The SPES Temporary Storage System: status and future perspectives

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INTRODUCTION

Radioactive isotopes produced at the SPES facility using the Isotope Separation On-Line (ISOL) technique will promote advanced research in nuclear physics and medical applications [1]. The core component within the SPES ISOL hall enabling the production of positive ions that are then extracted and accelerated to form a Radioactive Ion Beam (RIB) is called Target Ion Source (TIS) unit [2]. Here, the isotopes are generated as fission reaction products following the collision of a 200 μA 40 MeV Primary Proton Beam (PPB) with a target composed of 7 UCx disks. The target ion source will gradually age as a consequence of the proton irradiation, thus leading a progressive decline of the isotopes extraction process efficiency. The SPES operational schedule is designed in accordance with the need for regular replacement of the TIS unit, including a two-week irradiation period followed by a two-week cooling interval. Various studies have been carried out to model the ambient dose rate [3] and surface contamination of the of key components within the production bunker [4]. A highly radioactive environment emerged as a result, triggering the development of a comprehensive remote handling framework, designed to take care of the TIS unit life cycle throughout all of its steps without requiring human interaction [5]. The Horizontal Handling Machine (HHM), the primary SPES remote handling system, has access to the bunker to collect an irradiated TIS unit from the Front-End. After this phase, it is moved to the Temporary Storage System (TSS), an automated machine designed specifically for the hosting of radioactive units in a safe and shielded location permitting their radioactive decay [6].

Fig. 1. The TSS cartesian manipulator and the storage rack designed to host up to 54 TIS units.

Fig. 2. The Temporary Storage System (TSS) installed in the SPES target area (S041).

SYSTEM DESCRIPTION

In the single storage module, as basic functional units, six places are distributed among two layers and three columns. The TSS storage rack combines 9 modules, with a total storage capacity of 54 units. A 5mm lead vertical sheet and a 25 mm lead top lid surround each storage cell. The most radioactive TIS units will be stored in the inner positions, while the older vessels are progressively shifted towards the outer modules. This method will allow to maximize the shielding effect of the interposed layers, thus lowering the external environmental dose contribution. Following its removal from the SPES Front-End, the irradiated TIS unit is unloaded by the HHM and remotely placed on a sliding table. This enables it to be moved on the top of the TSS rack. At this point, the unit is stored in a predefined position through the cartesian manipulator, a 3-axis device capable of grabbing and moving various items, such as TIS units, shielding lids and support shelves, thanks to standardized gripping interface. The presented technologies were designed to enable fully automated safe storage of radioactive TIS units. Taking into account the TIS units production rates and the SPES run schedule, the TSS will allow to host exhausted chambers for a period of 2-5 years prior to being removed and sent to a dedicated Hot Cell for dismantling. Due to significant dose rate within the TSS storage area, specific measures have been put in place to ensure the system's reliability. They include using radiation-tolerant materials, selecting electromechanical switching devices, installing redundant actuation systems and developing robust control logics capable of withstanding possible fault conditions.

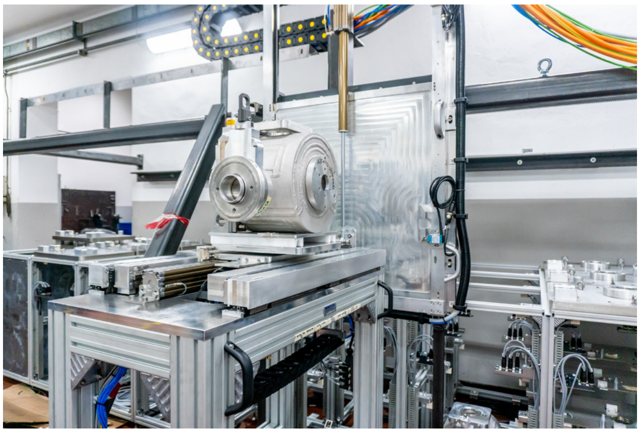

Fig. 3. The TIS unit loaded on the TSS sliding table during the Factory Acceptance Tests.

PRODUCTION AND INSTALLATION

Legnaro National Laboratory initially developed a TSS prototype with the goal of confirming the core design choice and system architecture. The demo included a single storage module and the entire cartesian manipulator system. Following this stage, the construction of the full-scale system was outsourced to a third-party company, which took care of the realization the TSS according to the INFN project. The system has been completely manufactured, assembled and cabled in an external site to permit the execution of rigorous Factory Acceptance Tests (FATs) aimed at testing its behavior under specific conditions. After successfully completing this phase, the TSS has recently been dismounted and installed in its final operating location, the S041 room within the SPES building. The top of the TSS storage rack is depicted in Fig. 1, where all the shielding lids enclosing the individual cells are visible. The inner portion of the zone contains the cartesian manipulator moving along designated rails. The TSS sliding table and the entire storage rack can be seen in Fig. 2.

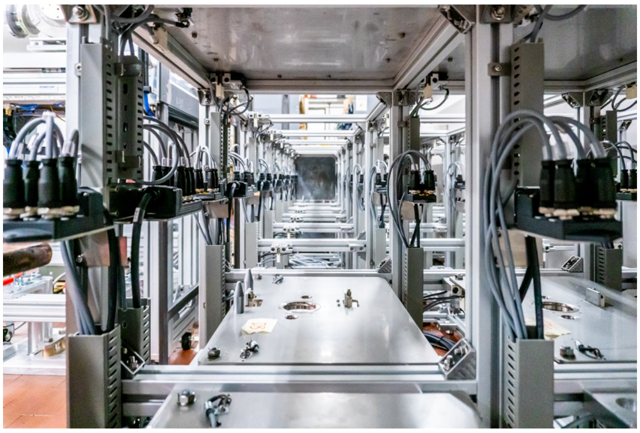

Fig. 4. Cabling of the mechanical limit switches used to detect the TIS unit presence within the storage rack.

The TIS unit installed on the TSS sliding table is displayed in Fig. 3. Multiple units have been used during the FAT execution to test the different storage positions and the manipulator movements. Fig. 4 reports an internal view of the TSS rack. Each storage cell has a dedicated sensor distribution box used to collect the TIS unit presence signals.

COMMMISSIONIG AND CONCLUSIONS

The first phase of the installation of the TSS mechanics has been completed. In the coming months, the storage rack will be enclosed by an airtight compound that will be employed to maintain the area depression and ensure a controlled airflow from zones with a lower risk towards the areas with a higher expected contamination risk. Once completed, the TSS signals will eventually be cabled to the system control cabinet, which will be installed in a protected area. This step will enable the execution of the Site Acceptance Tests (SAT), and the development of the ultimate control software in accordance with a comprehensive commissioning plan that will include functional, dysfunctional and endurance testing of the whole system prior to operation.

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