Canadian Fusion Fuels
Technology Project

ITER FUEL CYCLE SYSTEMS LAYOUT - CONCEPTUAL DESIGN REVISION 2.0

CFFTP-G-9015
(ITER-IL-FC-2.4-0-8)
OCTOBER 1990

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ITER Fuel Cycle Systems Layout
Conceptual Design
Revision 2.0

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1 General Description of the Layout

The Fuel Cycle Building (FCB) covers an area of 33 by 41.5 m and is 46 m tall. It has five full floors of which two have a partial mezzanine. The building is located in a quadrant between the NBI Power supply room and the vacuum pump room W 07 (in the Tokamak building) at the ground level. The individual elevations and important sections are indicated in Figures 1 to 7 included. The functional and numerical designation of individual rooms is indicated in Table 1.
The following systems are integral part of the fuel cycle, but these units are located in the Tokamak building:

1. *Fuelling - Pellet Injection.*
2. *Fuelling - Gas injection.*
3. *Emergency Fuel Storage (for fuelling).*
4. *Main Exhaust Backing Pumps.*

Systems located in the Fuel Cycle Systems FCB:

1. *Fuel Purification - Permeator Based.*
2. *Fuel Purification - Molecular Sieves.*
3. *Impurity treatment system - Catalytic reaction, water-gas shift Permeation based system*
4. *Impurity treatment system - Recombination, electrolysis based.*
5. *Impurity treatment system - High temperature isotope exchange - "Hitex".*
6. *Waste Water storage and treatment systems*
7. *Isotope Separation.*
8. *Waste Water Tritium Extraction.*
9. *Tritium extraction from Solid Breeder.*
10. *Tritium extraction from Test Modules.*
11. *Tritium Storage, Shipping and Receiving.*
12. *Tritium Laboratory.*

13. *Atmosphere Detritiation Systems.*

14. *Fuel Cycle Control Centre.*

15. *Tritiated equipment maintenance space.*

16. *Tritiated equipment storage space.*

17. *Control maintenance space (electronic workshop).*

18. *Health Physics Laboratory*

19. *Access, access control and facilities.*

There are other Fuel Cycle systems such as solid waste decontamination and disposal systems which will not be located in the FCB. These will located in other parts of the facility, namely connected with the hot cells.

Identification of Rooms in the Fuel Systems Building				
Room Content	Room	Figure	g of T	of cont.
Tritium Lab.(1)	W 01	3	var(2)	2
Health Physics Lab.	W 01a	3(3)	0	0
FCU, ICU	W 07	3	260(4)	2
Water storage	W 05	3	20	1
Water treatment	W 06	3	20	1
Trit. Maintenance	W 02	3	0-trace	0
Water distillation	W 04	3	0.56	1
Exhaust Backing P.	W 08		70	inert
Trit. Equip. Storage	W 03	3	trace	1
Trit. Storage	T 01	4	4000(4)	2
Cryo-distillation	T 03	4	300(4)	2
VPCE room	T 04	4	trace	1-2
Vertical access	T 11	all	0	0
Change and facility	T 02	4	0	0
Water storage	T 05	4	20	1
Emergency exit	T 13,14	all	0	0
Pellet injectors	R 91		70	2
Gas puffing	R 92		5	2
Emergency storage	R 93		0	2
Control maintenance	R 04	5	0	0 (5)
Processing analysis	R 02	5	0	2
Cryo-distillation	R 03	5	in T32	1-2
Control centre	R 01	5	0	0
Test Bl. T recovery	M 05,01	6	20	1-2
Solid Br.T recovery	M 02	6	20	1-2
HVAC and ADS	H 01	7	10	1

Table 1: Designation of rooms in the Fuel systems building and their tritium inventories

(1) - this is a two storey facility;

(2) - the tritium laboratory will have variable inventory but the upper limit may be in the range of 1.5 - 5 g.

(3) - Located in mezzanine above Tritium Laboratory.

(4) - The tritium inventory contained in these rooms is segregated to comply with the maximum system content of 200 g;

(5) - there will be no maintenance performed on any tritiated component in this room. Consequently, there would be no need for a glove box or a fume hood. Any contaminated component would be maintained in room W 02.

2 FCB Layout Design Issues

The FCB layout was undertaken as a cooperative effort between a number of ITER design units. Periodic review meetings took place and home process design teams were consulted and commented on the configuration of the layout and the actual interpretation of their initial, system specific requirements.
The considerations for locating the FCB adjacent to the Tokamak building or distant from it have received most attention. This is discussed in the next paragraph. One of important considerations of the layout are uncertainties with the location of the ground level in relation to the Takamak building. It is assumed that the most likely position of the ground level is level 'T' with probability progressively decreasing to level 'R' and above. Consequently the term "ground level" refers to the ultimate position of the grade as it will be determined for the real ITER facility. The access to the building will take place at the ground level where a portion of the access tower will be designated as a "clean" space. The overall building access control will take place adjacent to the entrance. From this room (room T 11), there will be only one door leading to the stairway and/or to the elevator, to the change room, to the tritium laboratory and to the processing rooms at that floor. The change rooms (T 02) have also personal access from the "tritium services" portion of the building and it will be used only under the unlikely event an operator is contaminated and needs to be de- contaminated before entering the "clean" portion of the building. Substantial discussion was linked to the proposed location of the dedicated Fuel Cycle Control Centre as opposed to relying on a single main operations control room which was intended to be located at a central position remote from the main Tokamak building. The argument recognized that the fuel systems will see intensive operation all year-round where the Tokamak control room would see such activity only during the operating phase but low intensity activity during shutdown. It was decided to keep a satellite fuel systems control room for the following reasons:

- *There is an existing need and intent to duplicate some operations in distributed dedicated control centres;*

- *Distributed Control Centre concept has been proven necessary in all operating industrial fission (such as DTRF) and new fusion facilities (such as TSTA and JET);*

- *The routine day by-day operation of the fuel systems and the campaign operation of the Tokamak would not be compatible and could lead to mutual interferences.*

Once the decision to have a dedicated control centre is accepted, there is a secondary decision to made where to locate it whether inside the building or in a separate, segregated location. The proposed design opts for an integrated location which is proven to be more convenient for the operating personnel. Such location is also consistent with available installations.
The following points were considered in the development of the building design:

1. *Minimal length and simple configuration of process lines between serviced and servicing systems;*
2. *Vehicle access to Shipping and Receiving;*
3. *Maintainability of major components.*
4. *Relative location and impact between the Tokamak and the FCB;*
5. *Use of a local control centre;*
6. *Single point operational access.*

3 Location of FCB and its Impact on the Tokamak Building

The following two alternative co-locations between the Tokamak and the Fuel Cycle buildings have been considered:

- **Alternative A**
  Attaching the two structures with a common wall or if needed, separate boundary walls with virtually no space between them.

- **Alternative B**
  Detached structures with at least 15* m distance from the nearest structure.

(* This was suggested to be the minimum distance necessary for exterior servicing between two detached industrial structures of such a size.)

The following considerations were discussed in positioning the building:

Safety of the Tokamak building in the event of accident in the Fuel Cycle building.
It was accepted that the boundary wall or walls, if required, could be designed in such way that any transfer of risk from the FCB to the Tokamak structure could be eliminated. Subsequent analysis concluded that there is not enough

hydrogen in the FCB systems to cause damage to the Tokamak structure. The layout will permit the use of blow-out panels if required and the critical components were positioned close to the wall facing away from the Tokamak building. It was concluded that there are no safety reasons for preferring one alternative over the other.

The desire not to include processes into the Tokamak building which could be located elsewhere.
The decision between A and B will have no impact on the Tokamak building as both alternatives achieve this goal equally.

The existence of regulatory constraints.
There were none known to be available which would compel the choice between the alternatives.

Good design practice.
The design choices for both alternatives, namely the problems with process piping interfaces, were discussed and solutions for both alternatives were proposed.

The impact on the design of the two structures.
Since both are being designed independently, there are no such limitations known at this time. Alternative B however, has the possible advantage of freedom associated with the opportunities to use the adjacent walls as exterior walls. Alternative A offers the advantage of simpler piping interface which for both building means that there is no need for dedicating space for collecting the 30 + pipes to and from the common transfer point.

Building construction.
It was agreed that if there is a separation between the two buildings, the construction work for both buildings and equipment installation work in the Tokamak building could be made easier and less costly. This was considered not an overwhelming advantage since the Fuel System building could be built later if needed. FCB was designed with the thought that the wall adjacent to the Tokamak building would not be available for installing its own equipment.

Routing of interconnecting process lines.
At the conceptual design stage there are known at least 30 and if the test modules are considered, perhaps 40 process lines that will have to cross between the two buildings. Alternative A offers an opportunity for each line to cross the boundary wall(s) at the nearest natural location. The Fuel Cycle building layout aimed at co-locating the serviced and servicing systems. Alternative B would require the use of at least one above ground and possibly one underground transfer point from which the piping is transferred between the buildings. The above ground transfer bridge will carry the double contained process piping and

a fully enclosed walkway which will preserve the containment function analogous to the building and will be sufficiently sized to permit maintenance on the piping. The underground channel will have to meet the same criteria. It is possible to eliminate the underground channel if tritiated drain is collected in a central tank in the Tokamak building from where it would be pumped to the elevation of the transfer bridge and further to the storage tanks in FCB. A transfer corridor will most likely need an air lock with the appropriate servicing and access monitoring systems at least at one end and possibly both ends. The relative uncertainty about the location of the systems in the Tokamak building serviced by the Fuel Cycle systems was pointed out as reducing the advantage offered by alternative A. However, this was considered in laying out this building. The most likely affected floors are reasonably consistent in shape and size. This allows for relatively easy switching entire floors to maintain co-elevation between the serviced and servicing equipment should the Tokamak building layout change.

The convenience of simplified piping associated with alternative A appears to offer a lasting advantage as compared with the initial advantage associated with the potentially simpler construction work offered by alternative B.

3.1 Conclusion

The above considerations have been discussed during several meetings and finally at a meeting of 16, August 1990 was decided to recommend and to proceed with the alternative A.

4 Layout Description

The following paragraphs describes the individual included in the FCB.

