaluation, and removal of tritium from plasma first wall components (PFC) surface, and packaging of radwaste as required.

1.5.4 Low Level Radwaste Building (23) and the Personnel Access Control Building (24)

The low level radwaste building (the radwaste building) and the personnel access control building (the personnel building) are located close to the tokamak, the tritium, and the hot cell buildings to facilitate the management of personnel exposure and health physics, and to minimise the length of radioactive waste treatment connections.

The low-level radwaste building is configured to facilitate the handling of potentially contaminated solids including paper, plastic, and other dry solid material as well as loaded filter and demineralizer beds. Filters and demineralizers are designed so that the beds can be sealed in disposable liners and handled as wet solid waste, or they can be regenerated if appropriate. It is not intended to store low-level waste, but rather to prepare it for transfer to approved off-site facilities. Materials can be packaged in containers appropriate for disposal. A de-watering step may be necessary before these materials can be transferred for disposal. A connection to the hot cell building provides for a common exit for these transfers. The low-level radwaste building will be constructed using cast-in-place reinforced concrete.

The low-level radwaste building also provides space for drain tanks and systems for processing mildly contaminated water. Floor drainage from radiologically controlled buildings, active laboratories, primary heat transfer systems equipment drains, and shower and laundry drains, is treated here. Occasionally, it will be necessary to remove primary coolant to the waste systems. Primary coolant, water which is spilled onto the floor and collected in drains within the radiologically controlled areas, fluid from active laboratory drains, and decontamination fluid, will be collected in tanks in the radwaste building and treated in a dedicated waste process stream. Fluid will be sampled before and after processing. This process stream will include oil separators, filters, and demineralizers. If the product water meets the specifications for primary coolant, but exceeds the allowable tritium content for release to the environment, it will be sent to a water detritiation system where tritium will be extracted and detritiated water can be discharged. If the water does not meet primary coolant specifications, it must be recycled until additional particulate and ionic activity have been removed.

The personnel access control building is a rectangular steel frame building in plan 36.0 m x 24.0 m, with a height of 7.4 m. This building is located so that it is contiguous with the tokamak building, the tritium building, the hot cell building and the low level radwaste building. The above-grade structures use structural steel framing. The building is divided into white and green zones, based on the potential for contamination. There are separate HVAC ducts to separate the rooms with different degrees of airborne and surface contamination. This building provides the single, controlled pathway for personnel access to the potentially contaminated zones in the connected buildings.

1.5.5 Pulsed Power Supply Complex

Magnet Power Conversion Buildings (32 and 33)

The two magnet power conversion buildings are two-level structures arranged as relatively long and thin structures to provide adequate indoor space for rectifier sets and related equipment, while also providing large exterior walls for connections to transformers. The two-level structural design has a simple foundation with a steel frame building. The structures must accommodate thermal expansion, and the long, thin configuration leads to a requirement for an expansion joint which divides each building into two structures. Rectifier and power conditioning equipment is located along the edge of each building. Rectifiers and power conditioning equipment are floor-supported. Transformers associated with 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 each of the two levels will be accomplished using air pallets or similar devices. The roof is structurally flat. Roof level equipment is primarily HVAC.

Transformer foundations include blast/fire walls to protect equipment in the buildings. High current power supply output is collected in air-cooled busbars, located on a second level above the converter sets in each building. Office and restrooms are designated for personnel support. The building provides some general services such as HVAC, lighting, power, drainage, fluids, and lifting capability.

Magnet Power Supply Switching Network Building (31)

This is a steel frame building with two levels. There are no large open or clear spans in the building, and it is a structural steel, column and beam configuration. Equipment is located at grade, on a second floor, and on the roof. Roof level equipment is primarily HVAC. Large doors at grade, and on an intermediate floor (at + 7 m) allow the installation and removal of equipment using portable equipment. Equipment located on the roof (+ 14 m) will be placed using road cranes from grade, although horizontal movement at both levels will be accomplished using air pallets, fork lift vehicles, or similar devices.

Alternating Current Distribution Building (36)

The AC distribution building is a reinforced concrete, two-level structure. Reinforced concrete is used because the DC battery room requires the strength of massive and strong walls to resist a potential hydrogen explosion. Heavy equipment is located at grade.

Neutral Beam (NB) Power Supply Building (34)

The NB power supply building is a two-level structure. There are no large open or clear spans in the building, and it is a structural steel, column and beam configuration. Equipment is located at grade, on an intermediate floor, and on the roof. Large doors at grade, and on an intermediate floor (at + 6 m) allow the installation and removal of system equipment using portable equipment. Equipment (primarily HVAC) located on the roof (+ 11 m) will be placed using road cranes from grade, although horizontal movement at both levels will be accomplished using air pallets, fork lifts, or similar devices. The roof is structurally flat.

1.5.6 Steady-State Power Supply Complex

Emergency Power Supply Building (41)

The emergency power supply building is a three-level structure with one mezzanine floor. The generators are located on the basement with isolated foundations due to their vibration. Stacks and heat rejection systems are located on the roof. The building is a reinforced concrete one. The major systems to be installed in the EPS building are the diesel generator sets (2), a small control centre for the generators, and the electrical load centre for the building.

