8.4 Port Handling Equipment

8.4.1 Function, Basic Configuration and System Boundaries

Remotely operated transfer casks constitute the principal means of handling in-port components, will remove or replace these components, and transfer them to and from the hot cell.

Docking of the casks to the machine will be directly at the flanges of the divertor ports, for the equatorial and upper ports via access corridors through aligning penetrations in the cryostat and bioshield. A similar docking procedure is carried out in the hot cell, using an emulation of the VV port to house the component during maintenance and associated activities. The cask sizes are standardised as far as the cask base or air transfer system is concerned (except for the neutral beam system cask). The cask envelope and the double-seal door system shape vary according to the components size and the constraints at each VV docking port. Table 8.4-1 lists design limits for the casks.

Table 8.4-1 Cask Enclosure Design Limits

Cask internal pressure	0.90 bar < p < 1.05 bar
Cask internal temperature	≤ 65ºC
Cask allowable leak rate	10^{-2} mbar litre/s

The casks together with all on-board equipment, including control elements, are part of the port handling equipment. The on-board features required to dock with the VV ports and the hot cell maintenance station are part of the port handling equipment. The docking features on the VV port and the hot cells, and the hot cell maintenance station itself, are also part of the port handling equipment.

It should be noted that additional tools are required for preparatory and finishing work prior to docking of the cask, such as port plug (or similar port-mounted system) cooling pipes cutting/re-welding, vacuum lip seal cutting/re-welding, inspection tools and heavy lifting devices (for bioshield plug removal and cryostat closure plate). These additional tools are general and special purpose items which are not described in this document.

To the greatest extent practicable, hands-on maintenance is the primary method of repair inside the cryostat.

8.4.2 Requirements

8.4.2.1 Environmental Conditions during Port Handling

The transfer casks will operate at the VV and hot cell ports. Therefore, they will be subjected to the environmental conditions as per Table 8.4-2.

Table 8.4-2 Cask Operation - Environmental Conditions

Radiation (dose rate inside VV)	Max 470 Gray/hr (10^6s after DRG1 operation)
Contamination	Activated dust, beryllium, tritium
Magnetic field	Zero
Vacuum vessel port temperature during cask operation	≤ 50°C
Vacuum vessel pressure during cask operation	0.1 MPa
Cask internal atmosphere	Dry air, gas

8.4.2.2 Maintenance

The port handling transfer cask system shall satisfy the following requirements:

1) Safely transport contaminated/activated in-vessel components and remote handling equipment between the VV ports and the hot cell using air pad technology for cask support (note: no shielding is required except for protection of the on-board cask equipment).

2) Allow connection to the VV port and hot cell via a double-seal door system for the purpose of gaining access to the active/contaminated environment without spread of contamination.

3) Be capable of handling the combined weight of its own gravity load, that of the in-vessel components being transported and of the on-board remote handling equipment. The cask platform and enclosure shall support the static and dynamic loads imposed during all modes of operation. Following an SL-1 seismic event, the safety confinement function shall be maintained as specified in the GSSR.

4) Be as compact as reasonably achievable to travel along the design trajectory through the building while maintaining adequate working clearance to the bounding constraints.

5) Be self-propelled and remotely controllable in all its transfer, docking and payload loading/unloading functions. It should be noted that during cask locomotion, the remote handling equipment inside the casks will not be required to operate. The precision shall be adequate to allow docking alignment, and to avoid collisions with boundary features along the route. The casks shall have on-board remote handling tools and devices to perform all the activities inside the cask required for loading and unloading the payload. The control system design shall allow cask control both from local control units and as part of the overall remote handling control system.

6) Under all locomotion conditions, travel at safe and controllable speed (as a guideline, a variable speed range between 0 and 1 km/h [16.7 m/min]). Speed control must be extremely precise particularly in the low speed range to allow accurate cask positioning and docking to the VV vessel and hot cell ports.

7) Be air-tight to prevent the spread of in-vessel contamination to the building environment, while being strong enough (or fitted with features) to allow them to withstand internal negative and positive pressure. In particular, the cask must be fitted with some form of

cask/vacuum vessel or hot cell pressure equalisation prior to opening the cask door.

8) Be fitted with a hardware and control system adequate for bringing the cask into position and precisely aligning it to the docking port. To facilitate this, the control system shall be assisted by the use of alignment features such as, for example, guides/pins and optical targets.

9) Be able to accommodate misalignments between the building floor and the port docking interface.

10) Be designed such that the internal and external components of the cask will be hands-on maintainable to the greatest extent practicable. In particular, the internal surfaces of the main enclosure shall allow easy decontamination and drainage.

11) Have rescue capability. For the rescue of on-board equipment or components there shall be a door on the rear end of the cask which can be accessed and docked onto by a rescue cask with a compatible door system approaching from behind the failed cask.

In order to recover from cask malfunction events, the design shall allow external power and other services necessary to restore functionality, to be connected to the cask, hands-on and remotely, from emergency service connection stations located adjacent to the VV port and hot cell docking stations.

12) Be of "standard design". The cask design shall be standardised to the maximum extent possible, particularly at the front end i.e. the cask front section interfacing with the vessel ports. To facilitate this, all vessel port flanges must be designed to have a common, "cask docking friendly" design. However, where absolutely necessary, different cask and specific double-seal door designs shall be provided where a standard cask is impractical. The air cushion based cask transfer system shall, however, be identical and interchangeable in all cases except for the IVT and NB casks, where this is not feasible.

8.4.2.3 Reliability

The cask transfer system shall operate with high reliably, thus minimising the likelihood of potential hazards arising inside the tokamak and hot cell buildings resulting from cask system malfunction. Rescue strategies shall be provided for all foreseen malfunction modes.

8.4.2.4 Durability

The cask design shall be such as to minimise radiation damage to its components during maintenance. This shall be implemented by using radiation hard parts providing long component life between replacements, and repair times as short as practicable for planned maintenance activities. Failure modes shall be studied and maintenance procedures developed which result in minimum personnel dose during repairs.

8.4.2.5 Access

Adequate access shall be provided for the port handling equipment (hands-on phase) and for the transfer cask access, in front of the vessel and hot cell ports, in the building between the tokamak and the hot cell, and in the lift. Access to the lift must allow front and sideways (when leaving for/returning from the NB area) cask movement.

Sufficient shielding shall be provided to allow hands-on maintenance inside the cryostat. The radiation exposure limits are shown in Table 8.4-3.

Table 8.4-3 Radiation Exposure Limits for Hands-On Maintenance

< 750 μSv/h	Maximum dose rate for access zone C
< 0.5 mSv/shift	Project guideline for individual dose per shift
< 30 person-mSv	Initial limit on collective dose for planned maintenance task (e.g. 15 persons @ 2 mSv or 30 persons @ 1 mSv)
< 20 mSv/a	Regulatory limit for total individual dose

8.4.3 Codes and Standards

- Control system standards:
  - IEC 204-1, 1992: Electrical equipment of industrial machines, or
  - ANSI/NFPA 79: Electrical standard for industrial machinery
- Machinery (Robot) safety standard:
  - ISO 10218, 1992 Manipulating industrial robots. Safety, or
  - ANSI/RIA R15.06-1992 Industrial robots and robot systems. Safety requirements
- Welding and inspection: generic at the time of procurement
- Materials: generic at the time of procurement
- Standard Control system items: generic at the time of procurement