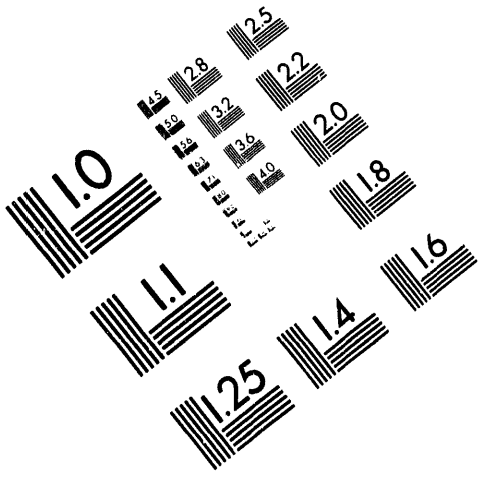

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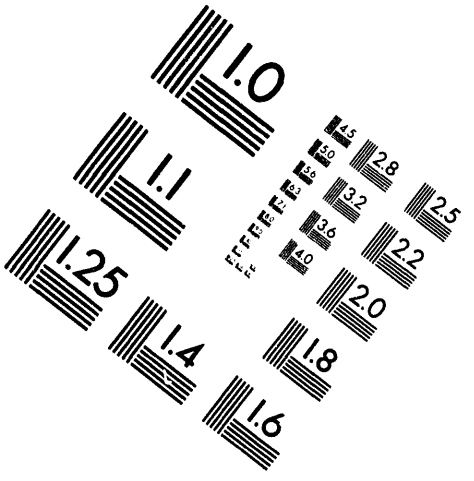

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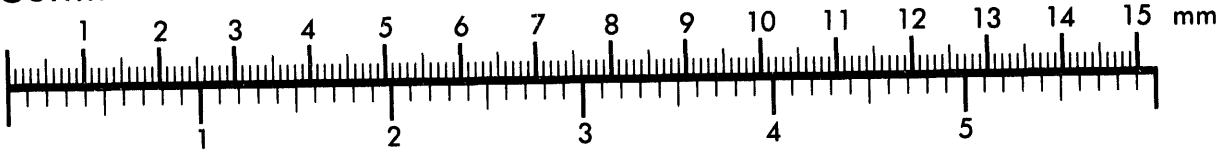

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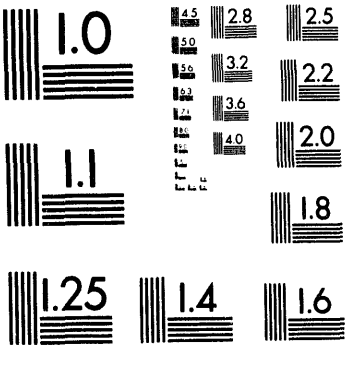

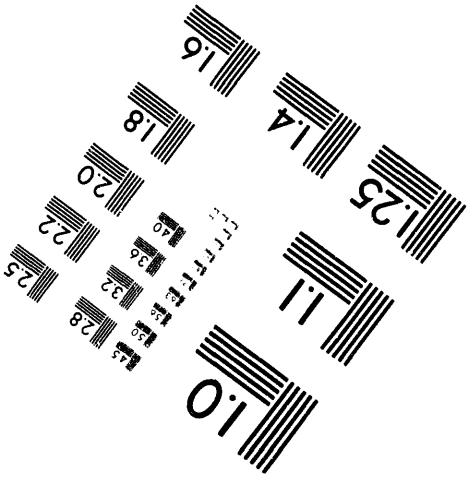

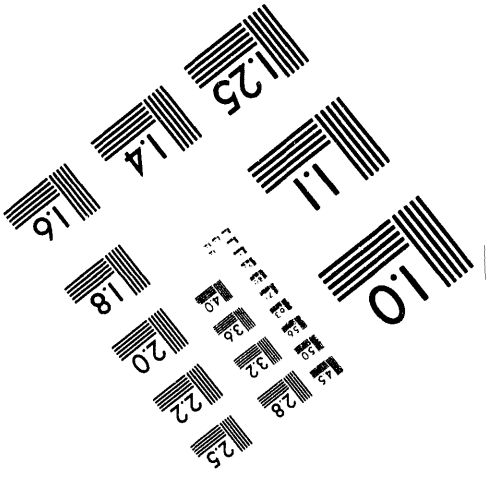

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Design, Operation, And Application Of The LLNL Portable Tritium Processing System