3.3 kV Power Supply Structures (44)

The 3.3 kV power supply structure is adjacent to and south of the cryoplant coldbox building (51). Switchgear is located along the edges of each of the structures, with the central aisle kept clear for handling and movement of equipment. Non-structural concrete walls separate the transformers and switchgear along buildings walls. Two power transformers for each structure are located outdoors on foundations which incorporate oil catch basins and fire and blast separation walls. The secondary side conductors penetrate the walls of the structures for connection to the switchgear. Amenities include a ventilation system, suitable for the equipment located in the structures, lighting and service power, fire protection, access control, and roof drainage. The single-level structural design requires a simple foundation with a steel frame structure. The roof on each structure is structurally flat. There are no large open or clear spans; it is a simple structural steel, column and beam configuration. Equipment is located at grade, and ventilation equipment on the roof. Large doors at grade allow the installation and removal of equipment using portable equipment. Minimal HVAC equipment located on the roof (+ 4.7 m) will be placed using road cranes from grade.

Electrical Load Centres

Electrical load centres (LCs) are located throughout the site at points of convenience for gathering the electrical load requirements for a building, a portion of a building, or a group of buildings. Load centres are served by tunnels from the main power supply areas, and feed the end users in those buildings.

1.5.7 Cryoplant Complex

Cryoplant Compressor Building (and PF Coil Fabrication Building #2) (52)

The cryoplant compressor building is built in the early stages of construction, and may be used initially for PF coil fabrication, unless these large coils are shipped to the site fully assembled. It is a single-level steel frame structure with a space for mechanical and electrical services. The building footprint is sufficient to provide for simultaneous fabrication of PF coils #1, 2, 5, and 6. Each coil will occupy 4 equivalent coil diameters, plus space for conductor laydown and spooling for a three-in-hand winding operation, although the module assembly station for a small coil will be inside the space allocated for a large coil. The height of the building is controlled by the height of the winding operation plus room for pancake and module handling tools, crane, and roof truss depth.

The tools, jigs, and winding fixtures needed for the largest coil determine the space requirements for the building. The heaviest module determines the crane capacity. The manufacturing process involves the application of epoxy insulating and bonding materials, vacuum impregnation steps, and preparation of conductor joints. The process requires cleanliness, lighting, and environmental control, which are similar to modern aircraft manufacture.

The building includes space for an electrical load distribution centre, which is part of the plant steady-state electrical power distribution system. Personnel areas such as offices, lavatories, change facilities, and other worker support functions will be provided using temporary buildings.

After the coil fabrication campaign, the PF coil fabrication building #2 will be converted to the cryoplant compressor building.

The cryoplant compressor building is a single-level structure with clear span. The building provides space for process equipment and is serviced by an overhead main 40 t bridge crane as well as by a 5 t bridge sub-crane, suitable for servicing and assembly and disassembly of the helium coldboxes. To maintain stability, the crane columns are built-up with an effective width of 2.5 m, resulting in 40 m between crane rails. The maximum hook height for the crane is 18 m. The north aisle is used for interior truck access and routing of services, both overhead and in a below grade utility trench. Large doors are provided at the east end of the building. The spaces for mechanical and electrical services, parts storage, and other worker support functions are provided at the west end of the building. Additional cryoplant equipment, and helium gas heaters for the final stage of warm up, are located outdoors.

Cryoplant Coldbox Building (and PF Coil Fabrication Building #1) (51)

As with the cryoplant coldbox building, the cryoplant compressor building is built in the early stages of construction, and may be used initially for PF coil fabrication, unless these large coils are shipped to the site fully assembled. It is configured in the same manner as the PF coil fabrication building #2, above, and will also be used to simultaneously fabricate PF coils #3 and 4. After the coil fabrication campaign, the building will be converted to the cryoplant coldbox building.

The cryoplant coldbox building is a single-level structure with clear span. The building provides space for process equipment and is serviced by an overhead main 50 t bridge crane and by a 5 t bridge sub-crane, suitable for servicing and assembly and disassembly of the helium coldboxes. The general configuration of the building is the same as for the cryoplant compressor building. The cold process boxes contain series of counter flow regenerative heat exchangers, cold turbines and valves. The streams of compressed helium and nitrogen are supplied to these cold boxes from the cryoplant compressor building. The space for mechanical and electrical services, parts storage and personnel areas such as local control room, offices, lavatories, and other worker support functions will be provided at the east end of building. Additional cryoplant equipment, including gaseous helium storage tanks, and LHe and LN_2 tanks, are located outdoors.

1.5.8 Laboratory Support Complex

Site Services Building (61)

The site services building provides space for industrial support systems including compressed and breathing air, miscellaneous gas distribution, chilled water, demineralized water, potable and hot water treatment, and auxiliary steam, which is used primarily for space heating and some electrical power distribution. It contains some areas dedicated to non-radioactive waste handling, the non-active chemical laboratory, space for warehousing of spare parts, machine shops, and offices.

The building comprises two areas: the main building and a small auxiliary boiler annex on a concrete slab at ground level.

The building is a single-level structure with a footprint of 75 m x 40 m and is 12.5 m high. The boiler annex is 16 m x 15 m x 7.3 m high. Internally, the main building is divided into three bays. Two 17 m wide bays at each side of the building provide space for process equipment and are serviced by overhead bridge cranes 20 t and 5 t. The centre bay is 6 m wide, and is used for interior truck access and routing of services, both overhead and in a below-grade utility trench. Large doors at several locations provide access to interior equipment during operation. The roof is structurally flat.