4.1 Access to the Building and Processing Areas

Access to the facility takes place at the ground floor in the centre of the building between the cryo-distillation and Tritium storage room. At this location a single access control point for the entire building is provided. A vertical access "tower" having dimensions 6 × 8 metres is located at the edge of the building (designated as T11 on all floors). This will contain stairs, personal transport elevator and, if required, a freight elevator or a combination of both. For transporting tritium-free and uncontaminated equipment. Large equipment would enter or leave the building through the vertical equipment access at the outside wall in the CD room during shutdowns. The central location was chosen to facilitate direct access to all work locations at each level with minimum need for crossing other rooms. The vertical access tower provides the additional opportunity for secondary access control between the tower and individual floors or rooms adjacent to the tower. Emergency escape routes are provided opposite to the main entrance tower. The route in the corners of the building where the normally inaccessible FCU modules are, is not extended to the lowest level. An open staircase is also shown in the DW room.

4.2 Fuel purification - room W 07

The minimum initial space requirement for these systems was 20×20 metres, but a more generous space was allocated in room W 07. To minimize piping runs the FCU were installed in the proximity of the main exhaust backing pumps (Room W 08 in the Tokamak building). The area of the room is approximately 600 square meters and the maximum hight is 9.4 meters. The allocated space is adequate for accommodating two parallel purification lines, namely the Molecular Sieves and the Permeator based fuel purification systems and in addition three alternative modules for the impurity treatment streams, the impurity Cracking-Water/Gas shift-Permeator (CWGP), the Oxidizing-electrolysis (OE) and the High Temperature Isotope Exchange (Hitex) processes or the alternative getter intermetallic purification process. It is assumed that one of the FCU systems may have to be shielded since they may contain activation products from the vacuum pump discharges.

4.3 Isotope Separation - room T 03

This system is located in a two-storey room between floors 'T' and 'M'. Additional space is provided in room R 03. Maintenance of equipment contained in cold boxes located just above level 'R' is done by lowering the cold box cover to the level below, namely 'T'. A large door may be required in that part of the building at the ground level 'T' in order to permit removal of items from the building. Open cold boxes would be than maintained from the ground floor elevation or from the elevation on which the exposed equipment is located. Pumps will be located in glove boxes or in a hard shell - pressure vessel type secondary containment. The longest CD column is approximately 7.5 meters long. The height of the room is 19.4 m. This provides more than the theoretical minimum of 7.2×2 = 15 m required for designing the column - cold box combination in such a way that the upper and lower shells could be removed for full access to the cryogenic components in that cold box. The CB internals are to be supported on or from the central section of the cold box. The CD pumps are expected to be small and consequently require only light local, floor supported hoisting devices. There is a sealed opening between the CD room and the Tritium maintenance room in the basement which will be used if tritium maintenance on some of the

CD equipment is required. Space in the corner of the building near the exterior wall is left clear of permanently installed equipment to facilitate vertical transport of components between the floors through the hatches provided.

4.4 Waste Water Storage and Treatment - room W 06

This system is functionally connected with the Waste Water Tritium extraction - water distillation columns and the Isotope Separation System and is therefore located adjacent to these systems. The water treatment system is located near the wall shared with the FCU (Room W07). There will be two storage tanks 200 cu. metres each located near the wall shared with the NBI backing pump room W 14 (in the Tokamak building). The external dimensions of the storage space would be 4 m diameter and 16 meters tall, which would be elevated for minimum pump suction pressure requirements. The water treatment system may have to be shielded and therefore the IX columns have been located in a corner of this room together with the appropriate pumps. During the Fuel Cycle Workshop the need for a sump for the water distillation room was discussed. Subsequently it was established that the maximum liquid content of a DW column would be approximately 3600 mols or $18\times 3600/1000 = 64.8$ m^3. With the room area of 17.5×7.5 m the liquid would rise 52 cm above the floor should one of the columns break and spill all its content. It the bottom of each door in this room is at least 55 cm above the floor (which would require three steps), there would be no need for an additional sump in this room. The detailed decision for such change was left for the subsequent EDA phase.

4.5 Waste Water Tritium Extraction - room W 04

The distillation columns for waste water (DW) are the largest single components in the FCB. These columns may have to be transported in sections and will be installed vertically. In any case there are basically two installation methods. One consist of installing prepacked sections the other involves installing an empty shell which would be installed and subsequently packed. Further, mainly in the fist column, there may be a need for cleaning the distributors at some occasions following major chemistry control failures or system upsets. The affected distributor would be accessed through a manhole or through disconnecting the section just above and hoisting the upper portion of the column. A sectioned column would be assembled by lowering individual sections in proper sequence into position through the roof of the building (prior to installing the portion of the roof and the top floor), assembling the column and seal-welding the connecting flanges. The DW columns are located near an exterior wall in which appropriate openings could be designed to facilitate access to the columns or to their parts at any time during or after construction is complete. The initial objective of the layout was to position the DW columns in such a way as to make them accessible from the main reactor crane. Unfortunately this is not possible since the space closer to the reach of this crane is occupied by the NBI Power Supply systems. However this feature is not of vital importance for maintaining or assembling the columns. Should there be a need for internal maintenance such as earlier described downcomer cleaning, the affected location would be accessed through the disconnected flange or through a strategically placed manhole. Unfortunately the most likely to be affected downcomer is on the feed which is on the tray number 480 which is 2/3 down the third of the three column sections. For this reason it is recommended that downcomer to be designed with a cleaning manhole even if the column is of the sectioned design. In the very unlikely event that a column is to be dismantled (or decommissioned), this would take place also by sections in reversed order and through the side or if feasible through the roof of the building. Such operation could take place by renting a large overhead crane. The weight of the column is well known and will be provided for sizing the structures and crane.

During the conceptual design of ITER waste water de-tritiation systems an alternative choice of the Combined Electrolysis and Catalytic Exchange has been investigated. The conclusion is that if the process becomes proven with demonstrated performance compatible with the data available from small scale and limited operating time experiments, the components would in general be smaller than the water distillation columns and consequently the process would occupy same or lesser space than provided in the present the DW room. There would be minor differences in space arrangement however. Due to the deferent shape and configuration of the CECE equipment the sealed portion of the space would be the entire basement portion of the room but it may not be necessary to extend such service above elevation 'T'. The purpose of sealing this room is mainly to avoiding contamination spread into the very tall portion of the W 26 room.

4.6 Fuelling - room R 91 to R 93

These rooms are and must be located in the Tokamak building and can not be located in the Fuel Cycle Systems building. There are three associated systems, each located in a separate and isolated but adjacent rooms. Their location was determined during earlier layout iterations and can be found as R 91 - Pellet injection, R 92 - Emergency Storage and R 93 - Gas Puffing Room, all at floor level 'R'.

4.7 Tritium Extraction From Solid Breeder and Test Blanket Tritium Recovery - room M 05,01

These two systems have been located on the entire floor "M".

4.8 Tritium Storage, Shipping and Receiving - room T 01.

This system is located in an L shaped space on the ground floor of the building to provide truck access. Comments have been made that for security reasons the location of this room would better be located in the basement. This is generally correct, however the inconvenience of a basement location was judged more significant than the security concern. In reality there is no demonstrated reason why it would not be possible to make the above ground location as secure as the underground one.

Figure 4 indicates a generous space between the unloading glove box and the front wall of the building. There is uncertainty if the unloading of the shipping container is to take place outside or inside of the building. This decision would be narrowed down in the subsequent design phase of ITER. However, it was concluded that the space provided will still be needed regardless of the unloading decision eventually made, namely for the truck to be unloaded or for storing the unloading device needed for transporting the container with overpack. The unloading bay would be provided with a barrier to prevent the accidental damage of the unloading glove box by the transporter or the truck.

4.9 Tritium Laboratory - room W 01

The detailed requirements for the Tritium Laboratory are not yet known. However, the position of this room is close to the FCU systems in room W 07. The rationale is that the laboratory would primarily support the FCU operation which will still be considered as experimental in nature.

4.10 Health Physics Laboratory - room W 01a

A room above the Tritium laboratory was provided for the need of the health physics laboratory and device storage.

4.11 HVAC and ADS - room H 01

These systems have been placed on the top level of the building where they can cover the entire floor.

There will be a number of HVAC and ADS units distributed throughout the Tokamak building facility to avoid difficulties in routing air to a central facility.

Systems located in the FCB are designated to serve only this building.

4.12 Fuel Cycle Process Control Centre - room R 03

The process control centre for the Fuel Systems has been located at the elevation 'R'. Several suggestions were made that this centre should really be at ground elevation, however no compelling reason to displace the tritium storage room was found. It was noted that many nuclear installations feature elevated control centres. It has also been observed that during the construction and commissioning phases a ground floor located centre is kept clean with a much greater effort than an elevated location. JET has also an elevated control room and the operators appear to be satisfied with this location.

4.13 Solid Waste Processing

There is no solid waste conditioning or tritium extraction planned to take place in this building. The sources would be only packaged (replaced parts) or taken in their pre- designed cartridges (filters, IX columns) and moved to a separate solid waste processing facility which is outside of this building. There the waste material would be packaged for disposal or these would be decontaminated with the tritium would be returned to the fuel systems for purification and recycle. Equipment that is to be replaced immediately and repaired later would be stored in the storage room adjacent to the Tritium Maintenance room at the lowest floor of the building (rooms W 02 and W 03).

5 Maintenance and Associated Equipment Transport Pattern

The maintenance capability and transportation access will include equipment located only in this building. With the possible exception of the water treatment components, the FCU2 and some test module tritium extraction equipment, components in this building are only tritium contaminated. Components located in the Tokamak building, such as vacuum pumps and pellet injectors and the equipment above may also be activation products contaminated and consequently will be maintained in the hot cells. Other equipment such as ADS, which are also located in the Tokamak building, will be maintained in situ or alternative maintenance facility. It is not desirable to take such equipment to the maintenance room W 02.

