8.1 Remote Handling Equipment - General

8.1.1 Functions, Basic Configuration and System Boundaries

The remote handling equipment performs the following functions:
- In-vessel maintenance
- In-vessel viewing and metrology
- In-cryostat maintenance
- Hot cell repair
- Remote handling test stand operations

For in-vessel maintenance the remote handling equipment maintains the following in-vessel components:
- Divertors
- First wall blankets
- Cryopumps
- NB injectors
- Diagnostic systems requiring remote maintenance
- Ion and electron cyclotron H&CD plasma-facing components
- Test blanket modules
- Port resident components
- Feed pipes requiring remote maintenance not included in the above system list

The viewing/metrology system includes remote handling equipment to perform the in-vessel viewing and metrology procedures.

For in-cryostat repair operations, hands-on and remote handling procedures shall be studied and partially prepared for extremely unlikely in-cryostat operations such as magnet (power and helium) termination joints and module bypass joint operations. Operations on large in-cryostat components involve extensive work. In this context, maintenance operations are mainly envisaged for the following components:
- Central solenoid disassembly/re-assembly
- Poloidal field coil disassembly/re-assembly
- TF coil and vacuum vessel sector disassembly/re-assembly

For hot cell repair and maintenance activities, remote handling equipment performs the following:
- Dust removal
- Cask docking
- Component transport, refurbishment, inspection and testing
- Waste processing

A remote handling test stand shall be provided together with the following associated facilities:
- Cask storage area
- Repair/testing facility

8.1.2 Requirements

Remote handling classification, maintenance frequency and intervention duration for the

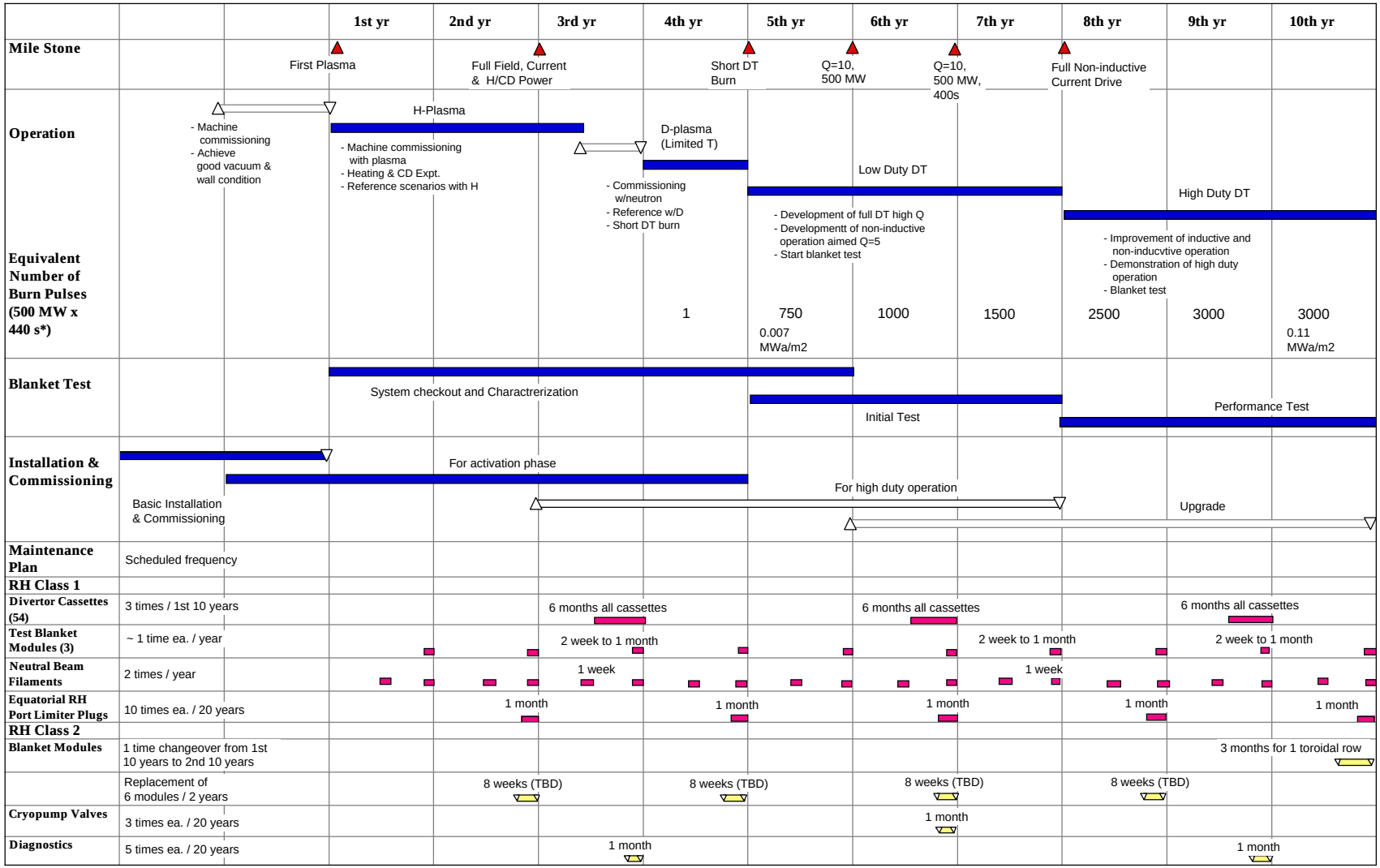
major ITER components are summarized in the Table 8.1-1. The tentative maintenance plan is summarized in Table 8.1-2 in conjunction with the ITER operation plan. More specific remote handling equipment requirements are elaborated for the specific remote maintenance functions presented in the following parts of chapter 8.