Cooling Towers

The design basis assumes a maximum cooling requirement of 1200 MW for periods of 3600s, however it is recognized that phased construction of the heat sink may be desirable, since this requirement will not occur until sometime after the start of the DT operating phase. Preliminary sizing indicates that four mechanical draft cooling towers are adequate to meet Iter's requirements, with a total capacity of 500 MW. The total area required by the towers is estimated to be 18 m x 66 m, including a 5 m deep concrete basin located beneath the towers, with a capacity of 6200 m^3. Cooling water would be gravity feed from the cold basin, through a 2 m diameter pipe to the Iter heat exchangers.

For the DT operating phase, additional basin capacity will be required. Earth basins for cold and hot coolant streams, sized at 16,000 m^3 and 22,000 m^3 respectively may be required and can be added to meet the full heat sink demand.

Cooling Water Pumping Station (68)

This structure has only walls and a simple roof, and no HVAC. Power for lighting and small power users, and a welding outlet, are provided. There is no crane, as pump maintenance will use temporary lifting devices. Fire protection is provided. The pumping station houses 10 pumps and two safety-related chiller cooling towers, one at each end of the structure.

1.5.9 Utility Tunnels and Service Structures

Utility Tunnels

Underground tunnels between buildings provide space for routing electrical services, cryolines, and other piping. In addition, these tunnels also provide routing space for electrical services, instrumentation and control wiring, fibre-optic cables, and general services such as lighting, power, and fluids.

The biggest user of the tunnels is the piping for the cooling systems for Iter, from the cooling tower basin to the tokamak building via a pumping distribution station, located just north of the site services building, and east of the tokamak complex. The pipe tunnels are equipped with sumps and sump pumps to collect rain water and leakage and pump the water collected to the site storm drain system. For areas of the tunnels containing potentially contaminated water, any collected leakage is first sent to the radwaste building for confirmation of the acceptability of discharging the water.

Electrical power is another large user of the utility tunnels. These tunnels link both the steady-state electrical power switchyard and the pulsed power switchyard on the west side of the site with the various buildings and electrical load distribution centres throughout the plant.

The tunnels form a network around the site. Combination tunnels are internally segregated for protection of the services from each other.

Service Structures

Electrical load centres are either located within buildings, or are located adjacent to buildings. Those adjacent to buildings require only a minimum structure to protect the equipment from the elements, and to provide an area for inspection and maintenance, but not other worker amenities, as these will be available from other areas on the site. Similar protection is required for the 3.3 kV power areas, and for the AC distribution building. In some cases, electrical power is transferred on bridge structures where the required access to a building is above grade.

There are other systems which incorporate large outdoor equipment, primarily tanks, which require foundations and, in some cases, include the concrete storage tanks themselves. These service structures include:

- foundation pads for large helium storage tanks used by the cryoplant, for fuel tanks used by the auxiliary boiler, for fuel tanks associated with the emergency power supply, and for water tanks associated with the demineralised and potable water systems.
- a reinforced concrete potable water basin sized to provide for 3 days of makeup for demineralised water and potable water storage systems (plus 10% for fire-water reserve).
- a large holdup basin available for temporary storage of industrial sewage so that, if the sewage streams become contaminated, the industrial sewage can be held while corrective action and procedures for processing are established.

1.5.10 Control Complex

Laboratory/Office Building (72)

The office building is a five-level structure with an auditorium, which provides the space for conferences and symposiums. The structure is proposed to be a structural steel framed building with 5 floor levels. Two penthouses are provided to house HVAC and elevator equipment. The office building is located outside the Iter high security fence, and is accessible to the offsite public, once they have been admitted to the Iter site. Two possible locations are shown on the overall site plan.

It is anticipated that the ground floor building amenities include a lobby and display area at the building entrance, cafeteria and kitchen facilities, locker and exercise area, computer room, library, conference rooms, auditorium, and various areas to house building support personnel and equipment. Floors 2 though 4 provide staff offices, workstations (cubicles), and meeting or conference rooms. HVAC and elevator equipment are located on the roof. The building provides some general services such as lighting, power, HVAC, fluids and is linked to other parts of the Iter site through communications networks.

Control Building (71)

The control building is located south and east of the tokamak complex, but still within the secured area (inside the security access control fence). It houses:

- basement level: machinery room, load centre, cable room, transformer room, library, meeting room, storage, offices
- ground level: control room, computer room, change area, visitors' rooms, offices, incident response area (with vehicle)

The control building is designed so that essential systems can be operated after a seismic event, and has the following size and characteristics.

Personnel and Vehicle Access Control Gatehouse

The gatehouse provides access control, such that all personnel and vehicle access is granted through this building. All personnel proceeding through on foot to the control building or other areas within the high security fence will also pass through this gatehouse.

1.6 Facility Layout

The Iter Facility is enclosed by two fence systems. The outer fence encompasses all the land area under control of the Iter operating entity. The inner fence surrounds a secured area and prevents unauthorised entry by persons or vehicles. All buildings and structures, except the cooling basins and structures, the office buildings, and the pulsed and steady-state switchyards, are inside the secured area. The layout is presented in Figure 2.2-2 of Attachment 2.