In general maintenance of tritiated components will have the following steps:

1. *Internal decontamination through process purge;*
2. *External decontamination;*
3. *Removal of faulty unit from the process or opening process for repair;*
4. *Replacement of faulty unit or repair in situ;*
5. *Packaging for transport to a tritium maintenance facility or for disposal;*
6. *Transportation of surface secured component through the facility.*

For tritium systems there is no remote handling repair foreseen. However there will be equipment which could, due to the presence of activated products, have radiation control needs. The equipment with such requirements could include ion exchange columns in the water treatment room (W 06) or filters at the main exhaust backing pumps room (W 08 in the Tokamak building). In the event of IX columns the resin could be slurried into shielded containers or as recommended to be replaced with the vessel as a cartridge. Filters are foreseen also to be replaced as a cartridge. In general transfer of equipment through the facility should be done only after the equipment was secured against activity release at its point of origin. Maintenance of the Fuel Cycle Systems equipment was discussed with the ITER remote maintenance team. It was concluded that no special remote handling equipment would be required. However, the remote handling equipment for ITER will have generic equipment designated for use under situations such as should ion exchange column envelopes be damaged etc. Under such events the manipulation space or configuration would not exceed standard equipment such as forklifts etc. for which the space is adequately provided.

The key pathway for vertical transport of heavy equipment located in any part of the building are two routes:

- *The internal route - through hatches located at the external wall of the CD room - T 03; with a building exit at the ground elevation;*
- *The external route - best to be adjacent to the internal route.*

The internal route consist of normally sealed but removable hatches all in the same location of the fuel systems building which if required would facilitate vertical transport of equipment from any floor of the building to the tritium maintenance room in the basement. Equipment that is not tritium contaminated and/or does not need to enter the tritium maintenance room, could stop

at the ground floor above the maintenance room and be transferred through the door to outside of the building. Alternatively, for such equipment the external route could be selected. Both the external and internal routes could be serviced by a common crane if its track is extended approximately 3 m (centerline of hook) beyond the edge of the building. The common direct use of the crane would take place only on the top two levels where the heaviest ADS, HVAC and blanket servicing equipment is located. If an equipment from, say level 3 is to be removed through the external route, it would have to be first hoisted to the top two levels and than transferred through the open wall to the outside of the building and subsequently lowered onto the ground. It was suggested that since a dedicated equipment transport pathway is provided, it be fully enclosed. This solution, however, is not recommended to be adopted since such enclosure would permanently restrict the use of such space to rare transportation needs and not allow the space to be available for the more important day by day use if only as lay down area or as access to or lay-down area for the equipment on that floor. A system of suitably designed doors in the upper two floors would open an area corresponding to the size of the largest component. This size would be tentatively minimum 7 m high and 4 m wide. However, if the crane is to have the flexibility of servicing both the external and internal routes, a full two storey opening for the crane and the slings must be provided.
Maintenance requirements associated with the water distillation columns have been described in section describing Waste Water Tritium Extraction - room W 04. Also the in situ maintenance of the CD equipment is described in paragraph Isotope Separation - room T 03. In the very unlikely event of need for removing main equipment such as entire cold box or a tank, monorail type cranes or portable or temporary, structure supported lifting devices would be used to transfer the equipment to the position of the vertical transport route or directly through the hatch into the basement for repairs. Equipment positioned into the centre of the vertical transport area would be handled by the earlier mentioned crane. Since the ISS bottom floor is at ground elevation, there is the option of direct equipment removal through a door or removable section of the wall. The following horizontal traffic patterns between equipment and the vertical access path are proposed:

Level below elevation 'T' (Figure 3): Most of the equipment concerned is in the FCU room and in the water treatment which is combined with the water storage tanks. With the exception of tanks which do not need to be removed, the largest single item is probably going to be a Normatex vacuum pump which is approximately 1.2 m in diameter and 3 m tall. Although most of the FCU equipment is probably going to be skid mounted, removal of complete skids is not foreseen but due to the experimental nature of the FCU, shall be made possible. The equipment would be transferred through a sealed sliding door into the adjacent tritium maintenance room where it will be repaired or further moved by way of the vertical transport crane through the transport "chimney" for removal from the facility. The water treatment equipment would also be horizontally moved through a sealed sliding door into the tritium maintenance room and further manipulated in earlier described way. In the detailed design of the facility a consideration would be give to extending the tritium maintenance room to outside of the building into a pit from where equipment would be removed without the need to interfere with the CD room T 03. This could be only justified if the maintenance of replacement of various FCU modules becomes to be a rather frequent affair.

Tritium storage elevation below 'R'(Figure 4): Tritium storage will be done in tanks and getter beds. The storage tanks are not foreseen to be moved. If there is a need for their replacement, this would be done directly through the door in exterior wall of the building. Also storage beds are designed to be maintained in situ. These will protrude through the bottom of the traditional glove box and their internals would be accessible by removing the vessel type secondary containment from the bottom of the bed. In the event that a bed or an entire package is to be replaced and or transferred into the tritium maintenance room, there are two options between which the detailed design can chose. The first and a probably more expedient one, is to provide a sealed hatch in the floor just beside the people vertical transport tower, just above the door to the tritium maintenance room. The equipment would be lowered into the FCU room from where it would be handled identically as the FCU equipment described earlier. The second and less expedient route would be to transfer the equipment through the ISS room towards the vertical transport hatch from where it would be picked by the vertical transport crane. It would be first hoisted and after removing the hatch lowered into the basement. The maximum size of equipment could be controlled by the size of the largest skid or glove box which would be intended to be moved as a complete unit.

CD room elevations between below 'M'(Figure 5): In this area only the CD auxiliary equipment such as pumps, analyzer glove boxes etc. are going to be located. These will be removed by local hoists or by an overhead crane which will travel on a track extended to the corner of the building where the vertical access hatch is located. Subsequent movement into the maintenance room or from the building would be secured through the main vertical equipment access hoist.

Blanket and Test Blanket tritium extraction room - elevation below 'H' and ADS room elevation below 'G'. Both these floors represent an open concept area where individual modules and equipment would be located. It is proposed that each floor would be serviced in the horizontal direction by a portable hoist unit which would be designed for both the largest and also for the heaviest item. Such item would be disconnected, hoisted from its position and transferred into the centre of the vertical access hatch. Subsequently the equipment would be taken by the crane and transferred by way of the internal or external transportation pathway. The heaviest components on the top floor could be strategically co-located with the main crane and its track could be configured in such way that the use of a single track unit could be considered.

6 Outstanding System Integration Issues

The are outstanding system integration issues, however none is seen as potentially having a major impact on the layout of the building. These are associated with confirming or developing the space requirements for:

1. *Refrigeration system*; It was preliminarily confirmed that the cryogenic load on the process can be conveniently secured by way of "parasitic refrigeration", which would eliminate the need for a dedicated refrigeration system. There are arguments both that the refrigeration system should and should not be dedicated. At the present stage of ITER design the "parasitic refrigeration" supply for the CD system appears to be able to provide higher reliability than a dedicated system. The incremental cost of this arrangement would be insignificant compared with a dedicated system. Consequently, the decision is for the integrated option. During the detailed design phase the service factor of the main refrigerator(s) shall be reviewed to verify that it still meets the continuous operation required by the fusion fuel cycle.

2. **Position of serviced systems in the Tokamak building**. Any changes in the anticipated location of the serviced systems would require switching of the floor contents in order to co-locate the mutually dependent systems and to simplify the piping runs.

3. **Position of the ground floor is not yet confirmed**

7 Changes to individual systems CDD's.

As a result of the system integration work the following changes to the reference CDD's have been initiated and the authors advised.
In the ISS system design the expansion tanks for CD1-CD3 have been combined and their function extended to facilitate system rundown capacity in addition to their initial role as overpressure protection devices for the distillation train. The expansion tank for CD4 will remain isolated as decided in the CDD, and its function was also expanded as a short term storage vessel. In addition the Tritium Storage System was charged with the additional task to provide backup storage capacity in the form of tanks for collecting the contents of the above short term storage/overpressure protection tanks.

8 Environment Control Requirements

In principle the Fuel Systems are designed to prevent chronic escapes from processing envelopes and consequently the intent is to have all the rooms ventilated without the need for continuous tritium recovery. However, ADS systems are provided to service a room where tritium escape has been detected. The rooms are also isolated from each other in order to minimize cross contamination and facilitate clean-up operations. However, there is an exception where the Main Exhaust Backing Pumps in room W 08 are under inert atmosphere with no access during operation. The tritium processing equipment located inside the FCB is, from the containment point of view, divided into the following limiting cases:

1. *Concentrated tritium gas under pressure*
   - in double containment such as the cryogenic distillation unit and fuel storage system.
2. *Concentrated tritium gas at sub- or atmospheric pressure*
   - in single containment such as CD4 expansion tank;
3. *Hydrogen with less than 1% tritium at less than 20 bar*
   - in single containment such as CD1-CD3 expansion tank;
4. *Tritiated water at atmospheric pressure*
   - in single containment such as DW.

The design approach will be based on the experience that during normal operation there are no chronic releases from the system. This is most effectively enhanced by operating the rooms at very mild sub-atmospheric pressure (at a few milimeters of water column) with the air de-tritiation system (ADS) on stand-by (see Figure 10 - case 1). All rooms are independently monitored for tritium and in the event of tritium excursion the ADS is activated and valved into the affected room as shown in Figure 10 -case 2. Such system is effectively applied for example at the Darlington Tritium Extraction Facility (DTRF). Access control for zones assigned individually to each floor or room would be carried out at each level and at the entrance point in the vertical access tower T 11. The vertical people access tower would be considered the clean area of the building and the access control would be carried out at the door connecting this access tower with the specific tritium carrying area. The Fuel Systems Process Control Centre (FSPCC) and the entrance portion of the change rooms, the field offices and facilities will also be controlled as clean areas. The personal decontamination showers will have a controlled access from the process areas however. This would provide an opportunity for operation personnel to enter the change area, dispose their clothing, decontaminate and then proceed into the clean areas. The layout designers have been aware of the requirement to have all systems with any significant levels of tritium under continuous environment purification mode. This requirement is met by continuous purification and monitoring of the secondary containment atmosphere namely:

- *CD system - treatment and monitoring the cold box atmosphere at the vacuum pump discharge;*

- *Glove Box systems - treatment and monitoring the glove box atmosphere at the dedicated, getter based inert gas purification system.*

The building zones, air and inert gas detritiation systems are described in ITER document *ITER Tritium Building Atmosphere Processing and Control Systems*; ITER-IL-FC-1.1-0-16. However, the following kind of systems will be used in the Fuel Cycle Systems building:

- **Glove Box Cleanup Systems - GBCS** These systems will be dedicated to the glove box or secondary containment purification. These may be based on the recombiner- drier or getter technologies.