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DESIGN, OPERATION, AND APPLICATION OF THE LLNL PORTABLE TRITIUM PROCESSING SYSTEM*

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ABSTRACT

A Portable Tritium Processing System (PTPS) has been developed at LLNL that could be applied to fusion energy related tritium processing and decontamination operations. The PTPS has four basic capabilities. These are: oil-free pumping, oil-free gas transfer, gas analysis, and gas phase tritium scrubbing. The design of the PTPS takes into consideration today's stringent release requirements, and utilizes secondary containment throughout the system. Because the system is portable, it can provide complete stand alone tritium processing, and can pass through a typical 36 inch laboratory door, and into confined spaces. This system can easily be moved to different locations within a facility such that the single tritium processing system can provide close-coupled support to multiple operations. Typical setup time for the PTPS is approximately two weeks. The PTPS has been in operation at LLNL for approximately one year. During this time, gram quantities of tritium have been successfully processed through the system. Releases to the stack attributable directly to the PTPS have been less than 0.1 curies, with most of this quantity being a product of maintenance operations.

I. INTRODUCTION

The Portable Tritium Processing System was designed and developed to provide a modern processing system for the removal of tritium from the LLNL Tritium Facility, Bldg. 331. Existing tritium handling systems at the tritium facility were old, singly contained, and had a history of unacceptable releases (by today's standards). It was therefore necessary to develop a new tritium processing system capable of accessing each of the old systems while meeting current stringent release guidelines. As the new system evolved, each important function of the system was designed into a separate module. That is, a cart was built to accommodate the hardware necessary to perform that particular function. Three carts, or modules, were fabricated, and each is completely portable.

The PTPS is capable of providing four basic tritium processing functions.

These four functions are: Evacuate present facility gas handling systems, and therefore, prepare them for disassembly; Transfer tritium from one container to another or to a shipping vessel that can in turn be sent to another DOE facility; Analyze gas compositions; and, clean up residual tritium concentrations.

In addition to the three carts, a portable central operations console is also used. The central operations console can operate the entire system, provide system interlocks, and conduct all necessary data logging and archiving.

II. SECONDARY ENCLOSURES

We have identified the three processing modules as the Pump/Transfer cart, the Clean-up cart, and the Gas Analysis cart. These units were designed and built using current glove-box technology. Each cart enclosure is a stand alone glove box based on present design features developed at LLNL, Sandia, and Mound. The size of the cart enclosures has been reduced to meet our project goals, one of which is to get the system into any lab through a typical laboratory door. Construction materials include 3/16" thick stainless steel cabinets with Lexan windows. Commercially purchased glove ports were installed through the windows at convenient locations so that internal operations could easily be performed. Each cart is equipped with passive negative/ positive pressure protection bubblers set for a 6" H_2O pressure differential.

The secondary enclosures are equipped with tritium monitors and are configured such that the Clean-up system can be attached in the event of a tritium spill within the enclosure. The secondary enclosures of the Gas Analysis cart and the Clean-up cart function as "ventilated enclosures" under normal operating conditions. In the event of a tritium release in one of the carts, the ventilation ports automatically close when the internal monitor senses the release. When the system requires maintenance, the carts are placed in a ventilated mode, and a window is removed.

