EBR-II FACILITY FOR CLEANING AND MAINTENANCE OF LMR COMPONENTS*

CONF- 860311--4

by

CONF-860311--4
DE86 007996

R. A. Washburn

EBR-II Project
Argonne National Laboratory
P.O. Box 2528
Idaho Falls, Idaho 83403-2528

Submitted for Presentation
at the
American Nuclear Society
Topical Meeting on Nuclear Power Plant Maintenance
March 23-27, 1986
Salt Lake City, Utah

*Work supported by the U. S. Department of Energy Reactor Systems, Development and Technology, under Contract W-31-109-ENG-38

EBR-II FACILITY FOR CLEANING AND MAINTENANCE OF LMR COMPONENTS

R. A. Washburn

Argonne National Laboratory
Idaho Falls, Idaho 83403-2528, U.S.A.

ABSTRACT

The cleaning and maintenance of EBR-II sodium wetted components is accomplished in a separate hands-on maintenance facility known as the Sodium Components Maintenance Shop (SCMS). Sodium removal is mostly done using alcohol but steam or water is used. The SCMS has three alcohol cleaning systems: one for small nonradioactive components, one for small radioactive components, and one for large radioactive components. The SCMS also has a water-wash station for the removal of sodium with steam or water. An Alcohol Recovery Facility removes radioactive contaminants from the alcohol and reclaims the alcohol for reuse. Associated with the large components cleaning system is a major component handling system.

INTRODUCTION

A Sodium Components Maintenance Shop (SCMS) has been designed and constructed for the removal of sodium from radioactive and nonradioactive sodium-wetted components so that hands-on maintenance activities can be performed. Highly radioactive components cannot be cleaned or maintained in the SCMS facility.

Sodium removal is primarily accomplished by the use of denatured ethyl alcohol, but steam and/or water is also used. Ethyl alcohol is used to clean sodium components that may possibly be damaged if cleaned with steam or water. Steam and/or water is used to clean sodium components whose function will not be impaired or will not be reused and for the disposal of bulk sodium.

This paper describes the SCMS facilities, alcohol cleaning systems, alcohol recovery system, and the major component handling system.

SCMS FACILITIES

The SCMS is a separate facility from the EBR-II reactor facility and thus the maintenance of sodium wetted components requires that components be removed from the reactor facility and transported about 150 meters to the SCMS for cleaning and maintenance. The SCMS allows for sodium removal and maintenance activities to be conducted anytime of the year regardless of weather conditions.

The SCMS consists of a High Bay which has attached south and north annexes, an associated outdoor uncovered alcohol storage pad and a contaminated storage addition as shown on Fig. 1.

The High Bay houses the facilities required for removing sodium from sodium wetted components. It contains the Large and Small Component Cleaning Systems and the Water-Wash System. There is space for disassembly, maintenance, and reassembly of the components. The high bay is approximately 12 m x 20 m in plan with clearance for a bridge crane with a 9.8 m minimum hook height. Two 13.5 Mg electrically powered, separately controlled hoists on a single manually powered 27 Mg bridge and one 4.5 Mg electrically powered bridge crane are installed on the building crane rails.

Vehicle and component access into the High Bay is through rolling hanger type doors located at both ends of the building. When the doors are fully open, a clear opening of about 6 m wide and 9.8 m high is available.

The south annex, known as the Equipment Annex, is 7.3 m wide x 14.6 m long and 4.3 m high on the low side. This annex contains suspect (HEPA) filters, an exhaust fan for the ventilation of the High Bay, power and motor controls, a 15,000 L retention tank for storing radioactively suspect waste water, and a 1135 L scrubber water holding tank.

The north annex, known as the Alcohol Recovery Facility (ARF), is 7.3 m wide x 7.3 m long and 4.3 m high on the low side. The ARF houses the equipment necessary to process the waste alcohol solutions generated by the SCMS cleaning operations.

An outdoor uncovered concrete pad is located approximately 9 m northwest of the High Bay. Alcohol storage tanks used in conjunction with the alcohol cleaning systems and alcohol recovery are installed on this pad. Above ground piping connects the storage tanks to the ARF and the high bay cleaning and process systems.