Space is allowed for the passage of services such as electrical power, cooling water, and movement of personnel and materials. Access is available for all phases of the project, including construction, operation, maintenance, and decommissioning.

1.7 Summary of Hazardous Substances

Construction and Commissioning

For the most part, Iter will be constructed and commissioned without the use of any radioactive substances, except for those used in gauges used in industrial construction (e.g. radiography). As well, certain systems (mostly diagnostic and the neutral beam heating and current drive) may incorporate small quantities of radioactive materials for the purpose of measurement, control or operation. Significant during construction will be the introduction of Beryllium. It is introduced in the solid form on the plasma facing surface of the blanket. The spread of beryllium outside the vacuum vessel is not expected to be significant, and controls will be in place from the outset.

The commissioning activities will include testing with hydrogen plasma (the HH phase). During this phase, tritium and radioactive products will not be produced. All activities involving the plasma facing components, as well as the handling of in-vessel components, will be subject to beryllium control measures.

Operating Phase

The operating phase begins with a deuterium (DD) plasma before progressing to a deuterium-tritium (DT) plasma. In the beginning of the DD phase there will be a limited neutron flux and a limited amount of tritium produced by successful fusion of the DD plasma, hence limited tritium and activated products are expected to be present in the beginning of this phase.

After sufficient information is obtained from the DD phase, tritium will be introduced for the DT operating phase. The neutron fluence will gradually build up to a target value of 0.3 MW-a/m^2 on the first wall by the end of life with successful DT operation. Tritium, activated components, activated corrosion products, and activated dust, are all expected to be present in the latter part of this phase of operation. The levels of activation for tritium, activated corrosion products and activated dust will increase gradually with operation. The levels of tritium, activated corrosion products and activated dust will increase gradually and will be monitored and assessed as operation proceeds. The level of activation of the in-vessel components will progress more rapidly such that personnel access inside the tokamak will not be possible after this phase of operation has begun.

During this operating phase, the on-going filtering of effluents and decontamination activities will produce a limited amount of low-level radioactive waste in the form of filters, rags, used protective clothing, etc. which will require disposal in an approved radiological waste site (such as the AECL Chalk River site).

Maintenance and refurbishment will be performed on activated in-vessel components in the hot cells provided. It is anticipated that there will be parts of these components, and occasionally entire components, that will not be repairable or re-usable. It is expected that there will be approximately 100 m^3 of this material. The current hot cell is designed to store up to 110 m^3 of activated components until such time as deactivation and decommissioning activities begin. It is also possible to expand the hot cell facilities if required to accommodate unplanned additional decontamination and/or storage requirements if they develop.

A summary of the radiological substances is provided below in Table 1.7-1.

Table 1.7-1 Radiological Hazard Description

Hazard	**Estimate**	**Notes**
Tritium	<3000 g-T	The target is to have less than 450 g-T of mobilizable tritium inside the vacuum vessel (met by regular detritiation of the plasma facing walls) and less than 450 g-T in the tritium process system at any time. If the targets are achieved, there would be <1500 g-T
	<0.005 g-T/m^3	At end of life for In-vessel component cooling water
	<0.0001g-T/m^3	At end of life for Vacuum vessel cooling water
Activated dust	< 100 kg W (project limit) plus C and Be	This is dust created from the erosion of plasma facing components and resides inside the vacuum vessel where it would be produced. The bottom of the vacuum vessel would be cleaned routinely to maintain the tungsten dust inventory below the project limit. Estimates of dust production indicate that >500 pulses are needed to produce 100 kg W, by which time < 40 kg C and < 20 kg Be would be produced.
Activated Corrosion Products	Total including deposits: ~2000 TBq Of which ~2 GBq per loop is not fixed oxide	These values are totals in each blanket cooling loop at shutdown. This is dominated by short-lived nuclides. 24h after shutdown, the ACP drops significantly. Key isotopes are Cr-51, Mn-54, Fe-55, Mn-56, Ni-57, Co-57, Co-58 and Co-60. The divertor loop and the VV cooling loops are not yet evaluated. The VV loops are expected to have low levels of activity, the divertor loop may add as much as 20 TBq of which ~99% would be Cu-64 with a 12.7h half-life.
Activated Gases	There are some gases in the Iter facility that will be activated. The most significant are Ar-41 and C-14 from air between the cryostat and bioshield, and impurity gases injected into the divertor.	

Solid Activated Material	~ 100 m^3	Solid activated metal and ceramic components requiring storage during the 20-year operating life-time of Iter. (this assumes an average material density of 8 t/m^3 and a 50% packing factor in containers)
	$<$3 000 m^3	Solid activated structural material and components including about 6600 m^3 which is a potentially re-usable concrete bioshield. It is estimated that 700 m^{3}6000 t to 12 000 t of activated materials will remain above IAEA clearance levels after 100 years. (Estimating 8 t/m^3 and a 50% packing factor in containers, this would amount to 1500 m^3 to 3000 m^3.)

