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Completion of IFMIF/EVEDA lithium test loop construction

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ABSTRACT

The EVEDA Li test loop (ELTL) successfully completed its construction and installation of a total of 2.5-ton Li in the frame work of the IFMIF/EVEDA as one of the ITER-BA. Design for the ELTL had been done from March 2009 to December 2009 in large part, and then the construction was started on November 2009 in the O-arai site of the Japan Atomic Energy Agency and completed on the middle of November 2010 after passing an authority inspection by a fire department in O-arai town. Subsequently, the 2.5-ton Li was installed to the ELTL by using a glove box in the form of ingots which is 240 mm long and 125 mm in diameter. The nitrogen concentration in the 2.5-ton Li was found to be 127 wppm. During the installation, the oxygen concentration and the humidity in the glove box were almost kept less than 20 wppm, and any large contamination by air was prevented during the handling of Li.

1. Introduction

The International Fusion Materials Irradiation Facility (IFMIF) is aimed at producing an intense high energy neutron flux generated by a deuteron (D+) – lithium (Li) nuclear reaction. In the current concept of the IFMIF, two 40 MeV-deuteron beams whose total current is 250 mA are injected into a beam target which is a liquid Li stream flowing at a speed of 15 m/s. The Li stream, hereinafter called the Li target, is a free-surface flow produced by a double contraction nozzle and flows through a concave flow channel in a vacuum of 10^{-3} Pa.

At present, Engineering Validation and Engineering Design Activities called EVEDA [1,2] for the IFMIF is carried out under an international collaboration known as the ITER Broader Approach (BA) [3,4] between Japan and the EU. The EVEDA tasks related to the Li target facility consist of six tasks which are (I) construction and operation of a Li test loop; (II) diagnostics for the Li target; (III) erosion/corrosion for loop structure materials; (IV) a Li purification system; (V) remote handling; (VI) IFMIF engineering design [5]. Among these tasks, as a major Japanese activity, the EVEDA Li Test Loop (ELTL) had been designed and constructed in the O-arai site of the Japan Atomic Energy Agency (JAEA), and the commissioning were completed at the end of February 2011.

This paper focuses on the construction of the ELTL completed on the end of November 2010. Regarding to the design activity for the ELTL, our previous paper presents on: the outline of the whole system [6]; the target assembly which produces the Li target [7]; a purification trap called cold trap [8]; the electro-magnetic pump [9]; safety handling of Li and a safety concept for the ELTL [10,11].

In this paper, specification and installation procedure for a total of 2.5-ton Li as well as the construction process are presented. Regarding to the Li installation, more than 1600 ingots were installed into the ELTL using a glove box temporally installed on the ELTL. Pressures, oxygen concentration and moisture both in the glove box and the ELTL were carefully controlled to avoid contamination by air. This paper also provides the important data on impurities concentration of the Li which has huge impact on material erosion and validation tests on purification traps to be conducted in the engineering validation activity of the EVEDA.

2. Outline of design and construction activity for the ELTL

The design activity for the ELTL had been done from March 2009 to December 2009 in large part. The ELTL was designed to have major components necessary to produce the Li target envisaged in the actual IFMIF, although the width of the Li target in the ELTL has been reduced to 1/2.6 of that of the IFMIF because of cost reduction. The ELTL features that it is able to produce the Li target as high flow velocity as 20 m/s in a vacuum condition of 10^{-3} Pa and that it equips a complete set of purification traps and monitors. The ELTL consists of two major Li loops which are the main loop and the purification loop. A piping and instrumentations diagram (P&ID) of ELTL is shown in Fig. 1. The main loop consists of the main circulation piping, a quench tank, an electro-magnetic

