Concept Design of the ITER Glow Discharge Cleaning System

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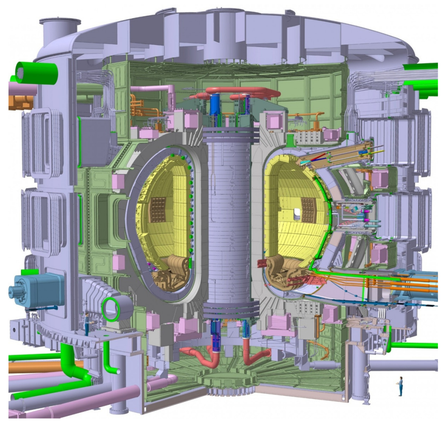
Abstract:
The concept design of ITER Glow Discharge Cleaning (GDC) system based on the present ITER baseline is introduced. This presentation lists the over-all description of the requirements, including the main function, GDC parameters, working positions at different states, main interfacing systems. The concept design for implementation is introduced. The near term plan is discussed.

ITER and its Wall Conditioning



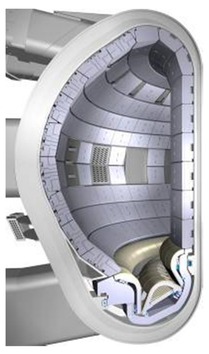
International Thermonuclear Experimental Reactor

http://www.iter.org/

"ITER, currently under construction in the South of France, aims to demonstrate that fusion is an energy source of the future"

"Wall conditioning for ITER"

-limit the outgassing, T inventory in PFCs



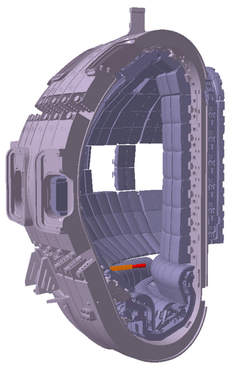
- Baking (superconducting coils between 5 K and 293 K)
  blankets at about 240° C
  divertor up to 350° C
  vacuum vessel and the other in-vessel components at 200° C
  all other surfaces exposed to the primary vacuum >180° C
  Lower temperature at or beyond the vessel ports boundary treated on a case-by-case basis.
- DC GDC (Hydrogen, Deuterium, and Helium)
- RF (IC/EC) wall conditioning (between pulses)

Design requirements and design boundary conditions

Main function of GDC

- The main function of ITER GDC system is to reduce and control impurity and hydrogenic fuel out-gassing, particularly oxygen, from plasma-facing components.
- The design of the GDC shall provide suitable nuclear shielding for the systems that are behind the electrode during the plasma operation.

GDC parameters



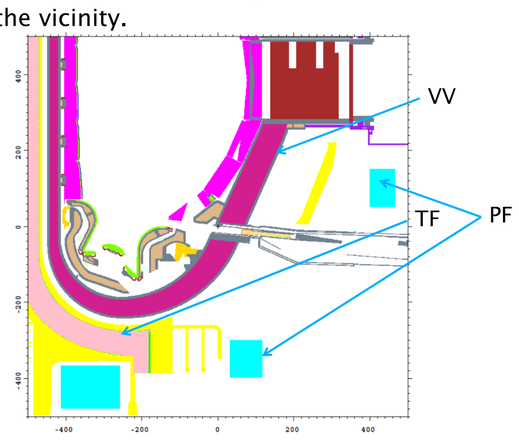
DC GDC is used in the present baseline design, which requires the magnetic fields to be zero.

Taking j=0.15 A/m^2, and ITER internal area be 1000 m^2. Total GDC current shall be about 150 A.

- Vacuum conditions: 0.1-0.5 Pa
- Operating temperature: up to 350° C
- Baking temperature: up to 240° C

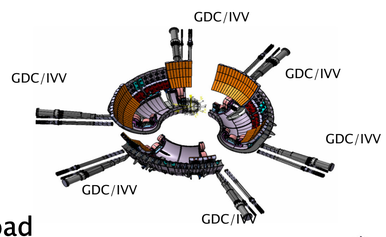
Nucl. Shielding

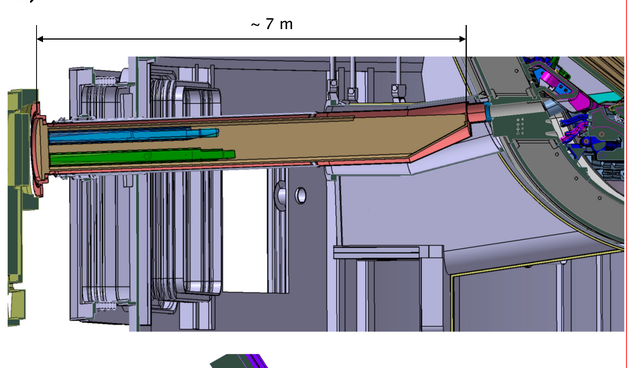
- Nuclear heat in TF assembly & PF coils;
- Helium concentration & DPA level in steel in the vicinity.



Integrated with In Vessel Viewing System (IVVS)

- GDC needs to be integrated with IVVS, which similarly requires uniform coverage.
- There are six sets of GDC/IVVS assembly on ITER.