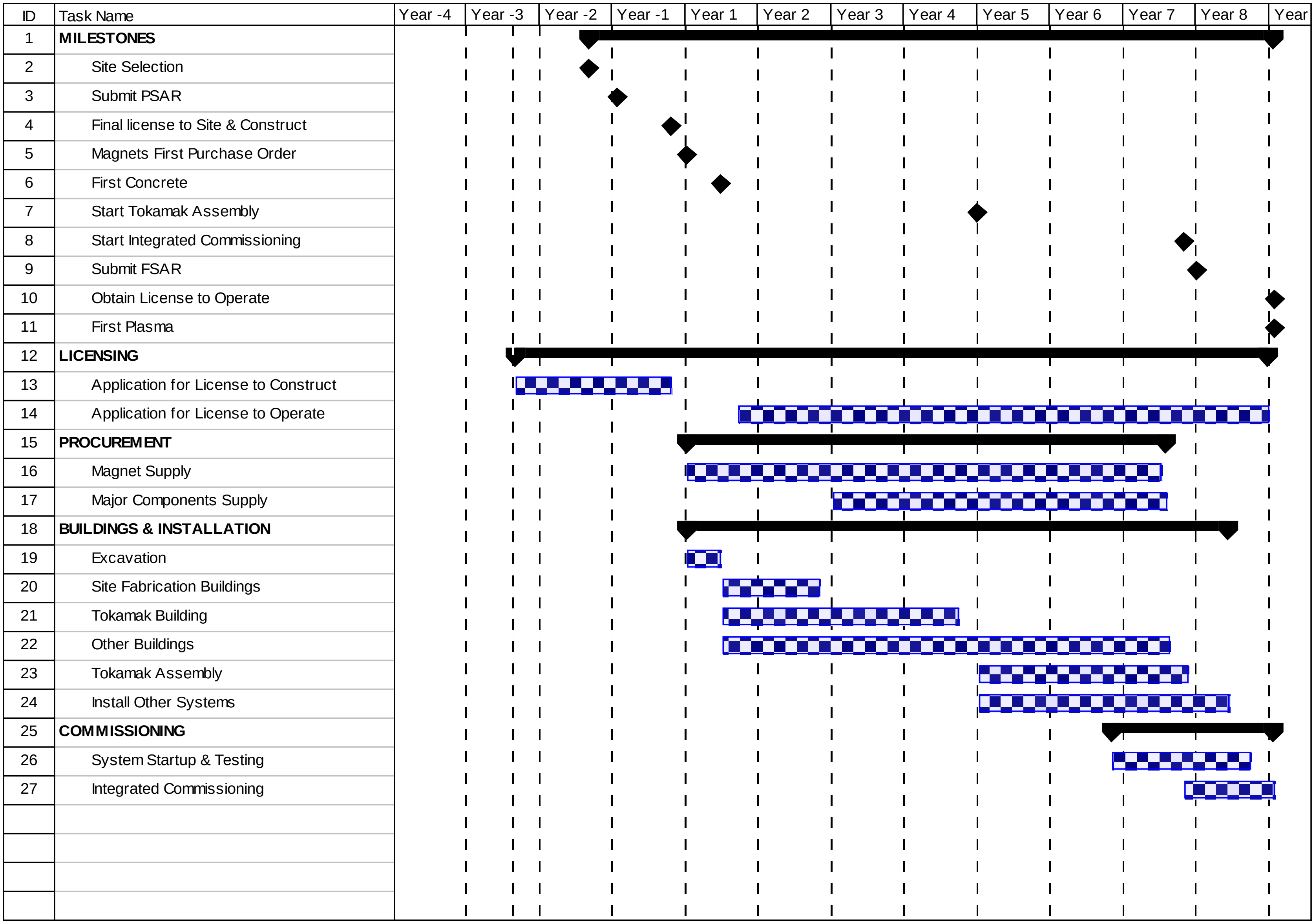
As well as radiological hazards, there will be chemical hazards for which there is extensive industrial experience. There are few details yet available on the inventory of these, except for beryllium, hydrogen, and ozone. A list of the chemicals that will be required is presented in Table 1.7-2. All hazards will be handled according to established industrial hygiene practices to ensure safe handling within the Iter facility and control from spread to the environment.

Beryllium is a hazardous material, a possible carcinogen for humans, and a known carcinogen for animals. The current design requires approximately 13 tons of beryllium on plasma-facing components as a 10-mm protective layer. Within the Iter facility, there may be dust of the bare metal, carbide, oxide, and possibly nitride.

Table 1.7-2 Chemicals Present at the Iter Facility

Chemical	Comment
Beryllium, carbon, iron, tungsten, titanium	Hazardous as small, respirable particles
Hydrogen	
Cryogenic helium and nitrogen	Chemically inert but can cause effects similar to thermal burns if exposed to body tissue
Freon or similar used in refrigerant systems	
SF_6 used as insulating gas	
Vacuum pump oil	If used in pumping systems it might become tritium contaminated.
Oil for electrical equipment	
Lead shielding	
Acid and alkaline cleaning and pickling solutions	In the work shops
Solvents like kerosene, acetone, and ethyl alcohol	In special safety cans
Diborane	Toxic and flammable gas potentially used for first wall conditioning
Demineralizing substances and spent resin from the demineralizing beds in the CVCS	
Halon or similar 1301 and carbon dioxide	For fire protection systems
Orthophosphates and calcium phosphate inhibitors	To control corrosion in the cooling water systems
Commercial products to control bacterial, fungal, and algae slimes in cooling tower water	