Located on the west side of the SCMS is the SCMS contaminated storage addition. This building is used for the temporary storage of sodium wetted components and of maintenance equipment. The storage building is a steel building 9 m wide x 12 m long and 5 m high at the eave.

Ventilation System

The High Bay has two separate ventilation systems. One operates during sodium cleaning operations and the other operates when cleaning is not being done. When cleaning operations are in progress, the air is brought into the High Bay from the outside through a steam preheat coil located in the north wall, the air passes through the High Bay, enters a HEPA-filtered exhaust system at the south wall, and is exhausted to a stack by a 4.7 m^3/s exhaust fan. Exhaust ducts are also provided near the ridge of the roof of

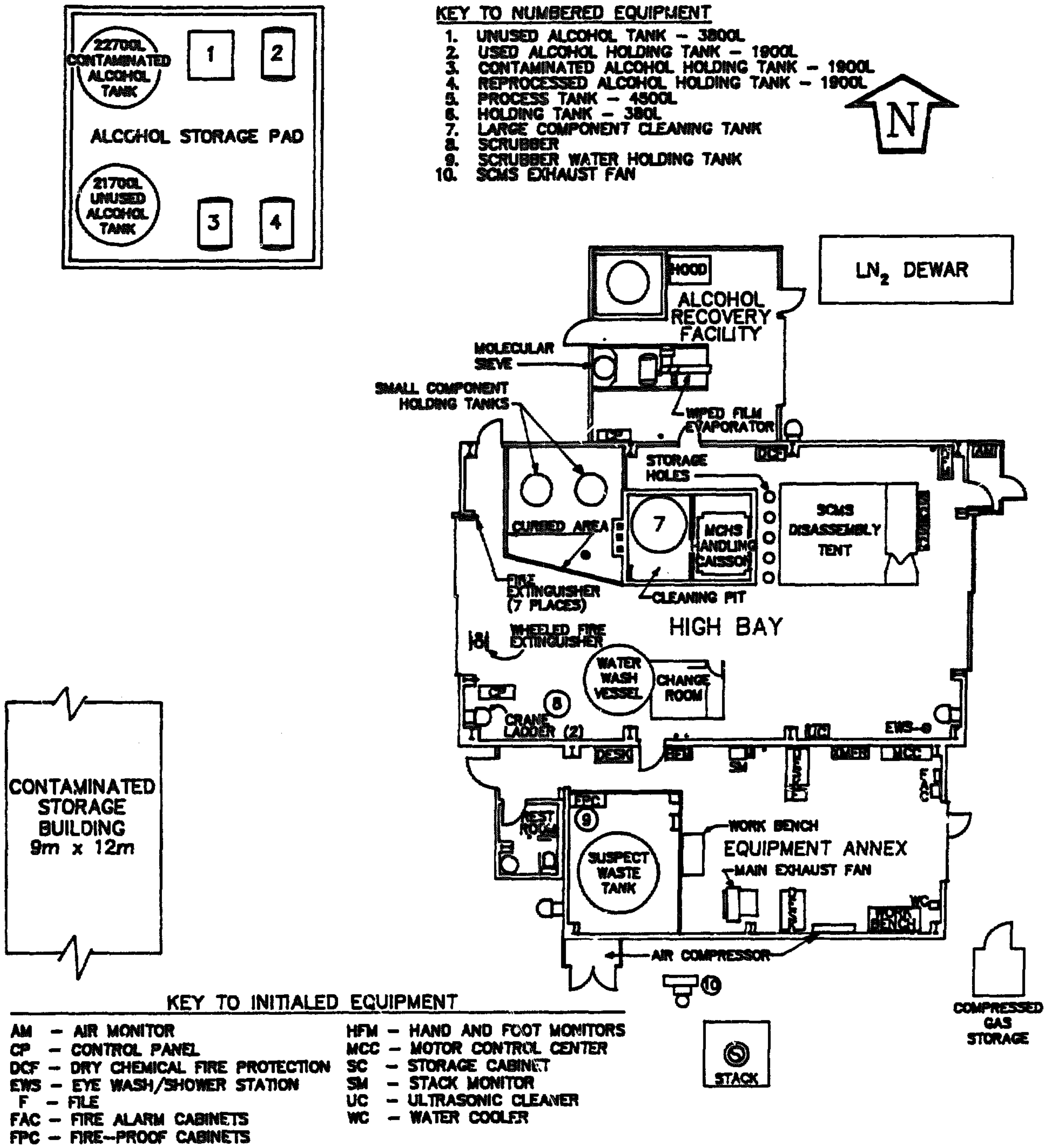

FIG. 1 SCMS LAYOUT

ACAD: SCMS-1

the High Bay to remove any combustible gas that may have collected in that area. When cleaning operations are not in progress, the HEPA-filtered exhaust system is shut down, and space heating is provided by steam unit heaters and ventilation is provided by a roof exhaust fan.

Suspect Liquid (Water) Waste System

The Suspect Liquid Waste System stores water from the water-wash vessel, scrubber, and from the High Bay floor drains. This system consists of a 15,000 L liquid-waste retention tank, a transfer pump, sand traps, and two floor drains located in the High Bay. The retention tank is located in a pit in the Equipment Annex. The waste is periodically dumped from the retention tank into a portable transfer tank for processing via the Radioactive Liquid Waste Treatment Facility ANL-W.

Water and Steam Service