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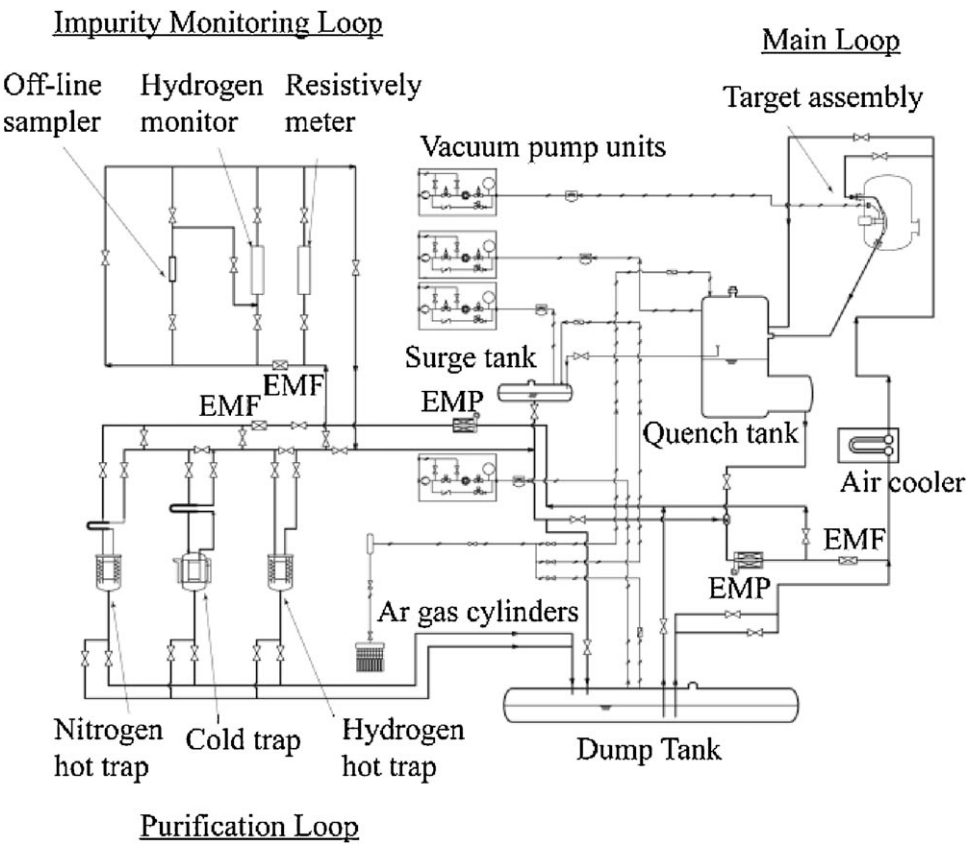

Fig. 1. Piping and instrumentations diagram (P&ID) of ELTL.

pump (EMP), an electro-magnetic flow meter (EMF), a Li cooler, a dump tank and valves. The tanks connect to Ar gas cylinders and turbo-molecular vacuum pump units to control pressure and vacuum. The purification loop is connected to the main loop at the upstream and downstream of the EMP. And the impurity monitoring loop is branched at the downstream of the impurity traps in the purification loop.

In the main loop, the maximum flow rate is 3000 L/min to produce the Li target flow at the velocity of 20 m/s in the target assembly in which the Li target is produced. The target assembly connects to a vacuum pump unit to operate in the vacuum condition (target value of vacuum: 10^{-3} Pa). Pipes of the main loop are made of S.S. 304, and the diameter is 4–6 inches.

The purification loop includes a cold trap aiming to remove oxygen, and two mechanical interfaces to install two hot traps aiming to remove nitrogen and hydrogen respectively. These two hot traps are designed and fabricated in one of the six Li target system tasks in collaboration with Japanese universities (the two traps are not installed yet at this moment). The impurity monitoring loop includes a Li sampler to analyze impurity concentration in the Li off-line, and interfaces to two on-line.

Fig. 2 shows a photograph of the ELTL after completion. The loop consists of three floors and a pit in which the dump tank is placed. The target assembly is installed in the 3rd floor inside of an air-tight vessel, and the height of ELTL is approximately 20 m from the ground level.

As for the construction phase, groundwork in an existing building in the JAEA O-arai site was started at the beginning of November 2009 and completed the middle of January 2010. The platform for the ELTL had been installed since January until March 2010, and then large components (e.g. tanks, electro-magnetic pumps) were installed in the platform. After completion of the installation, piping works for Li, Ar gas and vacuuming were started. Since two authority inspections are required for the ELTL to handle Li which is stipulated as a hazardous material in a Japanese act (Fire Service Act), an on-site pressure test as one of

Fig. 2. Front view of the ELTL.