Figure 1.3-1 Preliminary Construction Schedule



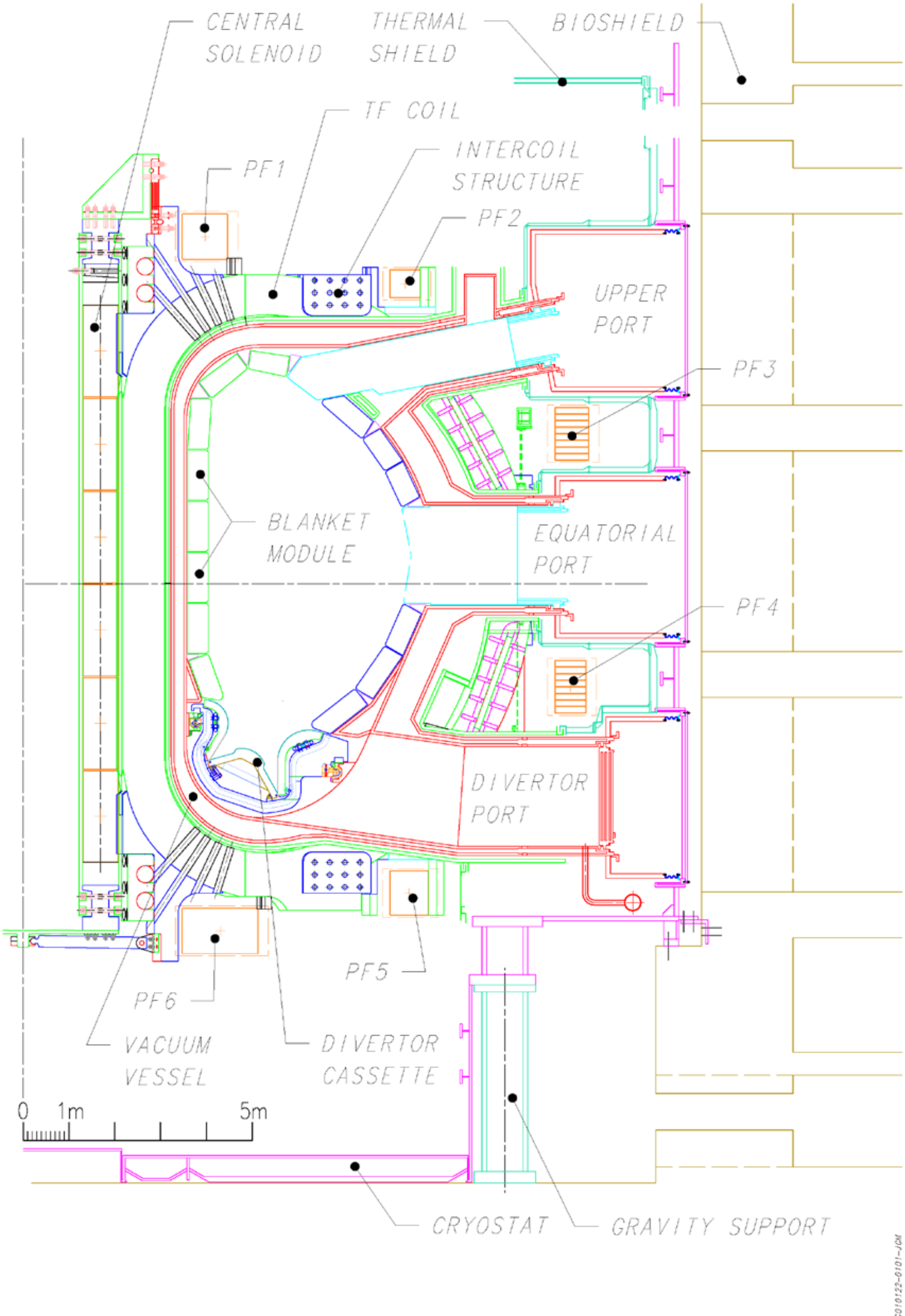


Figure 1.4-1 Iter Tokamak Cross-section

