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Progress of ITER Plasma Diagnostics Systems by Japanese Procurement
日本が調達するITER プラズマ計測装置開発の進展

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The preliminary design review (PDR) for the in-vessel components of MFC was held and successfully closed. Detailed optical designs of the PA2 diagnostic systems, such as ETS, PoPola, IRTh and DIM, have been carried out. In parallel, a prototype control and data processing system for ITER diagnostic systems complying with ITER standards were developed.

1. Micro Fission Chamber

The Micro Fission Chamber (MFC) diagnostic system measures the total neutron emission from the plasma for the evaluation of the fusion power. The MFCs will be installed upper (#12) and lower (#17) outboard behind the blanket module. At each position, two detectors with ^{235}U and one dummy detector w/o uranium are installed [1]. The in-vessel components of MFC, except those detectors, are installed in the ITER vacuum vessel before the first plasma.

The preliminary design review (PDR) for the in-vessel components of MFC was held in this May. In the preliminary design, the designs and installation procedures of the MI cable, welding of cable cramps, connection procedure of the MI cables were reviewed. It was shown that the seismic forces, thermal forces due to the nuclear heating, EM forces to the MI cables and cramps were within the criteria. Results of the thermal cycle test, vibration test, vacuum test and signal noise demonstrated that the MI cables were eligible for the signal cable in the ITER environment.

Since the feedthrough of the MI cable forms the vacuum boundary, the feedthrough must comply with the SIC (Safety Important Component). Classifications of SIC and VQC was agreed with the ITER organization and the detailed design of the feedthrough, including load analysis to thermal and EM forces and its installation procedure were performed (See Fig. 1). The PDR was successfully closed in this August.

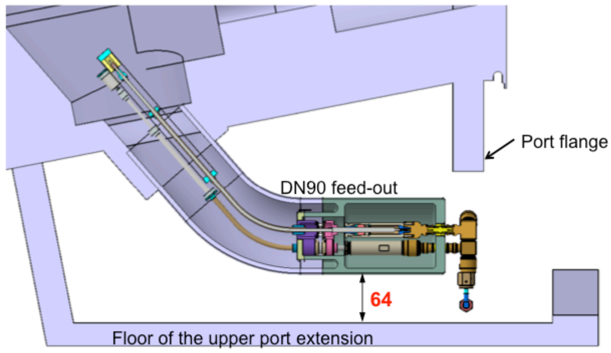

Fig.1. Structure of the Feedthrough

2. Design Progress of the PA2 Diagnostics

Since the preliminary design phase of the diagnostic systems under the second procurement arrangement (PA2) started effectively in this year, detailed optical designs of the edge Thomson scattering measurement (ETS), Poloidal Polarimeter (PoPola), Infrared Thermography (IRTh) and Divertor Impurity Monitor (DIM) have been carried out. In parallel, control and data processing system for ITER diagnostic systems complying with ITER standards are being developed. We successfully developed a prototype control and data processing system [2].

Preliminary design of the optical diagnostics, such as the PA2 diagnostics, must show engineering sound design in compliance with applicable codes and standards for ITER. All the diagnostics must obey several French orders related to nuclear facility because the PA2 diagnostics will penetrate several safety boundaries (i.e. confinement barriers). This requirement makes the architectures of the ITER diagnostic systems different from those of the existing diagnostic systems in the experimental devices.

Schematics of the PoPola optical transmission line and the radiological/ventilation/fire boundary is shown in Fig. 2 as a typical example to show the safety boundary concept. Since PoPola makes holes on boundaries between different classes of zoning, PoPola needs to provide additional security. An air-tight window is installed to make ventilation boundary and to enable a laser beam to pass. The window cannot serve a function of fire boundary. In order to minimize the total number of windows, the optical transmission line in the gallery has a function of ventilation boundary (i.e. the line is air-tight).[3]