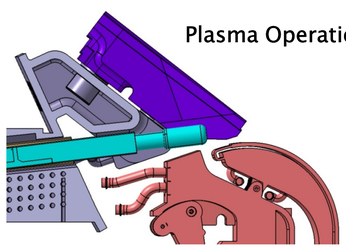
Heat load

During plasma operation,

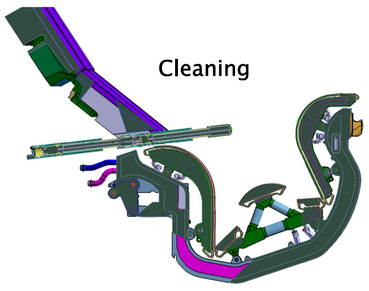
- Nuclear heating
- Radiation and charge exchange

29 kW each electrode at maximum.

Plasma Operation



Cleaning



During GDC, the rejected power at nominal operation is 0.7 kW per electrode, calculated from the anode voltage drop (~20V) times current plus ohmic heating.
-ITER Design Description Document 2001 version

GDC concept design based on the present baseline

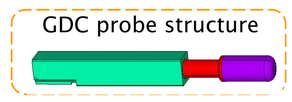
Electrode

Total Mass ~ 250 kg

Material candidates:

- Be,
- stainless steel,
- Copper alloy.

GDC probe structure

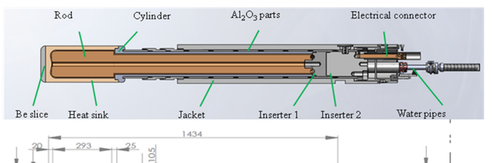


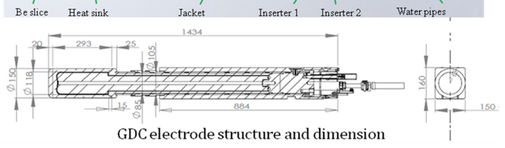
Cap (CuCrZr) [316LN]

Core rod (CuCrZr) [316LN]

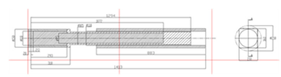
Shell (316LN)

Jacket (316LN)





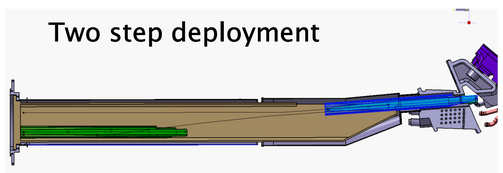
GDC electrode structure and dimension



Simplified GDC electrode

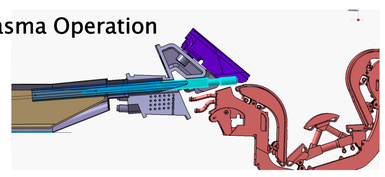
Mesh model

Two step deployment

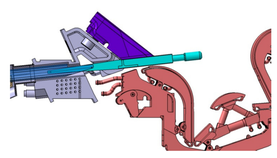


IVVS deployment will provide the service for moving GDC electrode among different positions.

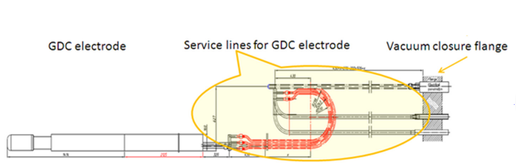
Plasma Operation

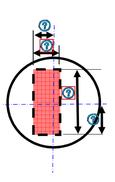


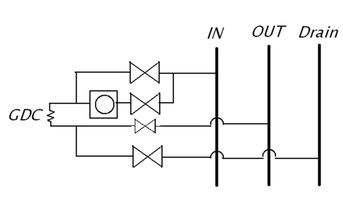
Cleaning



Service lines (cooling and electrical)



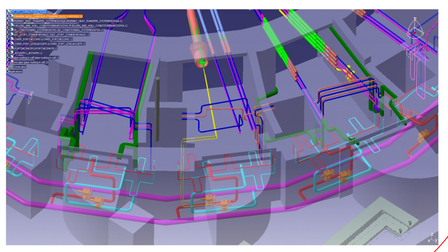




Flexible connection:

- Internal pressure~4MPa.
- Tmax~350 degree C.
- Length~7 meters.
- Moving at 10mm/s for ~6meters. A few times a month.

- A booster water pump is used for ensuring enough cooling water flow-rate.
- Connection to the "Drain" is for the depressurization of the high pressure water loop.



Open questions

Physics

- Glow distribution.
- Heat load on the electrode during DC GDC.
- Plasma facing material selections.

Engineering

- Bellows.
- Electrical cable, connector and feed-through.
- Electrical insulation.
- Anti-arcing.
- Electrode temperature measurement.

Near term work plan

- Nuclear analysis
  - Possibility of decoupling the glow and shielding functions.
  - Deciding the nuclear shielding position.
- Mechanical design for a lighter electrode head.
- Study for isolation of the port and the main chamber.
- Further research on in vessel space sharing with IVVS.

These need to be answered before the end of 2011.

Acknowledgement:
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This paper was prepared as an account of work by or for the ITER Organization. The Members of the Organization are the People's Republic of China, the European Atomic Energy Community, Republic of India, Japan, Republic of Korea, the Russian Federation, and the United States of America. The views and opinions expressed herein do not necessarily reflect those of the Members or any agency thereof. Dissemination of the information in this paper is governed by the applicable terms of the ITER Joint Implementation Agreement.