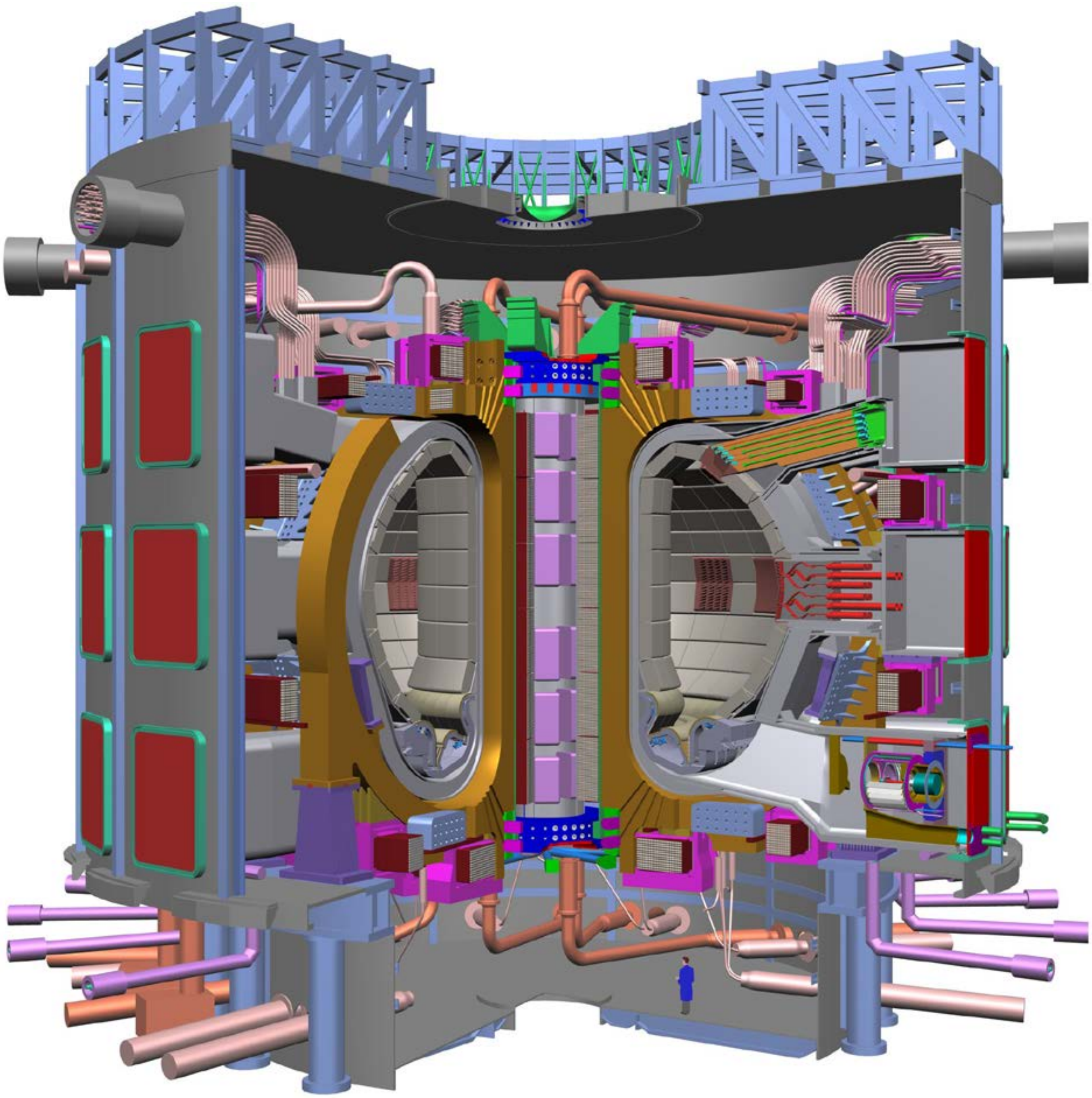


Figure 1.4-2 Iter Tokamak Cutaway

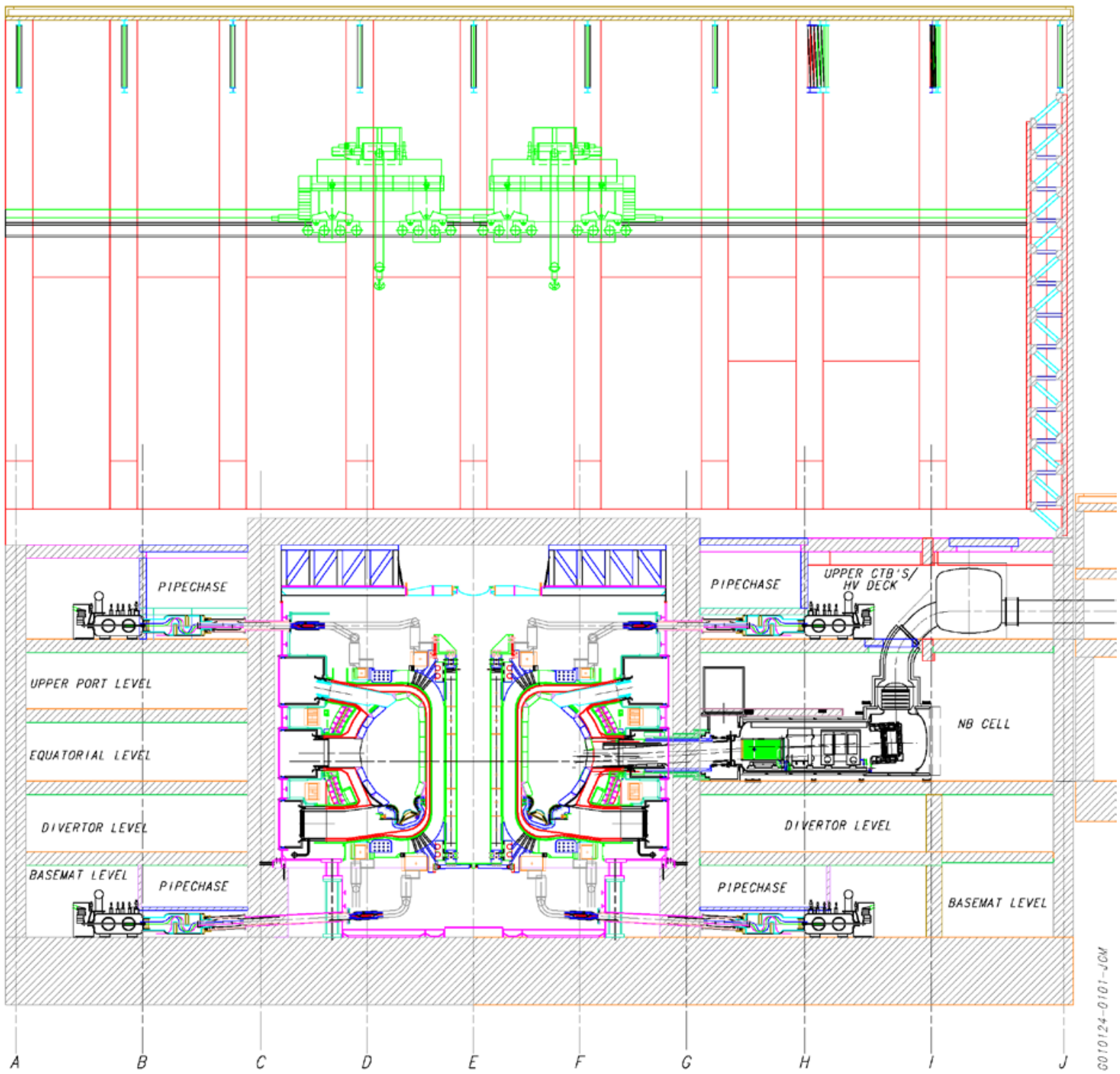


Figure 1.4-3 Cross-section EW