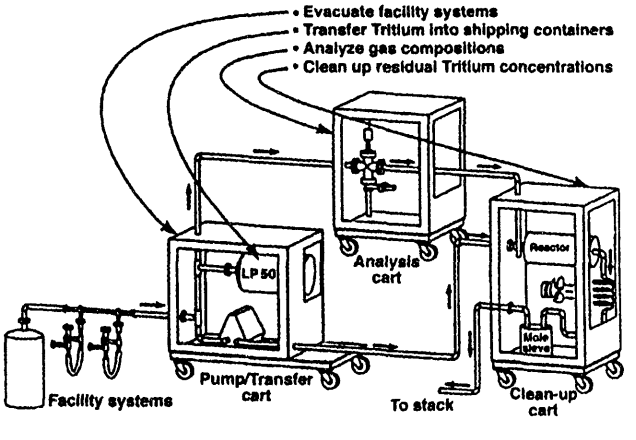

Figure 1. The Portable Tritium Processing System

III. SYSTEM DESIGN--PUMP/TRANSFER CART

The Pump/Transfer cart was designed to sustain the highest pressures that were expected to be found in our tritium handling systems. It can accept a working pressure of 215 PSIA at the system inlet. The pumping mechanism is made up of tritium compatible vacuum/transfer pumps with a base pressure of about one torr. Primary pumping is done with a metal bellows type pump, and additional pumping is accomplished through a scroll pump backed by the bellows pump. Both pumps are operated within the enclosure, but driven by motors outside the enclosure via a rotary feedthrough. The Pump/Transfer cart has several convenient features. It has an LP-50 container on board which can receive gram quantities of tritium for ultimate shipment to another facility. The LP-50 is installed and removed by accessing the cart through a door while the enclosure is being ventilated.

Another important feature of the Pump/Transfer cart is that it has on-board supplies of helium and argon gas. The helium is used to leak check the entire system, and the argon is used to dilute gases that may be combustible. The gas reservoirs can be filled from external sources when they become depleted.

A forty liter abort volume is included in the Pump/Transfer cart circuitry. This tank automatically receives gas in the event of inadvertent system overpressure. When the abort tank has accepted gas, it can be emptied by pumping with the system vacuum/transfer pumps.

All of the valving within the Pump/Transfer cart are pneumatic. Valve actuators are mounted remotely so that no spark source is ever present within the cart enclosure. To date, the Pump/Transfer cart has operated almost daily for over a year with no problems.

IV. SYSTEM DESIGN--GAS ANALYSIS CART

The Gas Analysis cart uses a commercially available quadrupole partial pressure analyzer with a range of 0 to 200 AMU. The unit selected is very user-friendly, and can be interfaced with a

computer program such as *Labview*, for data manipulation and archiving. We have found that the resolution of this instrument is sufficient to allow us to differentiate peaks at masses 3, 4, and 5 without difficulty.

The Gas Analysis cart is a separate module that serves several purposes. Not surprisingly, it's primary function is to analyze gases that have been pumped from a system, or from vessels that contain unknown constituents. Once a gas has been analyzed, the decision can be made as to how we handle that gas. If no tritium is found during analysis, the gas can be vented up the stack with no further processing necessary. If small quantities of tritium are identified, the gas can be pumped to the Clean-up cart for scrubbing. If the analysis reveals significant quantities of pure tritium, that gas will be stored in the LP-50 container aboard the Pump/Transfer cart.

There are two outstanding features of the Gas Analysis cart that must be mentioned. One is the addition of internal calibration gases. Hard plumbed into the analysis circuitry are two three-liter bottles that contain a mixture of gases whose quantities are known in hundredths of a mole-percent. An important and unique feature of this design is that no tritium is required in the calibration gas mixture. These calibration gases are periodically introduced into the analyzer so that system performance can be checked and adjusted if necessary. Minimal drift in specie identification has been noted.

Another feature of the Analysis cart is the incorporation of a SAES getter pump in the test volume. Because the SAES getter pumps hydrogen and its isotopes readily, but does not pump helium, the SAES getter is an effective tool in identifying which gas species appear at mass 3, or at mass 4. After over one year of service, the getter pump has been regenerated only several times.

The pumping system of the Analysis cart consists of a 50 liter/sec turbomolecular pump, and a rotary mechanical pump. Sample gases enter the test volume through a manually operated variable leak valve. System pressure can be read by a nude ionization gauge, but the ion gauge is never allowed to be on during analysis operations because we have noted unusual signal behavior in the quadrupole when the ion gauge is on. In over a year of operation, and with hundreds of samples analyzed, the Gas Analysis cart continues to perform reliably.

V. SYSTEM DESIGN--CLEAN-UP CART

The Clean-up cart is a portable "scrubber" system whose design is based on catalytic oxidation of tritium, with the resultant tritiated water collected on molecular sieve dryers. The design of this system also calls for tritium monitors in front of the reactors, and again after the reactors. This feature allows for the gauging of decontamination, which is believed to be greater than 10,000:1. Indeed, gases exiting the reactor stage of the cart are usually stripped of any discernible tritium. Gases processed through the Clean-up cart are typically stacked. All exhausted gases from the Pump/Transfer cart and the Gas Analysis cart are processed through the Clean-up cart before stacking.

