TRITIUM MONITORING AT THE TRITIUM SYSTEMS TEST ASSEMBLY*

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The Tritium Systems Test Assembly (TSTA) is a computer-controlled facility recently constructed at the Los Alamos National Laboratory in Los Alamos, New Mexico, to mock up full scale the fuel cycle of future fusion reactors. The TSTA fuel loop consists of a mock torus vacuum vessel, a vacuum cryopumping system, fuel cleanup and hydrogen isotope separation systems, and associated storage, delivery and transfer pumping systems. The maximum flow rate in the fuel loop is 360 moles of DT per day, comparable to the flow rates expected at fusion power reactors. To achieve this rate requires an inventory of approximately 1.5×10^6 Ci of tritium gas.

The major goals at TSTA are to demonstrate the effectiveness and reliability of its major subsystems in continuous operation and to show that this can be done with a high degree of safety. This safe operation is attained by a combination of containment and monitoring in depth, and the use of two tritium removal systems: an on-line Tritium Waste Treatment system (TWT) and an Emergency Tritium Cleanup system (ETC) for processing room air. All components that contain tritium are secondarily enclosed as are interconnecting piping between enclosures. Moreover, all of the tritium at TSTA is contained within the 3000-m^3 main experimental room, which provides a form of tertiary containment. In case of a significant release of tritium into the room, valves in the room ventilation ducts immediately isolate the room atmosphere, which is then processed by the ETC. Safety is further assured by the use of two main control computers, two back-up safety computers, an emergency generator, and an uninterruptable battery power supply which supplies power directly to the computers and the tritium monitors.

THE TSTA TRITIUM MONITORING SYSTEM

Critical to the control of any tritium released from the primary containment of the fuel loop is the tritium monitoring system. This system consists of stack and duct monitors, room monitors, and glovebox monitors. For monitoring the performance of the TSTA subsystems, there are also process monitors located in the fuel loop, in the tritium removal systems, and in the on-line gas chromatographs. The emphasis in this discussion is on instruments used to monitor for tritium released from the primary containment.

Table 1 lists the types of monitors being installed at TSTA and the numbers of each type, broken down according to their principal use or function. With two exceptions--the stack bubbler and the ETC water monitor--all are ionization-chamber instruments using the Kanne design with the outer chamber at ground potential and the inner chamber at high voltage. Sampled gas enters the space between

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TABLE 1

TRITIUM MONITORS USED TO MONITOR RELEASES
WITHIN THE TSTA EXPERIMENTAL ROOM

Number	Function	Location or Type	Range
3	Stack	Bubbler (1)	1 mCi-10^6 μCi/m^3
		Low-Range (1)	1-10^4 μCi/m^3
		High-Range (1)	10^{-3}-10^3 Ci/m^3
2	Exhaust Duct	Main Duct (1)	1-10^4 μCi/m^3
		Auxiliary Duct (1)	1-10^4 μCi/m^3
10	Room	Low-Range (8)	1-10^7 μCi/m^3
		High-Range (2)	10^{-2}-10^3 Ci/m^3
14	Secondary Enclosures	Gloveboxes (13) Vacuum System Enclosure (1)	1-2x10^6 μCi/m^3

the two chambers, which serves as a built-in ion trap, before entering the inner, measuring chamber.

Glovebox Monitoring

Including the process monitors, there are 50 instruments at TSTA, many of which incorporate innovations developed at Los Alamos. Figure 1 is a photograph of open-walled ionization chambers designed primarily for use in the gloveboxes. The response of these chambers is for all practical purposes identical to that of conventional flow-through chambers. Their advantages are simplicity of design and the elimination of a pumping system to introduce air into the chamber, usually the primary source of instrument failure. In use, the chamber is suspended from the roof of the glovebox and the small interface chassis is located outside of the glovebox itself. Mention should be made of the gamma check-source unit shown in the photograph. All of the low-range ion-chamber instruments incorporate a Ba-133 gamma check source normally stored in a small lead shield next to the chamber. Once a day, on command from the computer, a solenoid raises the source to a window in the shield and exposes the chamber. If the resultant chamber signal is not within prescribed limits, the operator is notified.

Electronics for the glovebox monitors consist of commercial electrometers and Los Alamos-built units housing the chamber power supply and two adjustable alarm circuits. The low alarm level (∿20 μCi/m^3), set comfortably above background, alerts the TSTA operator of an increase in glovebox concentration. The higher alarm (∿10^3 μCi/m^3) automatically begins purging the glovebox atmosphere to the TWT.