- **Recirculation Air Detritiation Systems - RADS** These systems will be in normal operation on stand-by and will be activated only during emergencies such as during tritium release into a room.

- **Exhaust Atmosphere Detritiation Systems - EADS** Such system will be connected in series with RADS and will detritiate the air to be discharged into the atmosphere as shown in Figure 10. This will keep the room(s) affected by a tritium release at mild under-pressure for tritium spread containment purpose.

- **Conventional Open cycle HVAC** It is foreseen that under normal conditions the Fuel Cycle building atmosphere will be closely monitored for tritium contamination and controlled by conventional, open cycle heating air conditioning and ventilation systems - HVAC. In an abnormal condition when tritium excursion occurs, the affected room(s) will be isolated from the HVAC and the RADS and EADS will be started.

In addition there will be a need to remove tritium from a process and process purge gas. Where possible this will be carried out by the process itself but final polishing will be done in the Gaseous Waste Processing System (GWPS).

(In present installations this function is usually undertaken by an appropriate GBCS). This system may also receive discharge from GBCS. In some design proposals such function was proposed to be carried out by the EADS. However, since the GBCS is foreseen to operate continuously and the EADS only when required during a tritium release, the GBCS discharge will be treated by the GWPS which will polish all process originated exhaust gases.

9 Fuel Cycle Workshop - August 1990

The Layout version Revision 1.0 of July 25, 1990 was presented and reviewed during the Fuel Cycle Workshop. The following corrections were suggested and implemented:

1. There was not enough space for storing tritiated equipment which would be replaced and subsequently repaired and saved for reuse. Equipment designated for disposal would not be stored here but would be transferred to the disposal site immediately. The VPCE room containing the VPCE reactor, feed evaporator and auxiliary equipment was suggested to be elevated one floor to make room for such storage to be adjacent to the maintenance room.

2. There was a lack of Health Physics laboratory. This will be now located in the mezzanine above the Tritium Laboratory.

3. There may be a need for adding shielding around one of the FCU units, around the water treatment system, namely the ion exchange beds and around the tritium extraction systems for the test modules. The reason being is that these systems are expected to contain activation products and individual air quality control systems may be required.

4. The building will eventually have its own dedicated exhaust stack. The use of the central exhaust stack was discouraged for reasons of flexibility, independence and lower cost.

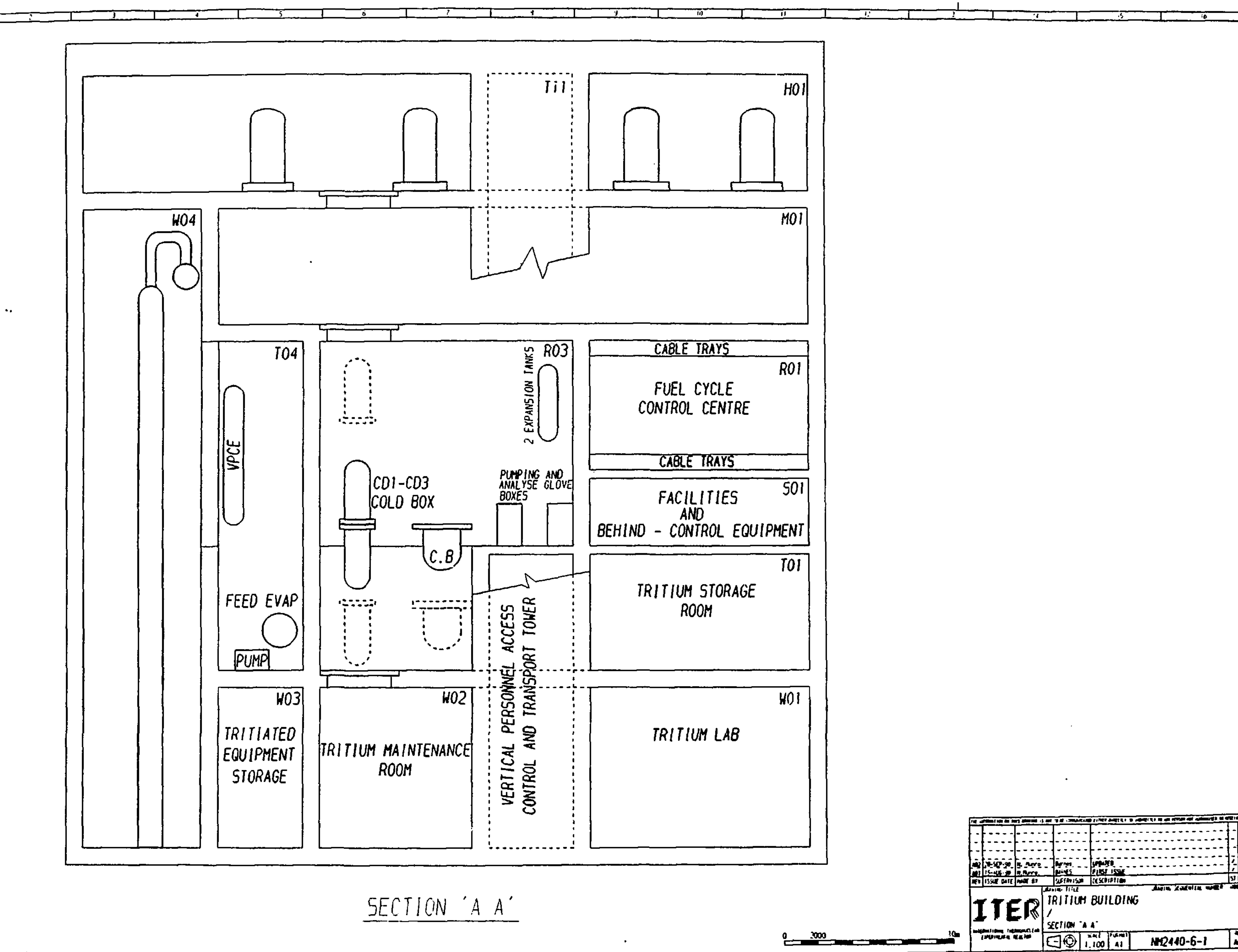
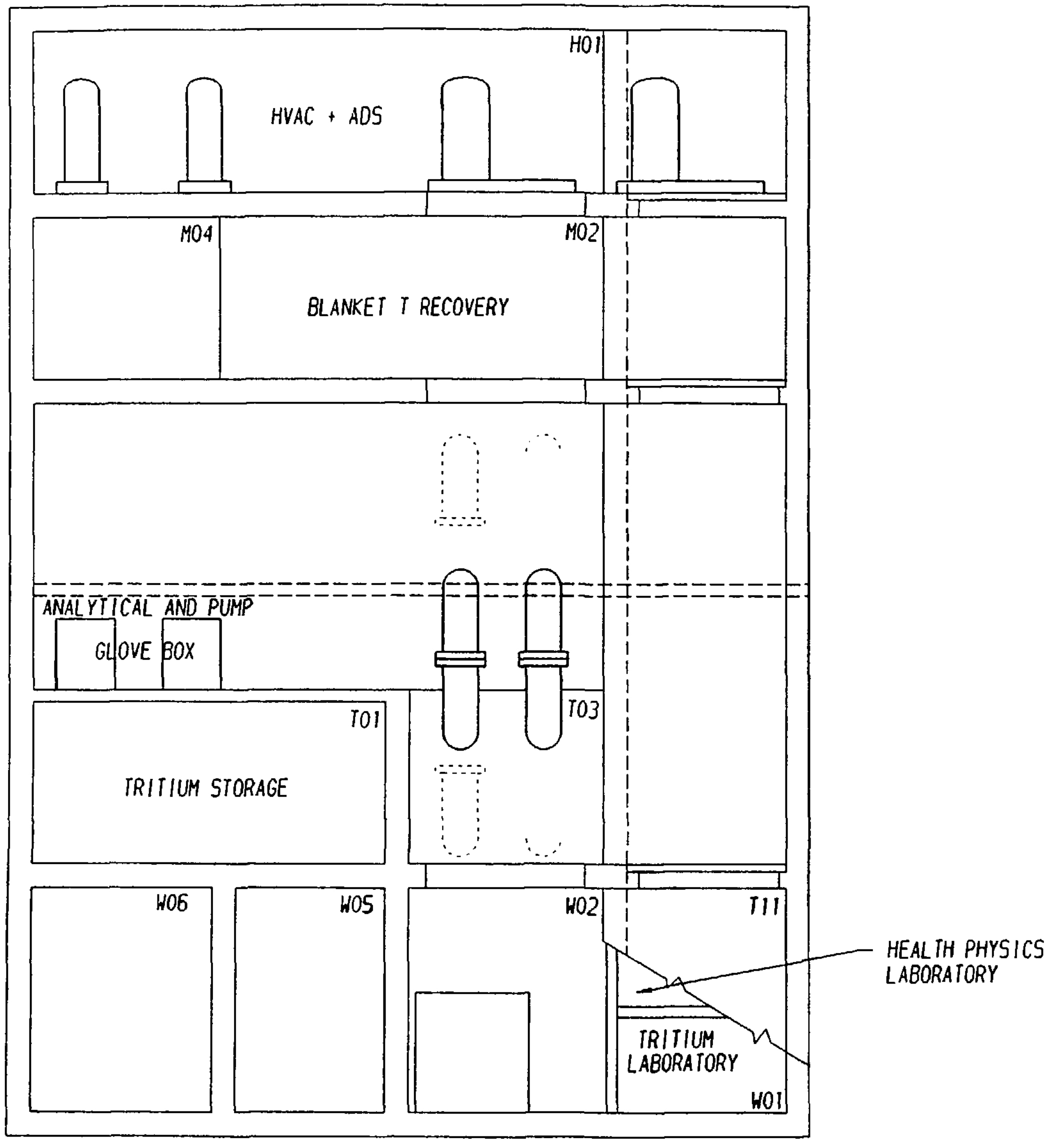

Ti1
H01
W04
M01
T04
R03
2 EXPANSION TANKS
CABLE TRAYS
R01
FUEL CYCLE CONTROL CENTRE
CABLE TRAYS
VPCE
CD1-CD3 COLD BOX
PUMPING AND ANALYSE GLOVE BOXES
FACILITIES AND BEHIND - CONTROL EQUIPMENT
S01
C.B
T01
TRITIUM STORAGE ROOM
FEED EVAP
PUMP
VERTICAL PERSONNEL ACCESS CONTROL AND TRANSPORT TOWER
W03
TRITIATED EQUIPMENT STORAGE
W02
TRITIUM MAINTENANCE ROOM
W01
TRITIUM LAB
SECTION 'A A'
0
2000
10m
ITER
TRITIUM BUILDING
SECTION 'A A'
1:100
A1
NM2440-6-1
A02

Fig.1.