Table 8.1-1 RH Classification, Expected Maintenance Frequency and Maximum Intervention Time Requirements

Component or Operation	RH Class	Frequency	Intervention Time
Divertor cassettes (54) including RH port components	1	3 times/1st 10 years, 5 times/2nd 10 years	< 6 months/all cassettes < 8 weeks/single cassette
Test blanket modules (3)		~ once each/year	2 weeks to 1 month
NB filament/cesium oven		2 times/year	7 days
Equatorial RH port limiter plug		~ 10 times each/20years	< 1 month
Equatorial RH port diagnostics plug		~ 10 times each/20years	< 1 month
Blanket modules (all or outboard region)	2	Once-only changeover at the end of the first 10 years	< 8 weeks/1 module < 3 months/1 toroidal row < 2 years/all modules
Blanket modules including NB modules		3 modules/year	
Baffle modules		6 modules/year	
Cryopump valve		2 to 3 replacements each /20 years (not scheduled)	< 1 month
RF antennae		≤ 5 times each/20 years	~ 1 month
ECH & CD system mirror		≤ 5 times each/20 years	~ 1 month
Equatorial / upper port diagnostics		≤ 5 times each/20 years	~ 1 month
NB ion source cesium cleaning (grid)		≤ 1 time/year	17 days (TBD)
NB fast shutter		≤ 1 time/20 years	1 month (TBD)
Vacuum vessel cryopump, cryostat cryopump, port bellows, diagnostics, NB rear liner, thermal shields, magnet termination and module bypass joints, CS, PF and TF coils, vacuum vessel sector and other in-cryostat components	3	No scheduled maintenance	

Note: RH class is defined as follows:
- Class 1: those components that require scheduled remote maintenance or replacement.
- Class 2: those components that do not require scheduled but are likely to require unscheduled or very infrequent remote maintenance.
- Class 3: those components not expected to require remote maintenance during the life time of ITER. The projected maintenance time in case of failure may be long.

Table 8.1-2 ITER Operation and Tentative Maintenance Plan for the First Ten Years



* The burn time of 440 s includes 400 s flat top and an equivalent time for which additional neutron flux is counted during the ramp-up and ramp-down.

** Fluence at outboard midplane (neutron wall load is 0.57 MW/m^2 on average, 0.65 MW/m^2 at outboard and 0.41 MW/m^2 at inboard.)

8.1.3 Codes and Standards

Industrial codes and standards shall be used as guidelines for the design, manufacturing and testing of remote maintenance equipment for nuclear applications, including the following.

- 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 & inspection: generic at the time of procurement
- Materials: generic at the time of procurement
- Standard control system items: generic at the time of procurement