Potable water and 1200 kPa steam is provided to the SCMS for cooling and heating of process equipment, for scrubber water, and for sodium removal and decontamination of components in the water-wash vessel.

Electrical

Electrical power (500 kVA) is provided at 480 V to the motor control center in the Equipment Annex.

The High Bay and the ARF are considered hazardous locations because of the possible presence of alcohol vapors, and as such, are classified by the National Electrical Code (NEC) as Class I, Division 2 locations. This NEC classification requires electrically operated components to be either intrinsically safe, designed for Class I, Division 2 locations, or installed in such a manner as to be suitable for use. Other areas within the SCMS complex are considered nonhazardous and use general purpose electrical components.

ALCOHOL CLEANING SYSTEMS

The alcohol cleaning systems consists of two small component cleaning systems, a large component cleaning system, and a storage system for used and unused alcohol. Both the small and large component cleaning systems use denatured ethanol for sodium removal.

The Small Component Cleaning Systems and the Large Component Cleaning System have many common interfaces, such as the alcohol storage tanks, the inerting gas system, the gas sampling system and the steam, air, and water systems. Figure 2 is a simplified flow diagram of the Small and Large Component Cleaning Systems.

Small Component Cleaning System

The small component cleaning system consist of a system for cleaning nonradioactive components and one for cleaning radioactive components. The small component cleaning systems are located in the High Bay as shown on