Fig.2.



SECTION 'E E'

ITER
TRITIUM BUILDING
/
SECTION 'B B'
1:100 A1 NM2440-7-1 A02

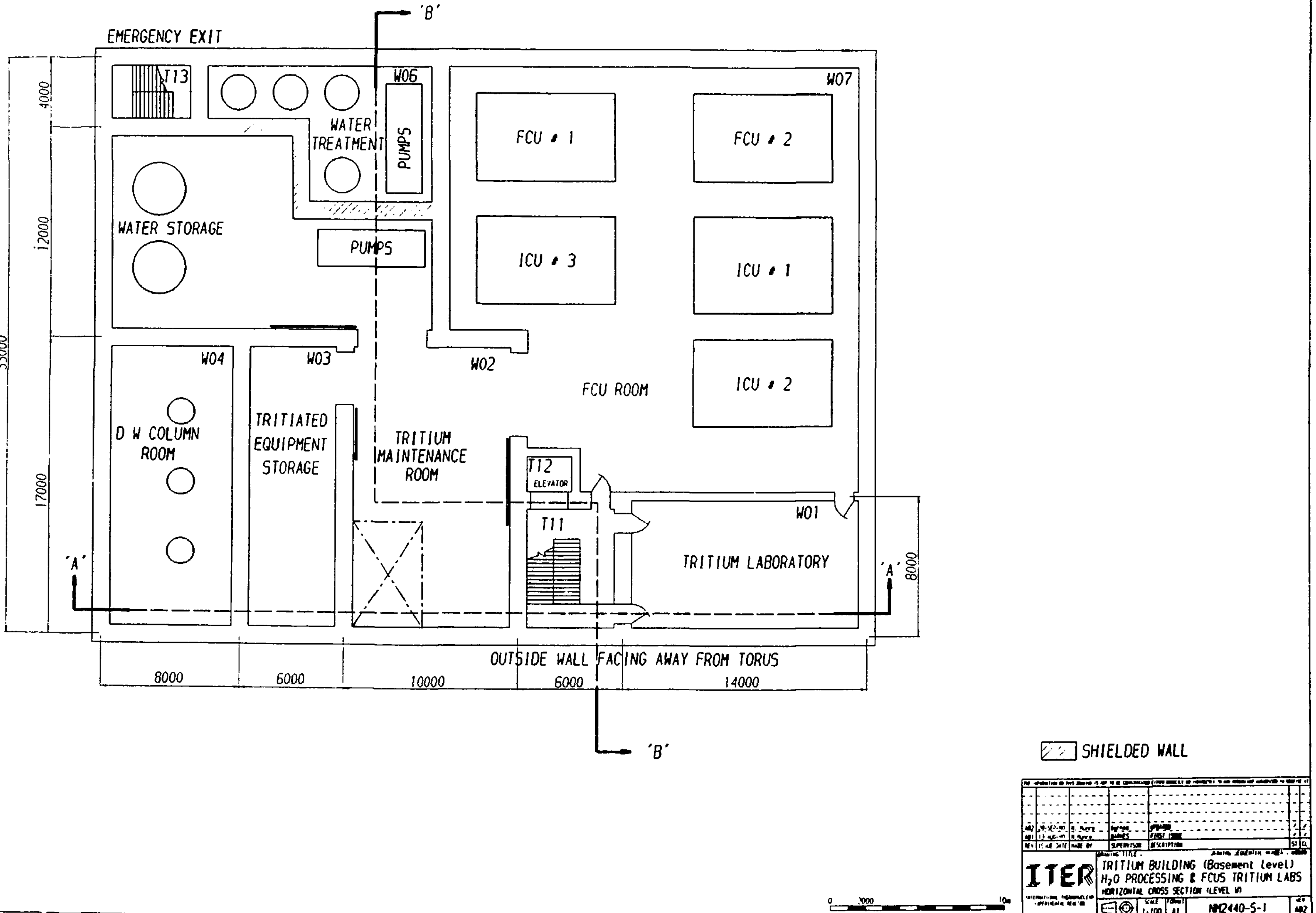

EMERGENCY EXIT
'B'
T13
W06
W07
WATER
TREATMENT
PUMPS
FCU # 1
FCU # 2
WATER STORAGE
PUMPS
ICU # 3
ICU # 1
W04
W03
W02
FCU ROOM
ICU # 2
D W COLUMN
ROOM
TRITIATED
EQUIPMENT
STORAGE
TRITIUM
MAINTENANCE
ROOM
T12
ELEVATOR
T11
W01
TRITIUM LABORATORY
'A'
'A'
4000
12000
33000
17000
8000
OUTSIDE WALL FACING AWAY FROM TORUS
8000
6000
10000
6000
14000
'B'
SHIELDED WALL
ITER
TRITIUM BUILDING (Basement Level)
H_2O PROCESSING & FCUS TRITIUM LABS
HORIZONTAL CROSS SECTION (LEVEL N)
1:100
NM2440-S-1

Fig. 3.

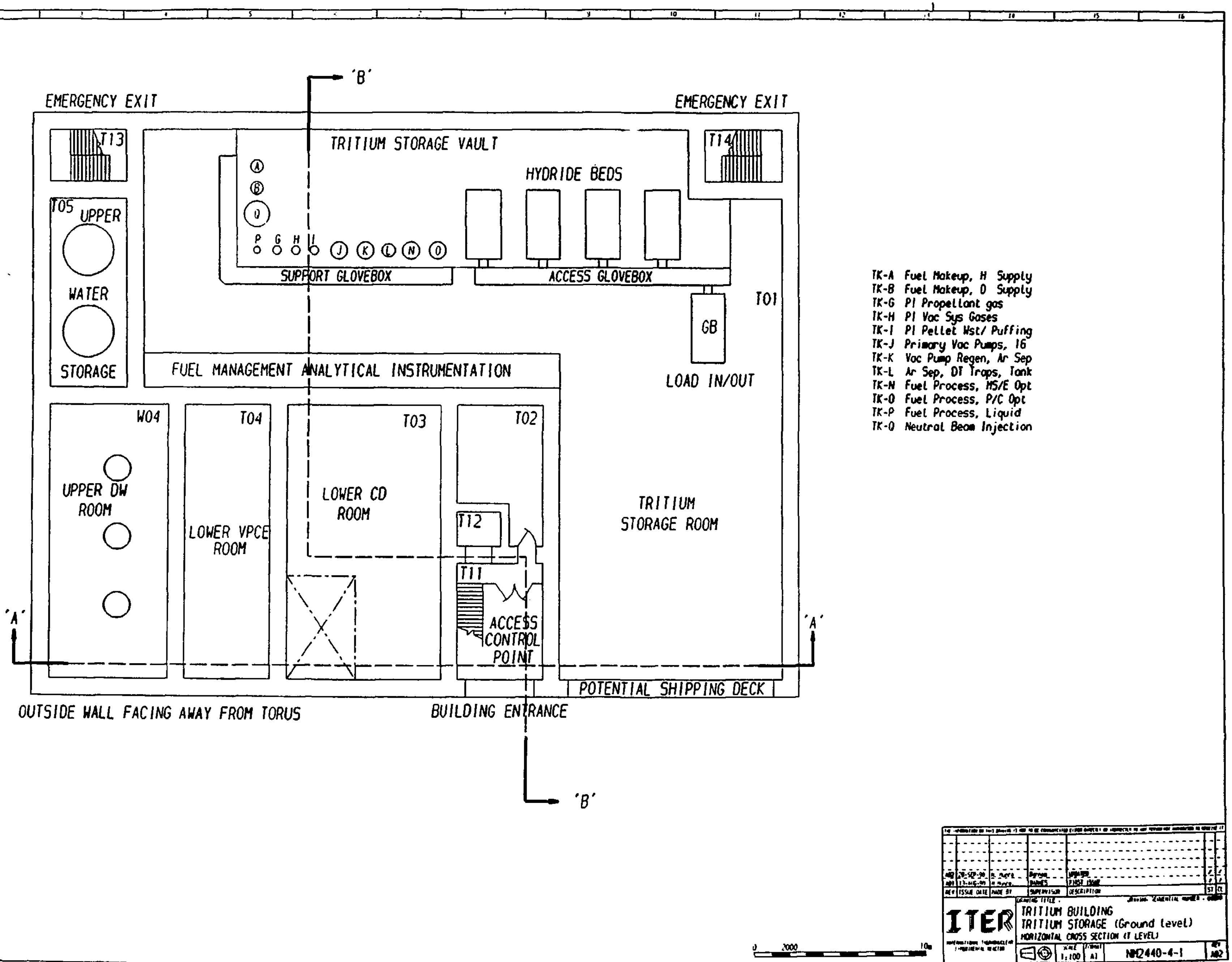

EMERGENCY EXIT
EMERGENCY EXIT
'B'
TRITIUM STORAGE VAULT
HYDRIDE BEDS
T13
T14
T05
UPPER
WATER
STORAGE
A
B
Q
P G H I
J K L N O
SUPPORT GLOVEBOX
ACCESS GLOVEBOX
T01
GB
LOAD IN/OUT
FUEL MANAGEMENT ANALYTICAL INSTRUMENTATION
W04
UPPER DW ROOM
T04
LOWER VPCE ROOM
T03
LOWER CD ROOM
T02
T12
T11
ACCESS CONTROL POINT
TRITIUM STORAGE ROOM
'A'
'A'
POTENTIAL SHIPPING DECK
OUTSIDE WALL FACING AWAY FROM TORUS
BUILDING ENTRANCE
'B'
TK-A Fuel Makeup, H Supply
TK-B Fuel Makeup, D Supply
TK-G PI Propellant gas
TK-H PI Vac Sys Gases
TK-I PI Pellet Wst/ Puffing
TK-J Primary Vac Pumps, 16
TK-K Vac Pump Regen, Ar Sep
TK-L Ar Sep, DT Traps, Tank
TK-N Fuel Process, MS/E Opt
TK-O Fuel Process, P/C Opt
TK-P Fuel Process, Liquid
TK-Q Neutral Beam Injection
ITER
TRITIUM BUILDING
TRITIUM STORAGE (Ground level)
HORIZONTAL CROSS SECTION (T LEVEL)
1:100
A1
NM2440-4-1

Fig. 4.

