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Preliminary safety studies for the DEMO HCPB blanket concept

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List of Postulated Initiating Event (PIEs) from FFMEA

PIE	Description
FB1	Loss of flow in all FW-BK (first wall blanket) cooling channels of one section from total four coolant distribution sections for the outboard or inboard segments (48 or 32) because stop of circulators for CCF (common cause failure)
FB2	Reduction of flow in all FW-BK cooling channels of one section of the outboard or inboard segments because stop of circulator in one SG (steam generator) line
FB3	Reduction of flow in cooling channels of one FW-BK module because internal clogging
AOP1	Loss of off-site power <1 h
AOP2	Loss of off-site power from 1 h up to 32 h
HB1	Loss of heat sink in all FW-BK primary cooling circuits because trip of both HP (high pressure) and LP (low pressure) turbines due to loss of condenser vacuum
HB2	Loss of heat sink in one FW-BK cooling train
LBB1	Loss of FW-BK cooling circuit inside breeder blanket box: rupture of a sealing weld
LBB2	Loss of FW-BK cooling circuit inside breeder blanket box: leak of a sealing weld
LBO1	LOCA Out-VV because large rupture of He manifold feeder inside PHTS vault
LBO2	LOCA Out-VV because small rupture of He manifold feeder inside PHTS vault
LBO3	LOCA Out-VV because rupture of tubes in a steam generator (SG)
LBV1	Loss of FW-BK cooling circuit integrity inside VV: Rupture of FW-BK module
LBV2	Loss of FW-BK cooling circuit integrity inside VV: Leak from FW-BK module
TBO2	Small rupture from PHTS CPS process line inside the PHTS vault (Outside VV), i.e. significant amount of tritium released into building
N/S	Not Safety Relevant

Priority list of the event sequences

- **Loss of power: AOP2**
- **LOFA inducing in-vessel LOCA: FB1**
- **Ex-vessel LOCA inducing in-vessel LOCA: LBO1, LBO3**
- **Loss of heat sink due to loss of condenser in the SWCS: HB1**
- **In-box LOCA inducing in-vessel LOCA: LBB1**

Proposal of the most severe accidents affecting the plant safety

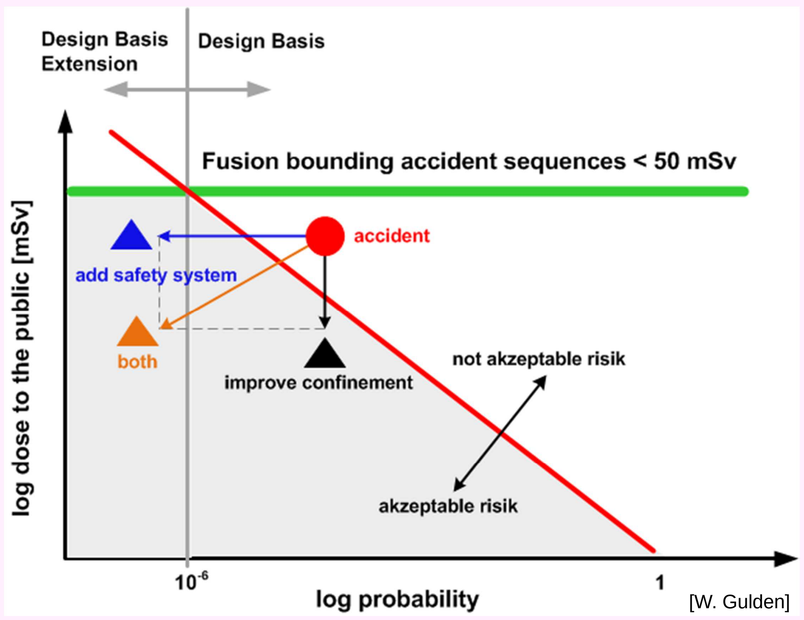
- **Station Blackout (SBO)**

  A total loss of all alternating current (AC) power as a result of complete failure of both off-site and on-site AC power sources ⇒ stop of all circulators, pumps and emergency diesel generators.

