RAMI ANALYSIS FOR ITER FUEL CYCLE SYSTEM

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ITER is an experimental fusion device with an ambitious scientific and technological programme. To be able to reach its objectives, an assessment of the technical risks has to be performed. The authors have defined the ITER RAMI (**R**eliability, **A**vailability, **M**aintainability and **I**nspectability) approach [1] and have been applying it to various systems in the ITER project aiming at improving inherent availability of the ITER machine operation and to achieve target availability which is defined in the Project Requirements. This paper highlights the RAMI analysis results of the Fuel Cycle System.

To begin with, a functional analysis of the Fuel Cycle System was performed to breakdown the system from main functions to basic functional levels. By using IDEFØ (**I**ntegration **DE**finition **F**unction – language **Ø**) model, the input and output for each function was defined, and the associated component that enables each function was identified. There are three subsystems in the Fuel Cycle System, namely (1) the Fueling and Wall Conditioning System, (2) the Vacuum System and (3) the Tritium Plant. Each system is closely linked together, and composed of several main functions. For example, the Fueling and Wall Conditioning System provides the following functions, i.e. to inject fuel particles or impurities into the plasma in the forms of gas and hydrogenic ice pellets; the former is mainly to control plasma detachment and enhancement of radiative cooling in divertor region, the latter is to control plasma density and ELM frequency. This system also provides hydrogen and deuterium to heating and diagnostics neutral beam injector.

Second, a reliability block diagram was developed in order to simulate reliability and availability of the system. Based on the functional description of the system, FMECA (**F**ailure **M**ode, **E**ffects and **C**riticality **A**nalysis) was performed. The severity and occurrence of each failure mode for a basic function was determined on the basis of MTTF (**M**ean **T**ime **T**o **F**ailure) and MTTR (**M**ean **T**ime **T**o **R**epair). For those risks having high criticality, risk mitigation provisions were proposed. Amongst the sub functions, we identified key functions which significantly impact the inherent availability of each system. In the Tritium Plant, two basic functions, namely to receive, store and supply the gases needed for ITER operation, and to separate hydrogen isotopes to provide products for fuel cycle, are the critical ones to be considered in order to achieve the required inherent availability target for the ITER operation.

In the next step, risk mitigation actions were proposed in order to decrease the level of severity or occurrence. In the initial pre-conceptual design of Vacuum Roughing System, frequency of failure of the mechanical pumps led to the loss of operational time. Therefore, alternative configuration, such as coupling torus and neutral beam roughing sets, was proposed to mitigate the effects of failure.

Finally, all the risk mitigation actions and recommendations were put together as RAMI requirements, and to be implemented during the ITER construction and operation. Detailed analysis will be provided in the presentation.

[1] D. van Houtte, K. Okayama and F. Sagot; “RAMI Approach for ITER”, ISFNT 2009, Xian