Another important feature of the Clean-up cart is that it can also function independently of the other modules for decontaminating large volume vessels such as glove boxes or maintenance hoods. Metal bellows pumps are used to circulate gases through the reactor and dryer beds. These pumps, along with mass flow controllers and tritium monitors, constitute an efficient package for processing gases with partial pressures of tritium. So, with these capabilities, the Clean-up cart has proven to be an effective stand alone decontamination tool not requiring the aid of the Gas Analysis cart or the Pump/Transfer cart.

Maintenance performed on the Clean-up cart includes replacing the molecular sieves, and the tritium monitor at the reactor inlet. These activities occurred after approximately one year of service. The tritium monitor was replaced because it's background became high enough to give erroneous readings during processing, and the sieves were replaced because we needed a benchmark by which to gauge future usage. Otherwise, the Clean-up cart has been operating on a daily basis with no reportable difficulties.

VI. CENTRAL OPERATIONS CONTROL

The PTPS is operated from a central control console. This unit employs a programmable logic controller (PLC), a system display monitor, and a computer. All electro-pneumatic valves can be operated from the monitor screen which displays a "map" of the system being used. In addition, the screen displays pressure information, temperatures, valve position, and all tritium monitor levels. The PLC provides all interlock protection for critical temperature, pressures, and tritium concentrations. The computer archives all system activities. This data can be recalled at any time in order to review a particular operation. The only problem that we've encountered in the central controller is inadequate storage space for the volumes of data being gathered during day-to-day operations. Old data must periodically be dumped to make room for current archiving.

VII. FUTURE APPLICATION OF THE PTPS

Although the PTPS is presently being used for manifold, vessel evacuation, and decontamination operations, we have plans for expanded future uses as well.

The PTPS is capable of processing glovebox environments by recirculating the gases through the Clean-up Cart. There are several gloveboxes at the Tritium Facility that will be serviced in the near future using the PTPS.

Likewise, a plan is being formulated to interrogate hundreds of drums containing "legacy waste" by building a process line in which the PTPS will be responsible for pumping and capturing low levels of tritium. Finally, we have identified a near term use of the PTPS in support of metal bed oxidation. This is a marketable service that has already attracted attention from Sandia National. Lab, and DOE facilities across the country.

VIII. CONCLUSIONS

LLNL has fabricated a Portable Tritium Processing System (PTPS) that can be moved from lab to lab and perform basic tritium processing operations. These operations include: oil-free pumping, oil-free gas transfer, gas analysis, and gas phase tritium scrubbing. The system is completely self-contained and able to get through a typical 36" door. The PTPS is made up of individual carts, or modules, that compliment each other in the tasks they perform. The carts are built to present glovebox standards, using 3/16" stainless steel construction with Lexan windows. Glove ports are commercially manufactured items.

Gas samples can be analyzed with the on-board partial pressure analyzer. Gases containing tritium can be passed through a reactor and cor verted to tritiated water. The tritiated water is captured on molecular sieve dryer beds.

Operation of the PTPS is through a programmable logic controller, with the system being displayed on a CRT. All pertinent information is also displayed and is easily accessible to the system operator.

After one year of operation, the PTPS has worked well, with few flaws and very little down time. The only mentionable concern is the lack of data storage, and this problem has been addressed.

There are several future uses of the PTPS that are being planned: One, is the processing of large vessels such as gloveboxes or maintenance hoods. Another future use of the PTPS is to support metal bed oxidation systems; a feature that has attracted the attention of several other DOE facilities.

ACKNOWLEDGMENTS

There are major contributors to the design and development of the PTPS. Thanks to Eric Fought for his careful planning and layout of the Pump/Transfer cart, and to Steve Holmes for his diligent participation in the fabrication of the Clean-up cart. David Cain provided his expertise in the development of the Gas Analysis cart, and thanks to Brian Kelly who welded all of the critical joints throughout the system. Greg Mack and Greg Soto were instrumental in programming and de-bugging the PLC and associated electronics, and thanks to the countless individuals who participated in this program. Finally, thanks to Tritium Facility

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