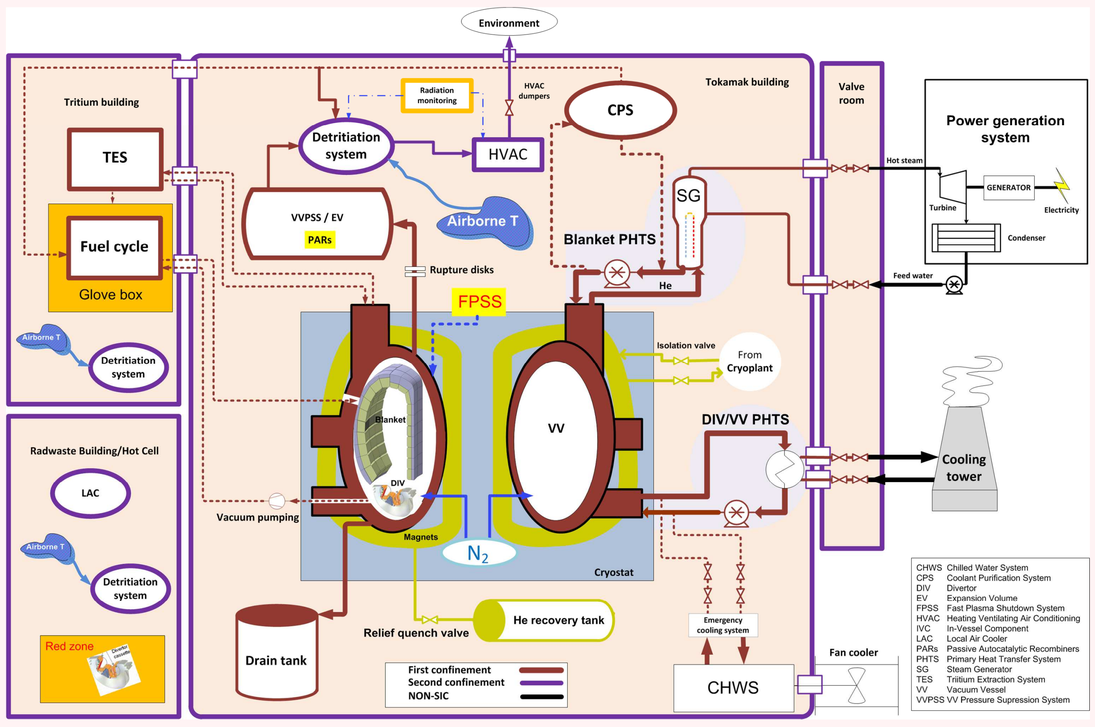
- **Bounding accident**

  No active cooling, no active safety system operating, and no intervention for a prolonged period are foreseen – the worst consequences of an accident driven by in-plant energies.

Safety risk approach



Confinement scheme*



** The scheme will be updated in the on-going safety program of EUROfusion.*

Main safety systems

- **VV and its extension (1st barrier, 1st confinement)**
- **VVPSS/EV (2nd barrier, 1st confinement)**
- **Cryostat (decay heat remove)**
- **FPSS (plasma termination)**
- **Emergency cooling (2nd barrier, 1st confinement)**
- **Tokamak and Tritium Building (3rd barrier, 2nd confinement)**
- **HVAC, N-VDS and S-VDS (3rd barrier, 2nd confinement)**
- **Common release point (3rd barrier, 2nd confinement)**
- **Nitrogen injection / PAR (Passive Autocatalytic Recombiner, avoid H_2 explosion)**
- **Coil fast discharge system (avoid arc in magnets, avoid short in magnets)**
- **Emergency power supply (supply emergency safety systems)**
- **Fire barriers / suppression (prevent propagation of fire)**

Safety relevant sources

- **Energy**
  - In operation: enthalpy in structure and coolant, plasma thermal energy, magnetic energy
  - Decay heat after the plasma shutdown
  - Energy from exothermal chemical reactions between materials (e.g. Be-air/steam etc.)
  - Energy release due to postulated H_2 explosion (H_2 production due to possible Be-steam or W-steam reaction by water cooling)
- **Tritium**
  - In the VV (PFC, blanket structure, Li_4SiO_4, Be, He coolant, He purge gas, armor W of divertor, divertor structural and heat sink materials, water coolant, Tokamak dust, etc.)
  - Out of the VV (PHTSs, TES, tritium plant, hot cells, cryogenic system, etc.)
  - Tritium losses into the environment
  - Tritium decay
- **Activation products**
  - in structures, Tokamak dust and coolant (corrosion)
  - Activated structural materials constituting the in-vessel components are made of W alloys, copper alloys and EUROFER
- **Dust**
  - aerosol particulate, broken flakes, globules, chunks, and other debris in the VV
  - radio-toxicity due to the high activation of tungsten
  - remove from the VV, if its inventory will approach the safety limit
- **ACPs**
  - in the divertor, VV cooling loops and other cooling loops related to auxiliary heating or diagnostics equipment using water as coolant
- **Neutron sputtering products**
  - neutron-induced sputtering as mechanism to produce radioactive inventories in the heat transfer system