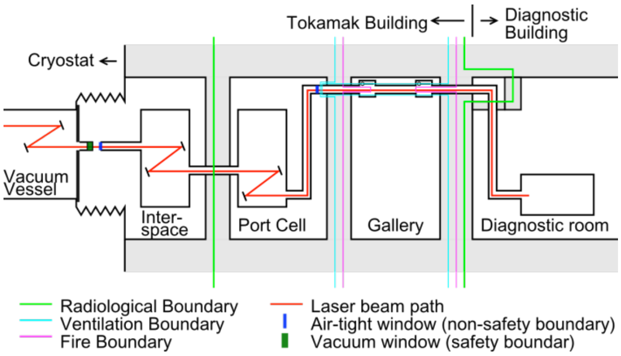

Fig.2. Schematics of the PoPola optical transmission line and the radiological/ventilation/fire boundary

The edge Thomson scattering (ETS) measurement requires injections of high power laser beam as large as 5 J into the vacuum vessel. A new type of the beam dump called "chevron beam dump" has been proposed for ITER. The key concept of the chevron beam dump design is to reduce the energy absorption per unit area on surface due to a large angle of incidence and the laser beam is absorbed gradually along the path, so that the laser-induced damages on the surface are suppressed. The stray light back to the plasma is also suppressed. (See Fig. 3)

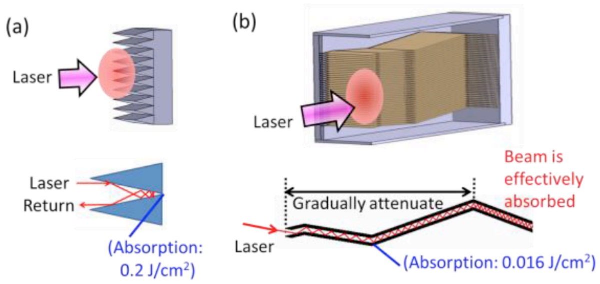

Fig.3. (a) Conventional (b) Chevron Beam Dump

In order to verify the idea, the laser irradiation effects onto the molybdenum samples were investigated. The laser-induced damage was detected by monitoring the level of the specular reflection. It was found that the laser-induced damage threshold (LIDT) is proportional to $N^{-0.26}$, where N denotes the threshold number of the incident pulses.

Since the absorption energy density of the chevron beam dump is 12.5 times lower than that of the conventional beam dump (see Fig. 1), the threshold number of incident pulses for the chevron beam dump is 17,000 times higher relative to the conventional beam dump when the pulse duration is 6 ns [4].

Since the reserved space for Infrared Thermography (IRTh) in the EQ17 port plug was reduced recently, the IRTh optics was redesigned. Fig.4 shows the front-end optics in the port plug. The front-end optics for the outer divertor measurement comprise a toroidal first mirror, which allows the IRTh to look tangentially, followed by a flat mirror, two toroidal mirrors, three cylindrical mirrors and two flat mirrors. The front-end optics for the inner divertor measurement comprises a flat first mirror followed by three toroidal mirrors and a cylindrical mirror. The intermediate image of each divertor target is formed around each window and transferred to the distribution and imaging optics, which is installed in the port cell, by the relay optics embedded optical alignment optics in it, and then measured by the detecting system. It was confirmed that both inner and outer divertor viewing optical systems including relay optics satisfy the required spatial resolution.

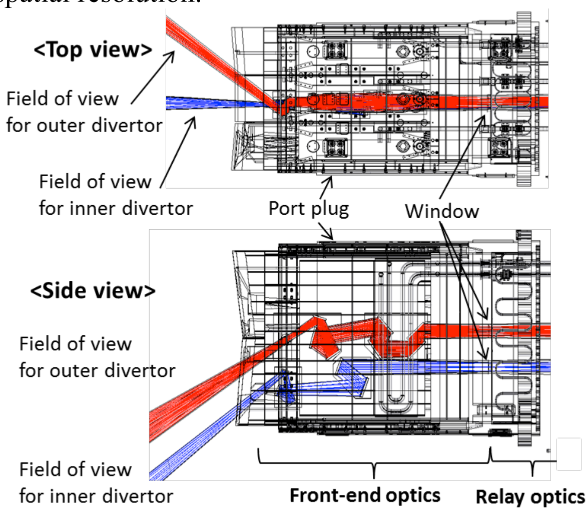

Fig.4. Front-end optics in the EQ17 port plug

References

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