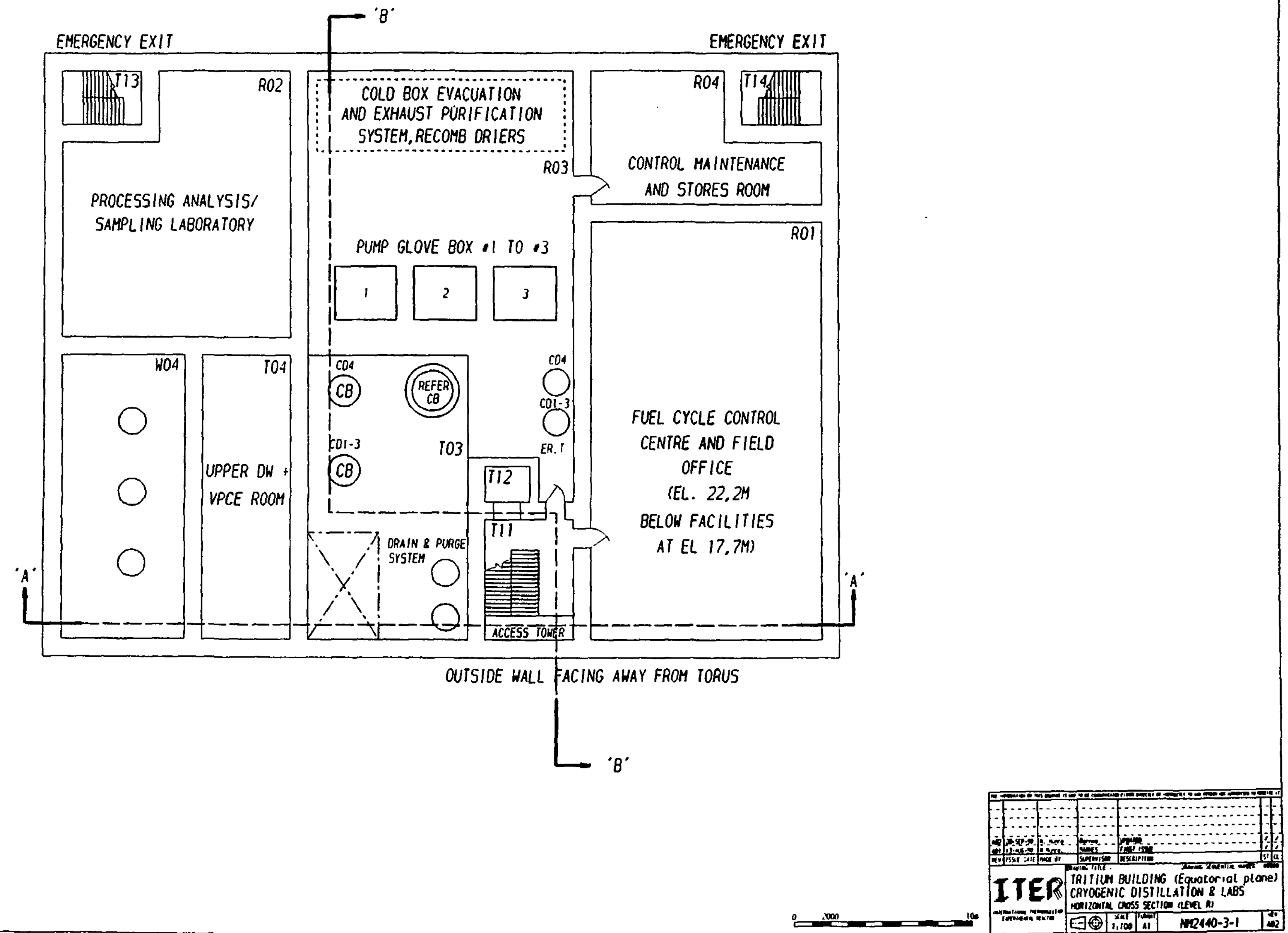
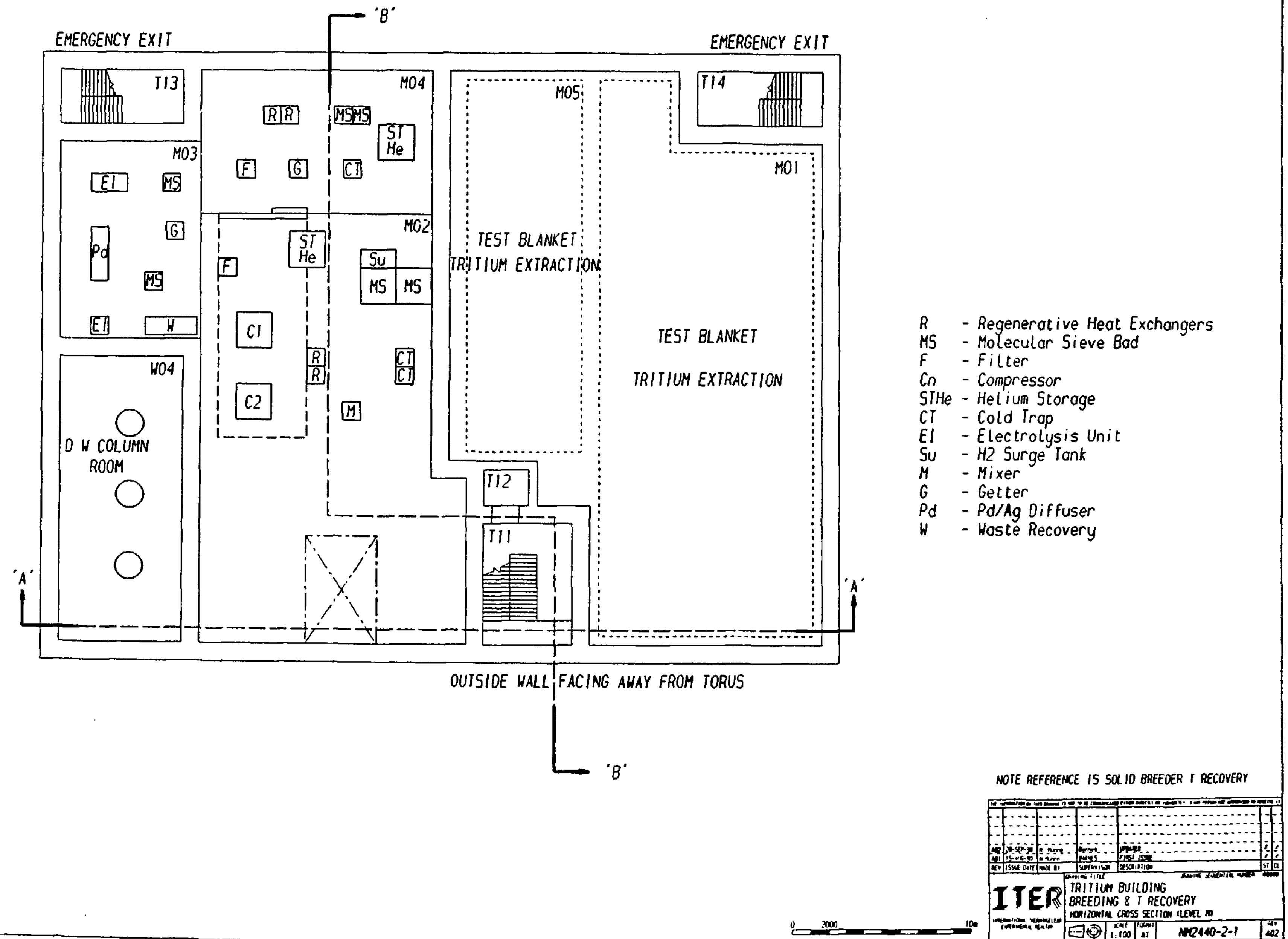

'B'
EMERGENCY EXIT
EMERGENCY EXIT
T13
R02
COLD BOX EVACUATION
AND EXHAUST PURIFICATION
SYSTEM, RECOMB DRIERS
R04
T14
R03
CONTROL MAINTENANCE
AND STORES ROOM
PROCESSING ANALYSIS/
SAMPLING LABORATORY
PUMP GLOVE BOX #1 TO #3
1
2
3
R01
W04
T04
CD4
CB
REFER
CB
CD4
CD1-3
CD1-3
CB
T03
ER.T
FUEL CYCLE CONTROL
CENTRE AND FIELD
OFFICE
(EL. 22,2M
BELOW FACILITIES
AT EL 17,7M)
UPPER DW +
VPCE ROOM
T12
T11
DRAIN & PURGE
SYSTEM
'A'
'A'
ACCESS TOWER
OUTSIDE WALL FACING AWAY FROM TORUS
'B'
0
2000
10m
SUPERVISOR
DESCRIPTION
REV
ISSUE DATE
MADE BY
ST
CL
FIRST ISSUE
ITER
TRITIUM BUILDING (Equatorial plane)
CRYOGENIC DISTILLATION & LABS
HORIZONTAL CROSS SECTION (LEVEL A)
SCALE
1:100
A1
NM2440-3-1

Fig. 5.



'B'
EMERGENCY EXIT
EMERGENCY EXIT
T13
M04
M05
T14
R R
MS MS
ST He
M03
M01
F
G
CT
EI
MS
M02
G
Pd
ST He
F
Su
MS MS
TEST BLANKET TRITIUM EXTRACTION
MS
EI
W
C1
R R
CT CT
TEST BLANKET TRITIUM EXTRACTION
W04
C2
M
D W COLUMN ROOM
T12
T11
'A'
'A'
OUTSIDE WALL FACING AWAY FROM TORUS
'B'
R - Regenerative Heat Exchangers
MS - Molecular Sieve Bad
F - Filter
Cn - Compressor
STHe - Helium Storage
CT - Cold Trap
EI - Electrolysis Unit
Su - H2 Surge Tank
M - Mixer
G - Getter
Pd - Pd/Ag Diffuser
W - Waste Recovery
NOTE REFERENCE IS SOLID BREEDER T RECOVERY
ITER
TRITIUM BUILDING
BREEDING & T RECOVERY
HORIZONTAL CROSS SECTION (LEVEL M)
1:100
A1
NM2440-2-1

Fig. 6.