Through the Tokamak Building

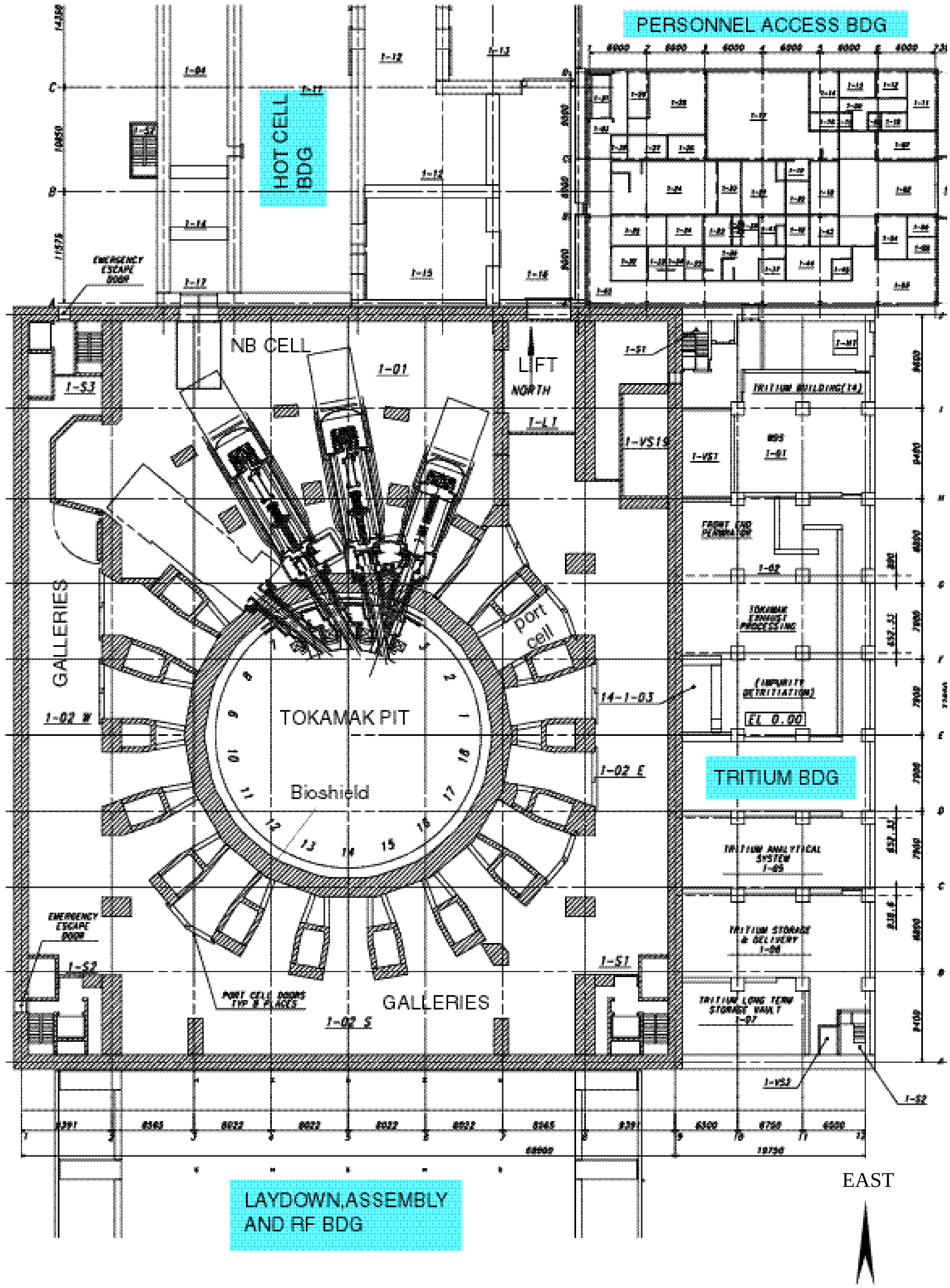


Figure 1.5-1 **Tokamak Building – Plan View of the Equatorial Level**