ITER In-Vessel Dust and Tritium Control Implementation Status and Plan

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Outline & Introduction

- **Licensing process of ITER ongoing**
  - Preliminary Safety Analysis Report delivered in March 2010
  - ''Décree de Autorisation a la Création de ITER'' (~Jan 2012)
  - Three necessary steps: answering to Safety Authority, (2010-11), Public Enquiry (Jun-July2011), Group Permanent (2011)
  - ITER main safety issues: In-Vessel Dust and Tritium together with ACP in primary cooling water circuits
- **Safety analysis based on in-vessel inventories**
  - **Dust (level of dust accumulation ∝ to the level of erosion)**
    - **≤1000 kg limit of mobilizable dust**
    - **≤11/76 kg (Be/W) dust on hot surfaces**
  - **Tritium (mainly in Be dust and co-deposited layers)**
    - **≤1 kg including tritium in the cryo-pumps**

In-Vessel dust&tritium control strategy

- **Measure dust&tritium and remove before reaching the limits**
- **Maintain the inventory as low as reasonable achievable**

Measurements

- **Dust : by an overall and local PFC erosion measurements validated progressively via**
  - **local dust measurement**
  - **analysis of dust, samples and material recovered from the VV**
  - **validation of the ratio dust/erosion and of dust production rate model**
- **Tritium: by a tritium tracking procedure assessing periodically the deficit in the inventory (T injected-T recovered-T burnt) supported by**
  - **Analysis of T in dust, samples and components recovered from the VV**
  - **Tritium retention measurement of in-vessel component surface**
  - **Validation of the on-line tritium balance measurements and model**

Removal

- **Dust :** recover dust as much as possible at any shutdown via MPD and also via CTM/CMM during cassette removal
- **Tritium:** PFC and VV baking, other wall conditioning techniques, removal of dust and components from the VV

Dust & Tritium Measurements

- **overall PFC erosion**
  - **Requirements**
    - 0.5 mm at ≤5m distances
    - ≤1mm at farther distances
  - **by IVVS(baseline): R&D and design optimization on-going**
  - **By other baseline diagnostics (initial studies started)**
- **divertor erosion: laser-based concepts**
  - FM LIDAR, Speckle interferometry, Digital holography
  - Studies ongoing, choice before CDR (2013)
- **local dust:** several gauges in divertor cassette area. Two systems under R&D in present tokamaks:
  - Capacitive diaphragm microbalance (ITA-EU, ITPA JEX at KSTAR)
  - Electrostatic grid
- **tritium retention: laser-induced spectroscopy**
  - LIDS, LIBS Studies ongoing, choice before CDR (2012)
- **removable samples: preliminary design by Feb 2012**
  - dust accumulation, erosion/deposition effects and tritium retention

Continuous integration and synergy among Diagnostics, RH, Physics, In-Vessel components and safety necessary

Validation through R&D on going, JET ILW, ITPA Tasks, IAEA CRP, etc… and non-nuclear phase of ITER (H2 programme).

Dust and tritium removal

- **Dust : Vacuum cleaning**
  - **via MPD with divertor cassettes in (≈ 15% of dust recovered)**
  - **Via MPD, CTM/CMM at divertor cassette removal (≈ 90%)**
- **Tritium**
  - **Baking of divertor at 350°C, Blanket at 240°C, VV at 200°C**
  - **≈ 50% of tritium in dust co-deposited layers released**
  - **Wall cleaning techniques, dust and in-vessel components removal**

ALARA criterion

- All efforts in reducing dust production and tritium retention
- Maintain the radioactive inventories (including uncertainties) as low as possible
  - **Dust**
    - **Remove dust as first operation of each shutdown**
    - **Clean cassettes and components before moving to Hot Cell**
  - **Tritium**
    - **Baking when necessary and before each VV venting**
    - **Dedicated plasma operation campaigns if necessary**

Dust on hot PFC surfaces

Safety issue: possible production of H2 in case of in-VV LOCA

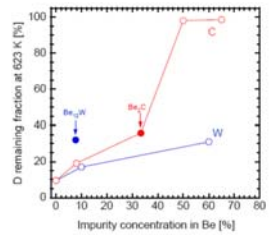
Three lines under studies/R&D

- Detect dust on hot surfaces and remove it (Low limits: 11/76 kg, Be/W)
- Inject inert gas on in-VV on O2 detection following a LOCA
- Model validation to show the non-contemporaneity of ingress of air with PFC high temperatures

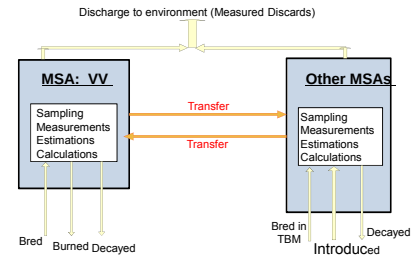
Examples of efforts on-going

Main dust localization
Cleaning via MPD with and without cassettes and vacuum cleaner

Tritium retention versus temperature



Tritium tracking for the Vacuum Vessel



Few main references

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