The Tritium Emissions Reduction Facility (TERF) system is utilized to protect the environment and the public from discharges of radioactive tritium. In general, small quantities of low concentration tritium-containing gas mixtures are handled. A process flow diagram of the collection and process systems is depicted in Figure 1.

Gaseous process effluent from all of Mound's tritium handling systems are collected by a series of headers and piped to the TERF system. The gases going to the TERF System are filtered, compressed, heated, and passed through reactors where the tritium and tritium-containing compounds are oxidized to form tritiated water. After cooling, the tritiated water is removed from the gas stream as the gases are passed through molecular sieve drying towers. The decontaminated gases are then monitored and released to the stack. The dryers are regenerated as required. The captured water is removed, collected, assayed, and packaged for burial.

The tritium concentration in the inlet, on the average is 1 ppm, but on occasion could be as high as 1,000 times this value. The TERF System design criteria for tritium emissions is less than 200 curies per year for routine operation. The routine gas flow rate is 25-80 cfm with a sprint capacity of 180 -225 cfm (with both compressions). The approximate gas composition is 75% nitrogen, 5% oxygen, 18% argon, 2% helium, and traces of tritium. TERF System gases which still contain concentrations of tritium to high for direct discharge to the atmosphere, are diverted to the surge tanks, after they have passed through the reactors and the dryers.

Excessive flows received at the inlet to the TERF System can also be diverted to these surge tanks. The maximum excessive flows expected are 300 cfm for 10 minutes, followed by 250 cfm for 20 more minutes. After these times the flows are expected to be controlled (down to 200 cfm or less). The surge tanks are piped in parallel with a total value of 5,600 cubic feet. This value allows one to start at 0.5 psia, accept twice the flow estimated above, and still have an internal pressure of only 13.5 psia.

The gases enter the TERF System at room temperature and at a pressure of -2.0 psid (below room atmospheric pressure). Gas temperatures are unchanged by filtering, but the pressure is slightly reduced at the outlet of the filter unit. Particulate material and mists are filtered and collected from the gas before the gas enters the compressors. The large volume of the filter system will tend to smooth out pressure, composition, and flow fluctuations to the compressors.

Brink filters are particulate collection devices which use packed fiber beds to remove liquid droplets and solid particles from gas streams. The tortuous pathway through these beds makes them very effective in collecting small particles (near one micron in diameter) as well as large oil droplets. These beds are also very resistant to plugging; hence they do not rapidly (overnight) plug. The beds also protect the compressors from damage or wear caused by particulates and oil in the TERF System gases. The filters are in parallel, each having sufficient capacity to allow for filter maintenance while maintaining the TERF System operation.

The gases entering the TERF System may be diverted to the two evacuated 2,800 cubic foot surge tanks if the flow is temporarily greater than the system capacity, if incoming gasses are in the explosive or flammable range, or if the process system becomes inoperative. High tritium concentrations (above the alarm level) in the TERF System exit gas are also diverted to the surge tanks, until the tritium concentration returns to normal. The piping leading to this surge tank can withstand a hydrogen deflagration, while the search tanks cannot. Whereas hydrogen is combustible when its concentration reaches 4.0% in air, it does not explode with oxygen unless its concentration is at least 14% in air. The largest credible source of hydrogen at Mound that could be sent suddenly to the TERF System is a size 1A cylinder of hydrogen (240 cubic feet). If a 240-cubic-foot batch of hydrogen were released into the TERF System, in spite of all the present precautions against this happening, the combustible gas analyzer would detect it and send it to the surge tank. The concentrations of hydrogen and oxygen in the surge tank would be calculated from the combustible gas and option meter readings. If either the hydrogen concentration is below 14% or the oxygen concentrations below 7%, then it will be pumped out slowly into the TERF System inlet gases and processed. If the instrumentation determines that the hydrogen in the surge tank(s) is potentially an explosive mixture, then the tank(s) is/are diluted with nitrogen until these concentrations fall below their critical values before being processed. This procedure protects both the surge tanks and their associated piping: The much lower pressure of the incoming mixture, or the presence of diluent in the tank, also keeps the mixture out of the explosive range.

The surge tanks are located outside of T-Building on a concrete pad. Since the surge tanks are normally maintained at a negative pressure, leakage of tritium from the tanks could only occur in the unlikely situation where the surge tanks were pressurized and a leak occurred simultaneously.

The gasses are pumped into the TERF System by compressors, which maintain an inlet pressure of 10 to 12 psia and a discharge pressure of up to 100 psig. The entering gas temperature is about 70 ° F and the exit gas temperature from the compressor is approximately 250 ° F. In the next step of the process, the tritium containing gases are reacted in catalytic reactors. The reactors are usually operated at 475 ° F and 30 psia, however, they can safely operate at temperatures up to 600 ° C and at pressures up to 100 psig. An oxygen meter and combustible gas analyzer are installed upstream of the filter system to measure the oxygen and combustible gas concentrations in the gases to the reactors.

The gases from the reactors are cooled by passing them through a heat exchanger (chilled-water-cooled) and then fed to a series of parallel absorption trains filled with Type 4A molecular sieve or equivalent. These units reduced the water vapor concentration to less than 10 ppm. The adsorption trains are normally operated at room temperature and approximately 15 psig, with at least one train on-line at all times.

The adsorption trains are regenerated by heating nitrogen gas to 600 °F and passing it through them countercurrently, until the water has been stripped down to less than 1 lb of water per 100 lbs of molecular sieve. The regeneration gas is fed to the downstream side of the dryer being regenerated and is removed on the upstream side. The water is then removed from the nitrogen stream by passing it through coolers. In this process the nitrogen stream is cooled down to -20 ° F. The regeneration is done at atmospheric pressure.

The TERF System is instrumented so that detailed performance of all major equipment components can be evaluated by analyzing the gas being processed. Sampling ports are placed at strategic points on the system so that gas and water samples may be taken and analyzed to determine system performance. Instrumentation is also provided to monitor the general performance of each unit. This includes temperature, pressure, flow rate, moisture level, and tritium concentration for each major piece of equipment that can cause a change. The TERF System inlet header is equipped with a flow meter and a tritium monitor to identify the amount of gas and its tritium concentration. The alarms for the TERF System are monitored during the normal workweek by the operators. At other times they are connected to an automatic telephone dialing system which alerts Mound TERF operators and supervision if an alarm has been activated.

The temperature, pressure, flow rate, moisture level, and tritium concentration data are logged automatically at the process control center. All out-of-normal parameters are identified. The system is instrumented with a computer-controlled combustible gas monitor. The monitor (computer) will sound and alarm if the gas concentration entering the system approaches the lower combustible limit, and diverts the gas into the gas surge tank. This monitor will detect all of the anticipated combustible gases in the TERF System (hydrogen, methane, larger molecular weight hydrocarbon gases, solvents, and organic cleaning compounds).

The TERF System is computer-controlled with very limited ability for manual operation. A Distributed Control System (Foxboro) is used to monitor, log, and display parameters of interest, and activate an alarm if anything is outside preset conditions selected by operations, engineering, and safety personnel.

FIGURE 1-1 — The TERF Process