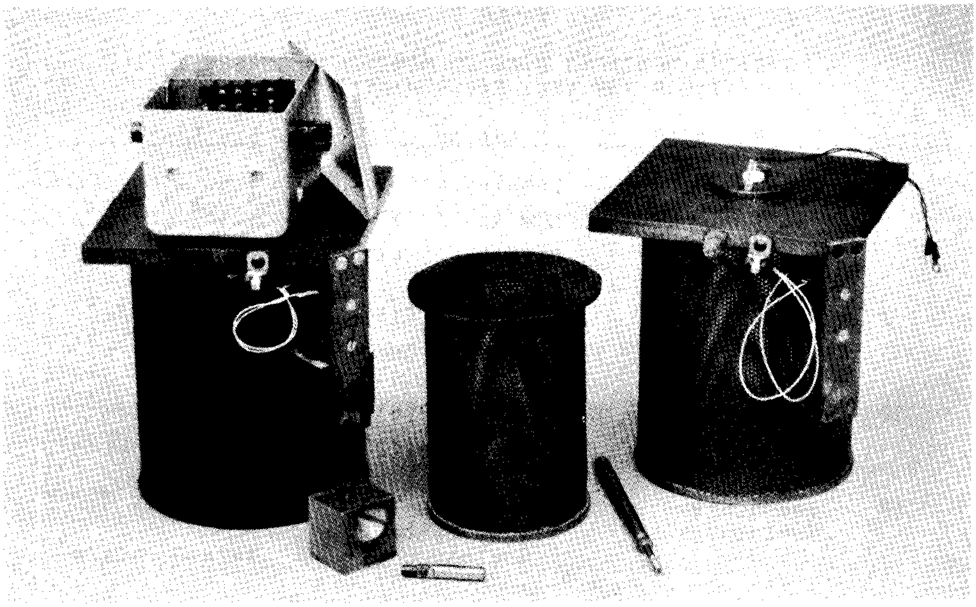

Fig. 1. TSTA-designed, open-walled ionization chambers used for monitoring the gloveboxes. The assembled chamber on the left is covered with a cloth dust cover. The appendages are the gamma check-source units for automatically checking the performance of the instruments (see text).

Besides local alarms on the tritium monitoring instruments, visual/audible alarms are also provided to the TSTA operator, who can then quickly determine the cause of the alarm before taking appropriate action.

Room Monitoring

Room monitoring is accomplished mainly by instruments commercially-built to TSTA specifications. The range of the eight principal room monitors covers 7 decades and incorporate three alarm circuits (tripping at $\sim$10 $\mu Ci/m^3$, 10^2 $\mu Ci/m^3$, and 10^4 $\mu Ci/m^3$). These instruments employ flow-through chambers to enable each instrument to monitor several points simultaneously. By means of pressure switches in the sampling lines, the computer monitors their flow rates as it does for the three stack monitors, which also employ pumps.

Two high-range room monitors employing commercial picoammeters and 0.1-ℓ open-walled ionization chambers cover the concentrations that would be realized should gram quantities of tritium be released into the experimental room.

Stack and Duct Monitoring

The stack is monitored by three instruments (Table 1). The glycol bubbler operates at about 80 mℓ/min and incorporates a flow controller and a catalyst for differentially monitoring the oxidized and elemental forms of tritium. The main stack monitor uses a 10-ℓ flow-through chamber and Los Alamos-built electronics. Two adjustable alarm levels, presently set at ∿10 and 10^4 $\mu Ci/m^3$, are provided. This instrument has integrating capability with its own alarm, set at 10 Ci. The computer rezeroes the output each day. With the range of the instrument only 10^4 $\mu Ci/m^3$, a high range tritium monitor using a flow-through 0.1ℓ chamber and a commercial 6-decade logarithmic picoammeter is also used to monitor the stack. Duct monitoring is accomplished with open-walled chambers placed directly into the (two) exhaust ducts being monitored. The electronics are identical to those of the main stack monitor.

Besides simply monitoring room releases, the main stack and both duct monitors along with the main room monitors are critical to the prevention of major releases to the environment. Should any one of these monitors alarm at its high trip level (∿10^4 $\mu Ci/m^3$), the building evacuation alarm is sounded and the room air is isolated by ventilation duct valves, independent of the operation of the computers. In addition, if any two such monitors alarm at this level, the ETC is automatically turned on. The duct and stack monitors, having integrating capability, will also isolate the cell if the tritium released to the environment within a 24-hour period exceeds the preset value.

Process Monitoring

Process monitoring is accomplished by commercial electrometers and Los Alamos-built interfaces coupled to stainless-steel chambers whose size varies from 20 mℓ for the gas chromatographs to 1.5ℓ for the tritium removal systems.

In the case of some of the process or glovebox monitors, there may be significant memory effects for chambers exposed to a wide range of concentrations. Should this become a chronic problem, the chambers will be gold plated or redesigned with grid walls that minimize the surface area of the measuring volume.

All of the instruments mentioned above are monitored by the main computers, which also provide redundant alarms to back up the instruments' own alarm circuits. Another safety feature incorporated in most of the tritium monitors is the continuous monitoring of the instruments' high and low voltage power supplies by the computer. For the instruments important to safety, there are also provided hard-wired readouts in the control room and in an auxiliary Support Center.

The prevention of significant tritium releases to the environment is an important goal in itself. It is all the more important for an energy program that wishes to demonstrate that the fuel it must use can be safely handled and contained. At TSTA we have attempted to make the tritium monitoring system, which is critical to this control, as reliable and effective as we could reasonably make it.