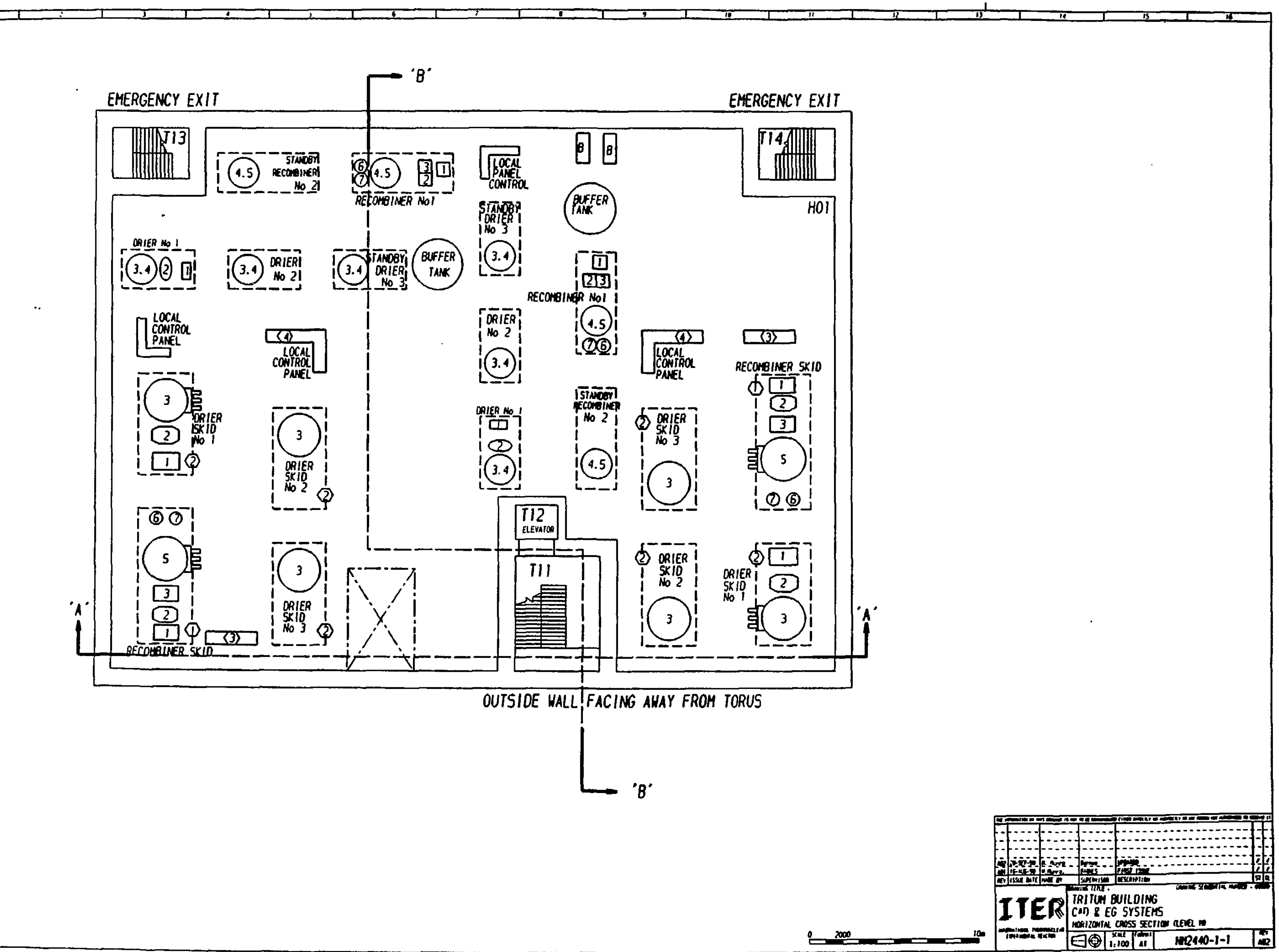
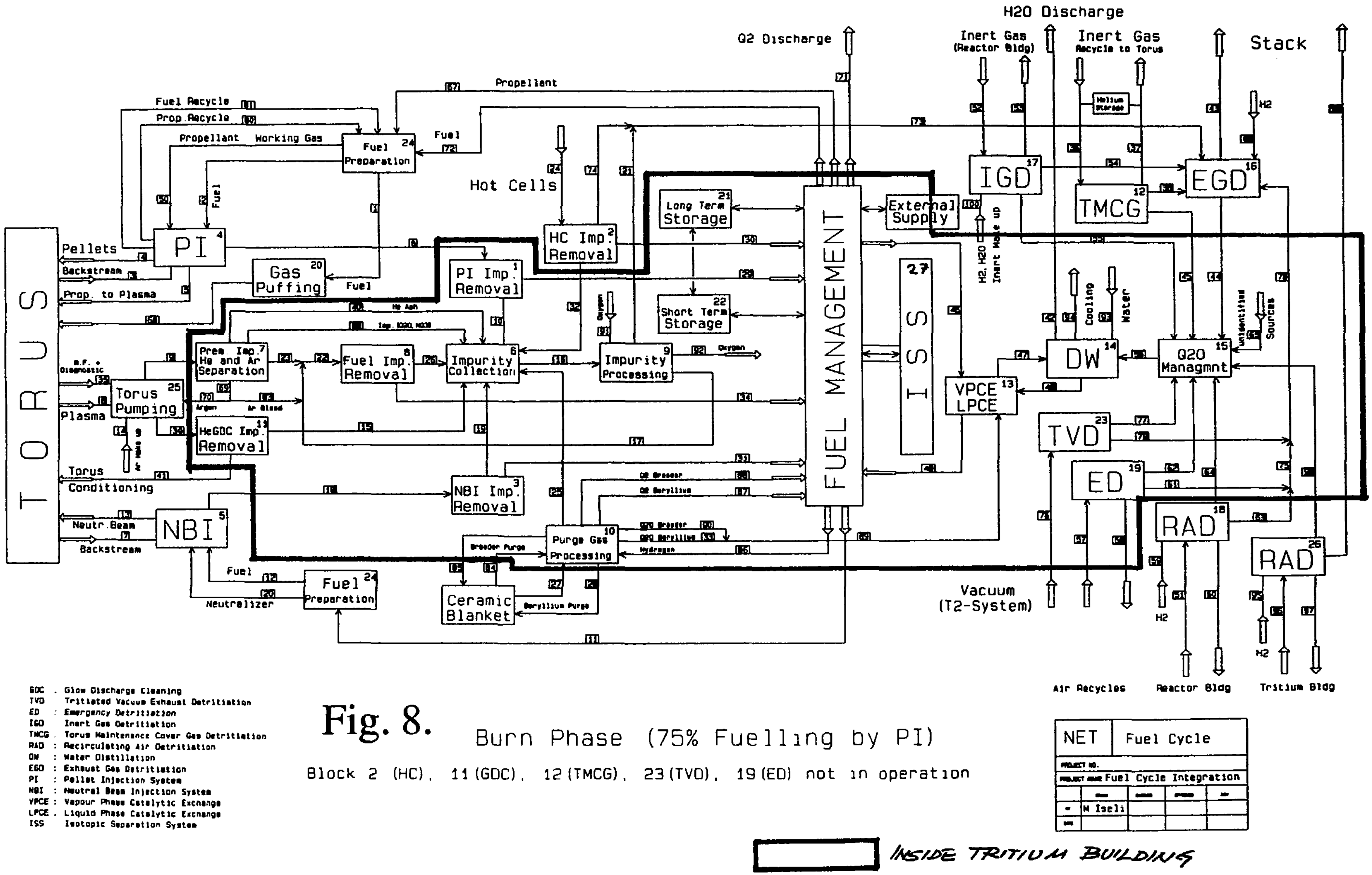

'B'
EMERGENCY EXIT
EMERGENCY EXIT
T13
T14
STANDBY RECOMBINER No 2
4.5
RECOMBINER No1
LOCAL PANEL CONTROL
BUFFER TANK
H01
DRIER No 1
3.4
DRIER No 2
STANDBY DRIER No 3
BUFFER TANK
STANDBY DRIER No 3
RECOMBINER No1
LOCAL CONTROL PANEL
LOCAL CONTROL PANEL
DRIER No 2
LOCAL CONTROL PANEL
RECOMBINER SKID
DRIER SKID No 1
DRIER SKID No 2
DRIER No 1
STANDBY RECOMBINER No 2
DRIER SKID No 3
T12
ELEVATOR
T11
DRIER SKID No 3
DRIER SKID No 2
DRIER SKID No 1
'A'
'A'
RECOMBINER SKID
OUTSIDE WALL FACING AWAY FROM TORUS
'B'
ITER
TRITUM BUILDING
C&D & EG SYSTEMS
HORIZONTAL CROSS SECTION (LEVEL 10)
NH2440-1-1

Fig. 7.

