

Tritium Gas Chromatograph System (GC)



❖ Features & Benefits

Process Evacuation:	Evacuation of tritiated process lines down to vacuum.
Hydrogen Channel:	Baseline separation and allowing quantification of H ₂ , HD, HT, D ₂ , DT, and T ₂ using a TCD and an Ionization detector.
Impurity Channel:	Ability to see contaminants such as Ar, N ₂ , CO, CO ₂ and O ₂ in fueling gases at the ppm level.
Computer Control:	Pneumatic valve control and data acquisition integrated with local computer control
Small Footprint:	3' x 4' table or 3' x 4' wall mounted plate that easily fits inside a tritium lab.

❖ Key Performance Items

- Baseline identification of all hydrogen isotopologues
- Sensitive hydrogen and impurities detection
- Tritium effluent cleanup from GC to reduce emissions

Overview

The Gas Chromatograph unit was designed to support fusion oriented tritium fuel cycles as a small footprint support skid to qualify fusion fueling gas. The system utilizes a commercial analytical GC unit retrofitted for tritium service to offer a robust solution for fueling gas analysis. The system incorporates a tritium exhaust cleanup system to minimize emissions from the GC.

The GC utilizes two channels, one for hydrogen species and one for contaminants. The hydrogen channel uses an iron-doped column to stratify the species before entering the detector array. The impurities side uses commercial PLOT columns to cut the hydrogen peak from the spectrum to allow for increased baseline resolution. The detection system comprises a flow through dual cell thermal conductivity detector (TCD) and small volume tritium monitor fitted with Torion ITM electronics whose signal is processed in the workstation as a GC detector.

Both channels exhaust the effluent to getter beds that capture elemental tritium and other tritium bearing species. Tritium sample vessels are designed to allow for micro-liter gas injections that minimize dead volumes reduce waste and contamination of the assayed sample. A vacuum system is also provided to ensure all process lines and the interspace between the GC and sample valve are capable of being evacuated with the exhaust sent to the tritium cleanup system.

The systems are available as a table with all associated equipment mounted within the frame or a table mounted GC with all associated tritium capture equipment fixed to a wall mountable plate.

Theory of Operation

Tritium Loop

A small aliquot of tritium containing fuel gas is injected into an iron-doped column and eluted with a neon carrier to flow over a TCD and tritium monitor. These columns stratify the gas allowing the TCD and tritium monitor to detect the individual hydrogen species as they exit the column. The TCD detects all isotopes of hydrogen while the tritium monitor detects the tritium constituents. The small quantities of tritium in the exhaust are passed over a hydride bed to capture as elemental hydrogen downstream of the detectors before being exhausted to stack.

Impurity Loop

Two PLOT molecular sieve columns are used to cut the hydrogen peak from the impurity chromatogram to sharpen the impurity chromatogram. This allows for baseline species identification due to the increased resolution. This is vital to determining the quality of tritium fueling gas. The small quantities of tritium in the exhaust are also passed over a hydride bed to capture hydrogen bearing species before the impurities are exhausted to stack.

Specifications

GC System	
Injection Volume	Custom: dependent on assay volume pressure, 80 - 100 μ L typical for 1 atm in assay volume 98% of injected gas used in the analysis
Vacuum System	Scroll pump
Operating Pressure	Vacuum to 1.5 atm
Operating Temperature	15 – 100 °C
Tritium Capture System	
Elemental Getter Bed	500 g getter bed: - 0.6 std. liters of H ₂ gas - 1.5 kCi of Tritium capacity
Operating Pressure	Vacuum – 250 psig
Operating Temperature	15 – 350 °C
Physical	
Dimensions	Wall mounted Effluent Collection: (6009H1) Table mounted Effluent Collection: (6009H2)
Leak Tightness	< 1x10 ⁻⁹ std. cc/sec helium with 1 atm helium upstream
Services	
Electrical Power Requirements	120 VAC, 15 A 120V, 20 A dedicated for GC unit
Cryogenics	Liquid Nitrogen for hydrogen column
Gas Requirements	Neon, 30 - 85 psig, Research grade Helium, 30 - 85 psig, Research grade

