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Construction and commissioning of a hydrogen cryogenic distillation system for tritium recovery at ICIT Rm. Valcea

George Ana [a,*], Ion Cristescu [b], Mirela Draghia [c], Ciprian Bucur [a], Ovidiu Balteanu [a], Mihai Vijulie [a], Gheorghe Popescu [a], Claudiu Costeanu [a], Nicolae Sofilca [a], Iulia Stefan [a], Robert Daramus [a], Alina Niculescu [a], Anisoara Oubraham [a], Ionut Spiridon [a], Felicia Vasut [a], Carmen Moraru [a], Sebastian Brad [a], Gheorghe Pasca [c]

[a] Institute for Cryogenic and Isotopic Technologies, Rm. Valcea, Romania
[b] Karlsruhe Istitute for Technologies, Tritium Laboratory, Eggenstein-Leopoldshaffen, Germany
[c] ISTECH, Timisoara, Romania

HIGHLIGHTS

- Cryogenic distillation (CD) process is being employed for tritium separation from tritiated hydrogen mixtures.
- Process control and safety phylosophy with the detritiation plant from Rm. Vâlcea.
- Tests undertaken prior to commissioning of the CD system from Rm. Vâlcea.
- Preliminary experiments with the CD system (non-radiological).

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ABSTRACT

Cryogenic distillation (CD) of hydrogen in combination with Liquid Phase Catalytic Exchange (LPCE) or Combined Electrolytic Catalytic Exchange (CECE) process is used for tritium removal/recovery from tritiated water.

Tritiated water is being obtained after long time operation of CANDU reactors, or in case of ITER mainly by the Detritiation System (DS).

The cryogenic distillation system (CDS) used to remove/recover tritium from a hydrogen stream consists of a cascade of cryogenic distillation columns and a refrigeration unit which provides the cooling capacity for the condensers of CD columns. The columns, together with the condensers and the process heat-exchangers are accommodated in a vacuumed cold box.

In the particularly case of the ICIT Plant, the cryogenic distillation cascade consists of four columns with diameters between 100–7 mm and it has been designed to process up to 10 mc/h of tritiated deuterium.

This paper will present the steps undertaken for construction and commissioning of a pilot plant for tritium removal/recovery by cryogenic distillation of hydrogen. The paper will show besides preliminary data obtained during commissioning, also general characteristics of the plant and its equipments.

1. Introduction

During normal operation of a CANDU type reactor, this faces a specific problem in the form of tritium generation by neutron absorbtion by the heavy water used as moderator and cooling agent. The tritium concentration rises up to a stationary level in each system, when trtitium forming is balanced by its radioactive decay. For the moderator system of a CANDU-6 reactor (such as the ones from Cernavoda NPP) the tritium concentration is approximately 3–3.3 TBq/kg and in the primary heat transfer system 75–100 GBq/kg [1].

In view of limiting the doses taken by the operating personal of the reactor due to the rise of the tritium concentration, and for minimizing the risk of environment contamination, steps have been taken for designing a detritiation plant connected to the reactors systems. In support for this activity, commissioning and testing of a pilot plant at ICIT Rm. Valcea for heavy water detritiation is undergoing in view of confirming the design parameters.

The process employed for heavy water detritiation at ICIT Pilot Plant and also for Cernavoda NPP is a combination of two processes:

* Corresponding author.
E-mail address: george.ana@icsi.ro (G. Ana).

