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Design principles of a nuclear and industrial HVAC of IFMIF

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HIGHLIGHTS

- Parameter of Derivate air Contamination (DAC) allows to associate the type of air ventilation.
- The construction and operation of IFMIF will be subjected to the regulations of the country in which it will be sited.
- Structures, systems and components are assigned a particular safety important components (SIC, 1–2 and Non-SIC) clarification that is based on the consequences of their failure.
- Reliability, Availability, Maintainability and Inspectability (RAMI) analysis has given a great contribution of the facility to optimize the configuration, particularly for the HVAC system.

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ABSTRACT

In 2013, the IFMIF, the International Fusion Material Irradiation Facility, presently in its Engineering Validation and Engineering Design Activities (EVEDA) phase, framed by the Broader Approach Agreement between Japan and EURATOM, accomplished in 2013 its mandate to provide the engineering design of the plant on schedule [1].

The IFMIF aims to qualify and characterize materials that are capable of withstanding the intense neutron flux originated in D-T reactions of future fusion reactors due to a neutron flux with a broad peak at 14 MeV, which is able to provide >20 dpa/fpy on small specimens in this EVEDA phase. The successful operation of such a challenging plant demands a careful assessment of the Conventional Facilities (CF), which have adequate redundancies to allow for the target plant availability [2].

The present paper addresses the design proposed in the IFMIF Intermediate Engineering Design Report regarding the CF, particularly the IFMIF's Nuclear and Industrial HVAC design. A preliminary feasibility study, including the initial configuration, calculations and reliability/availability analysis, were performed. The nuclear HVAC design was developed progressively; first, by establishing a conceptual design, starting from the system functional description, followed by the identification of the corresponding interfacing systems and their technical requirements. Once the technical requirements were identified, safety zones were identified based on the radiation classification, frequency dose and parameter of Derivate Air Contamination (DAC). The zone color was determined to match the room's radiation classification. The system design was further developed by defining and creating a Block Diagram with basic and additional information, eventually resulting in a Process Flow Diagram concurrent with the equipment layout definition. Subsequently, we studied and developed the various Piping & instrumentation diagrams (P&ID's), air duct layout and equipment list for different air handling units, air ducting as well as a layout plan of the equipment piping, which was eventually integrated into the 3D model of the building and coordinated with others subsystems of the IFMIF.

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1. Introduction

IFMIF will generate a neutron flux with a broad peak at 14 MeV of the Li (d,xn) nuclear reactions generated by parallel deuteron beams colliding onto a liquid lithium jet. The two accelerators will generate beams of 40 MeV and a current of 125 mA, each in CW mode, with a common footprint of 200 mm × 50 mm [1]. Fig. 1 shows the schematic configuration of the IFMIF plant divided into five facilities: Accelerator facility, Test facility, Lithium facility, Post-irradiation Examination facility and Conventional Facility. The last facility, "Conventional Facility", and more specifically the Nuclear and Industrial HVAC Design Principles, is the topic of this article. The main function of the Heating, Ventilation and Air Conditioning (HVAC) System is to provide sufficient air throughput to ensure acceptable air quality for the continuous access of personnel to selected areas of the IFMIF. The served areas include areas where the contamination risk is excluded (Industrial areas) as well as those with a contamination risk (Nuclear areas). An important function is to assume dynamic confinement, i.e., a pressure differential between contamination zones. HVAC systems in potentially contaminated areas have the safety function of protecting both the personnel and the environment from the uncontrolled release of radioactive materials. Therefore, the HVAC systems are designed for high availability and easy maintenance. The HVAC systems do not serve the hot cells and glove boxes operating in an inert gas atmosphere, which require closed loop atmospheres with a decontamination system that are maintained under control the contents of tritium and other gas impurities. Each HVAC system is capable ensuring comfortable environmental conditions for the working staff of the plant and the appropriate thermo-hygrometric parameters for the equipment housed on the IFMIF premises. Furthermore, each HVAC system will protect workers and the environment from contacting activated particles (in the form of chips, dust, aerosol, and activated air) due to the uncontrolled release from high potential and/or permanent contamination hazard rooms to low contamination areas or to the environment (this concept is detailed by ISO 17873:2014 [3] and is referred to as Dynamic Confinement).