Drawings

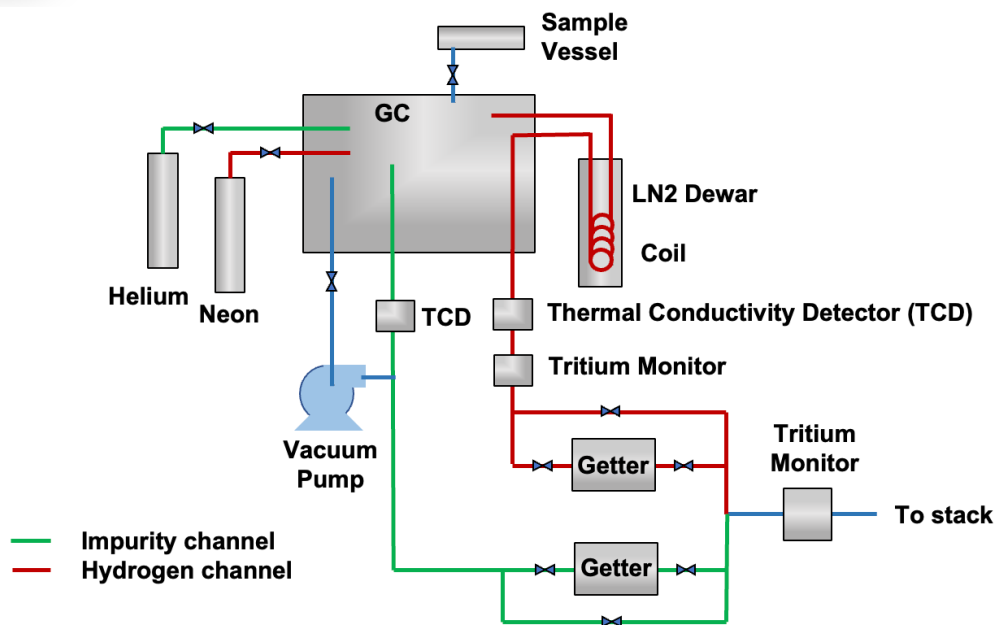


Figure 1: GC tritium process loop sample Process Flow Diagram

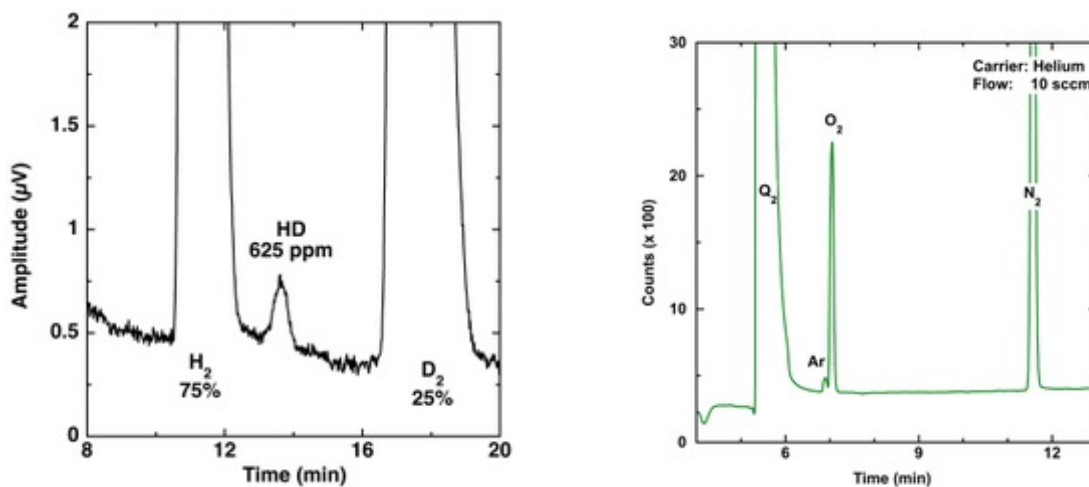


Figure 2: GC HD chromatogram (left) and impurity chromatogram (right)