BLOCK FLOW DIAGRAM OF THE ITER/NET FUEL CYCLE



GDC : Glow Discharge Cleaning
TVD : Tritiated Vacuum Exhaust Detritiation
ED : Emergency Detritiation
IGD : Inert Gas Detritiation
TMCG : Torus Maintenance Cover Gas Detritiation
RAD : Recirculating Air Detritiation
DW : Water Distillation
EGD : Exhaust Gas Detritiation
PI : Pellet Injection System
NBI : Neutral Beam Injection System
VPCE : Vapour Phase Catalytic Exchange
LPCE : Liquid Phase Catalytic Exchange
ISS : Isotopic Separation System

Fig. 8. Burn Phase (75% Fuelling by PI)

Block 2 (HC), 11 (GDC), 12 (TMCG), 23 (TVD), 19 (ED) not in operation

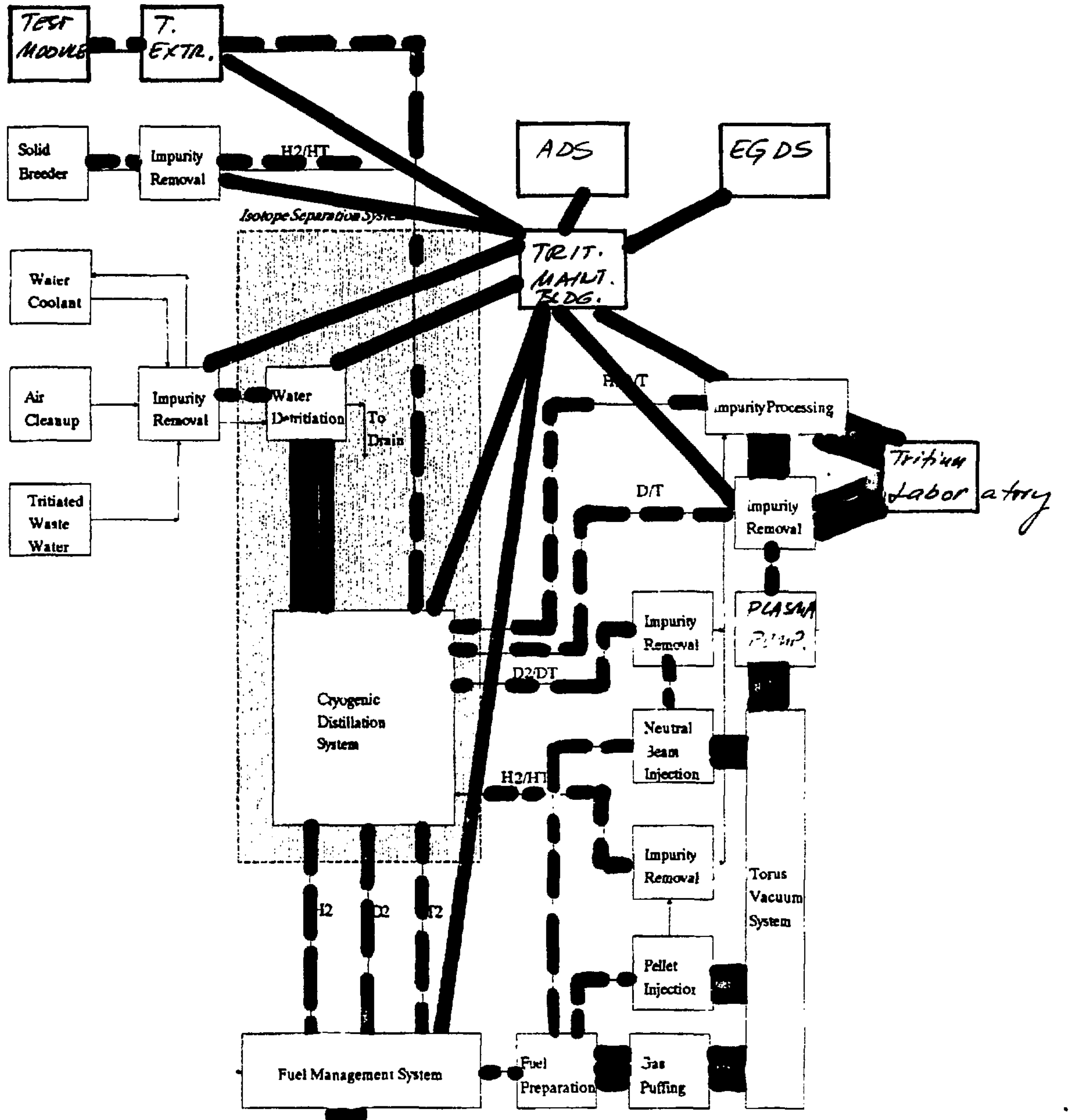
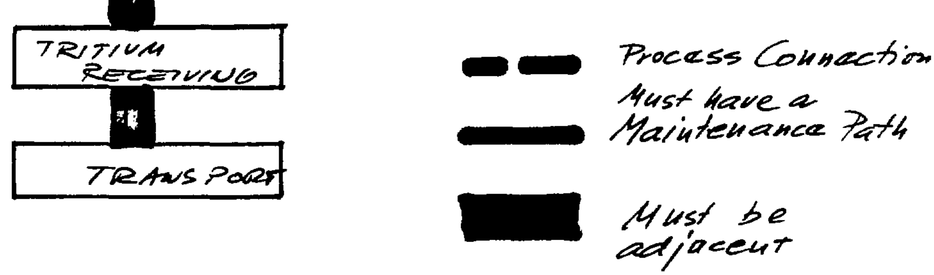
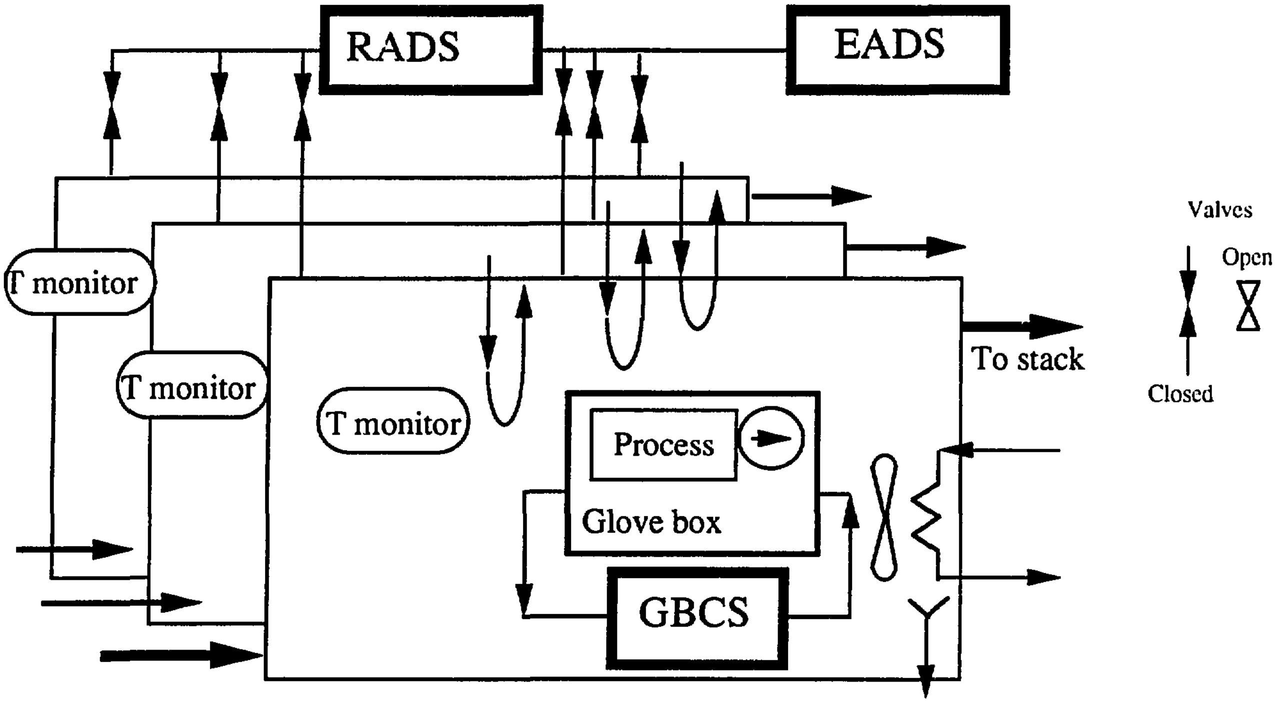
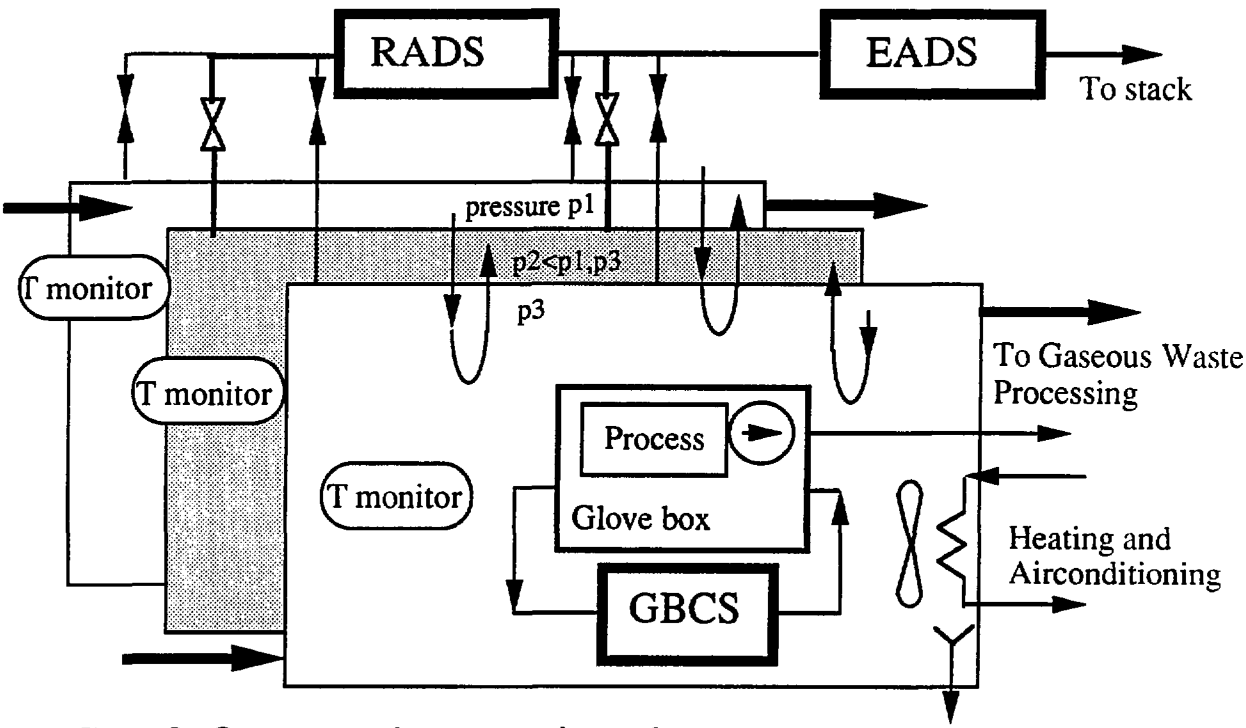


Fig. 9. ITER fuel cycle [illegible]um flow schematic. The water detritiation





Case 1 Normal Operation



Case 2 One room is contaminated.

Fig.10. Atmosphere Purification Systems in Fuel Cycle Building.

OKK September 90