2. System function and basic configuration

The HVAC System will thus be designed to perform the following key functions:

- Supply water to the humidification coils of the Air Handling Units (AHUs).
- Condition Air (heating, cooling, humidification and re-heating treatment).
- Supply conditioned and filtered air to different rooms, considering the room specific risk, containment functions and maintenance of the climatic and hygienic conditions.
- Ensure a negative (gauge) pressure to rooms characterized by potential/permanent contamination.
- Extract air from different rooms.
- Filter air that presents the possibility of containing airborne contamination.
- Release air to the environment.
- Provide the capability of intervening on components for easy maintenance and high availability.

To accomplish the above-mentioned functions, the HVAC System includes cold and hot water generators: Air Handling Units (AHUs), fans, valves, dumpers, grills, and air ducts, as well as the corresponding instrumentation and sensors.

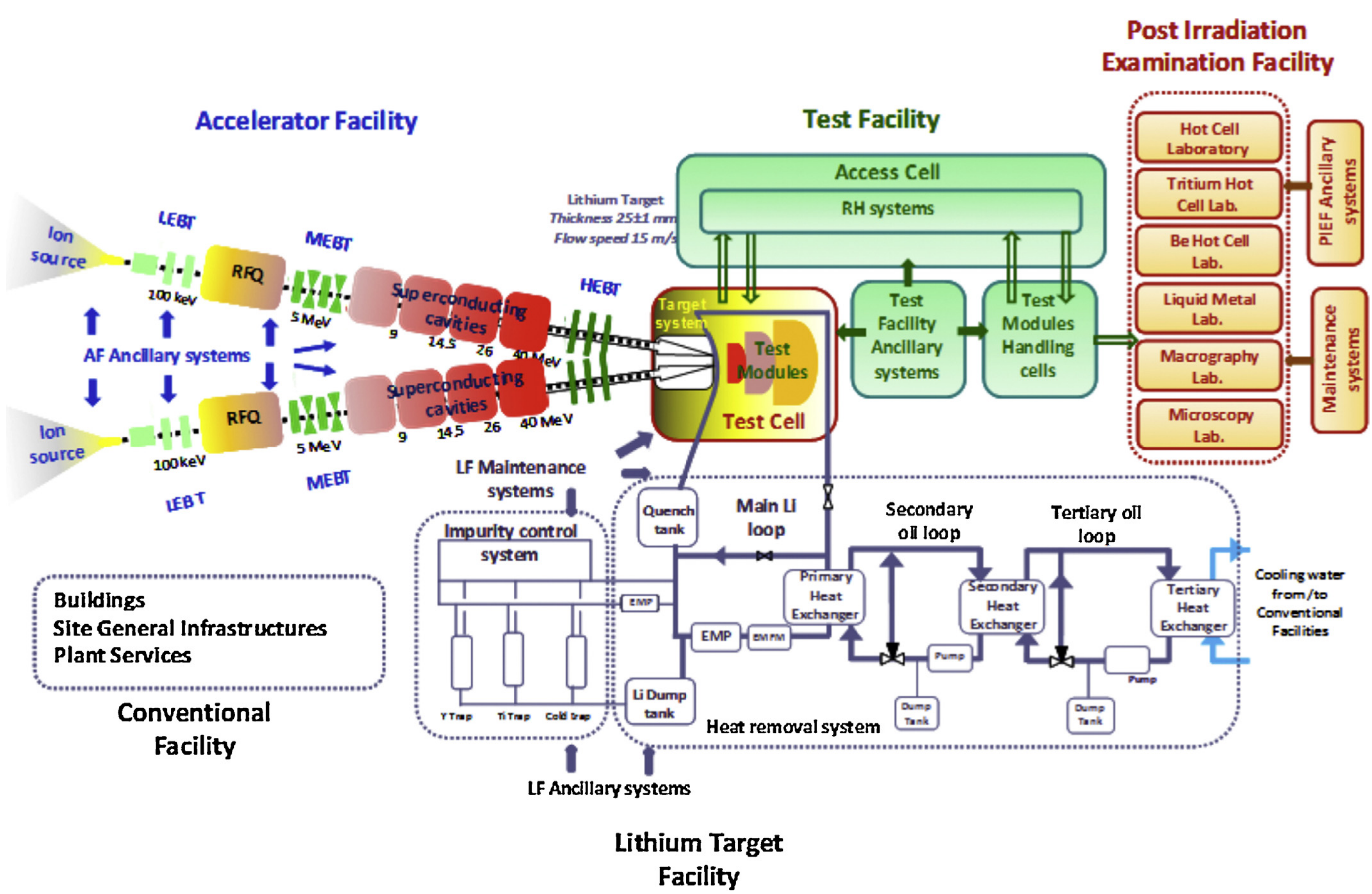

Fig. 1. Schematic configuration of the IFMIF plant.