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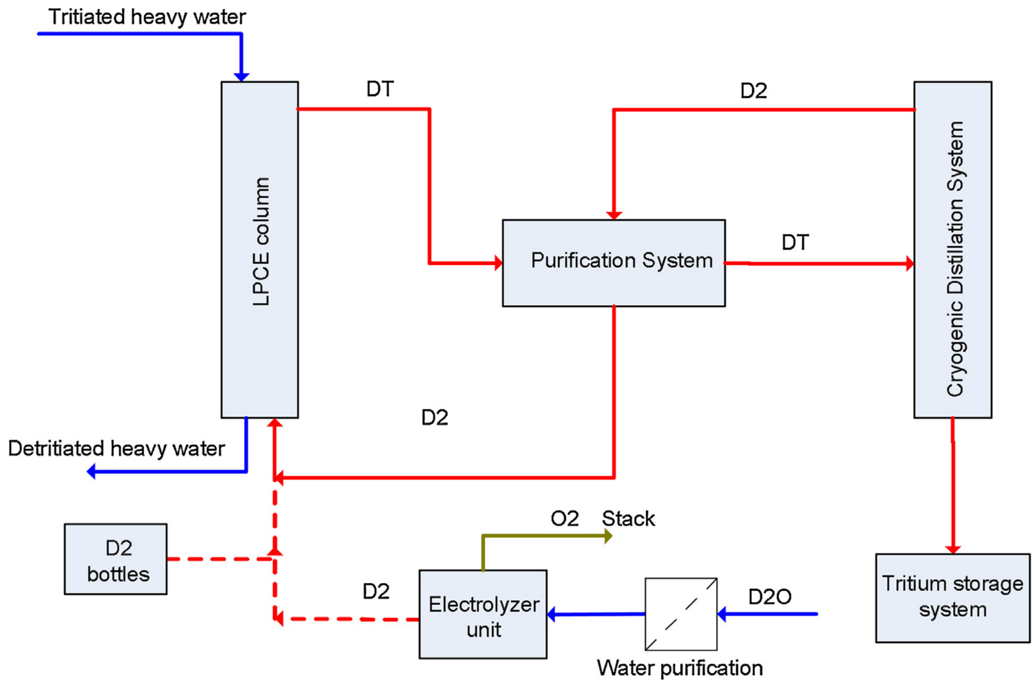

Fig. 1. Simplified block diagram of the combined LPCE/CD system at ICIT Rm. Valcea.

Liquid Phase Catalytic Exchange (LPCE) and Cryogenic Distillation (CD). The system is in the phase of non-radiological commissioning and testing.

2. Plant configuration

A simplified flow diagram of the combined LPCE/CD system at ICIT Rm. Valcea is shown in Fig. 1. The main component of the LPCE process consists of a 5 m catalytic exchange column filled with a mixture of structured packing and hydrophobic catalyst, both developed by ICIT, to promote the isotopic exchange of hydrogen isotopologues. The CD system (Fig. 2) consists of a four column cascade of different diameters ranging from 100 down to 8 mm, filled with structured and random packings. Each column is equipped at the top with its own condenser connected to a 1000 W (at 20 K) helium refrigeration unit which provides the cooling capacity. At the bottom, each column has been foreseen with electrical reboilers with 3 redundant resistors.

All components are placed inside a vertically double-chambered confinement (cold box): columns, heat-exchangers and all cold components are accommodated in the vacuumed lower part of the cold box, while the warm components such as pumps and ana-

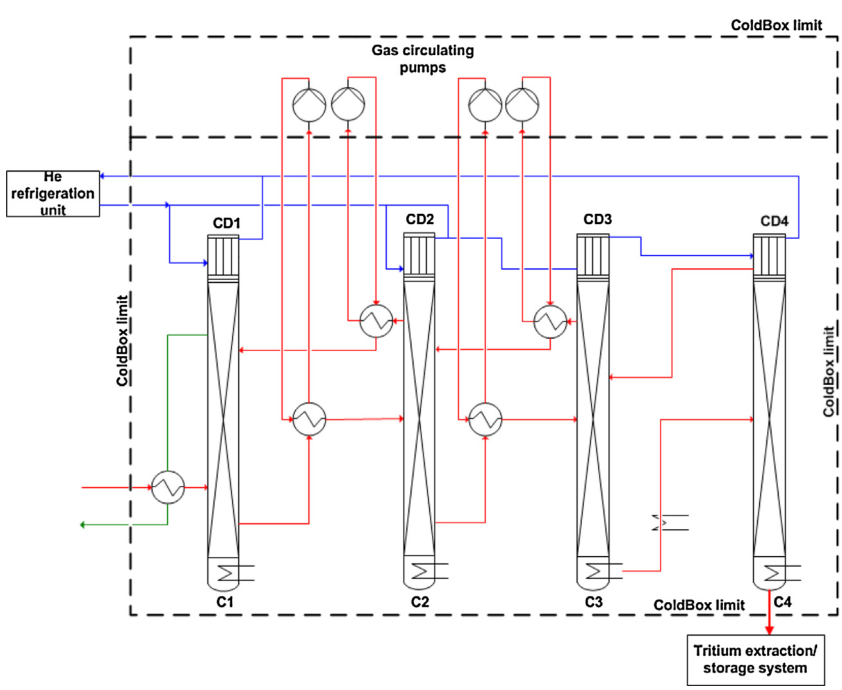

Fig. 2. Simplified flow diagram of the CD system.