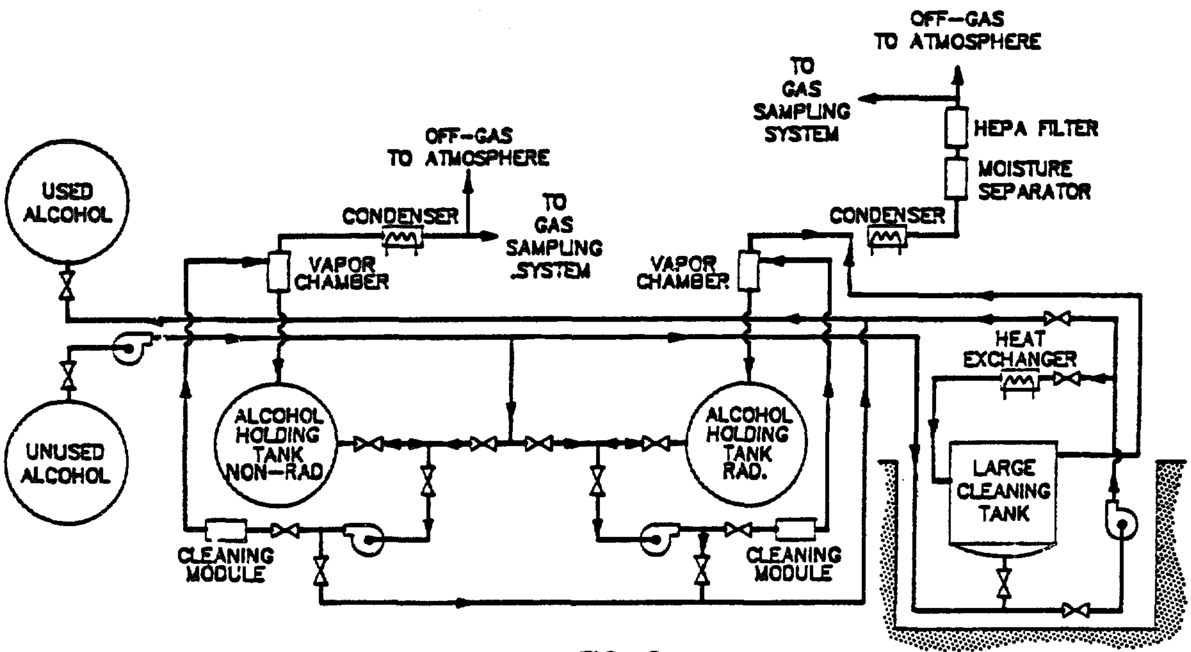

FIG. 2
SIMPLIFIED SCMS ALCOHOL CLEANING SYSTEMS FLOW DIAGRAM

Fig. 1. Each system basically consists of an alcohol holding tank, an alcohol recirculation loop, an off-gas system, an inert gas system, and a gas sampling system as shown on Fig. 2.

Alcohol Holding Tanks: The alcohol holding tanks have a nominal capacity of 1135 L. Each tank is a double walled vessel so that steam for heating and water for cooling may be introduced into the annulus between the walls to raise or lower the temperature of the alcohol as a way of controlling the alcohol-sodium reaction rate. Each tank is provided with a normal vent for venting nitrogen and hydrogen. An emergency vent is also provided which contains a safety valve. Each tank has an equipment hatch so that small components can be placed directly into the tank for cleaning.

Alcohol Recirculation Loop: The recirculation loop contains a pump, valves, instrumentation, and a cleaning module for holding the component to be cleaned. The cleaning module may be nothing more than a length of pipe with flanges and end fittings for attachment of the alcohol lines or a simple vessel to accommodate a component. In many cases the component itself is used as a cleaning module if only the interior requires cleaning.

Large Component Cleaning System

The Large Component Cleaning System consists of a large cleaning tank, an alcohol recirculation loop, an off-gas system, an inert gas system, a gas sampling system, and storage tanks as shown on Fig. 2. The cleaning system is located in the High Bay adjacent to the small component cleaning systems as shown on Fig. 1. The large component cleaning system was specifically designed to clean the primary pumps, fuel transfer arm, storage basket, and the intermediate heat exchanger. The approximate size and weight of these components are:

Primary Coolant Pump	18.4 Mg	1.2 m Dia x 6.4 m long
Intermediate Heat Exchanger	29.5 Mg	1.5 m Dia x 6.7 m long
Transfer Arm	16.3 Mg	2 m x .6 m x 5 m long
Storage Basket	22.7 Mg	1.7 m Dia x 6.1 m long

The cleaning tank is located in a pit to provide sufficient overhead access for installation and removal of large components.

Large Component Cleaning Tank: The large component cleaning tank has a nominal volume of 22,700 L. The tank is about 2 m in diameter and 6.8 m long. The tank has a bottom fill and drain line and a normal vent that leads to the off-gas system used by the small radioactive component cleaning system. The tank also has an emergency vent containing a safety valve.

Alcohol Recirculation Loop: The recirculation loop contains a pump, a heat exchanger, valves, and instrumentation. The pump recirculates alcohol during cleaning and transfers alcohol to the used alcohol storage tank. The heat exchanger heats or cools the alcohol to control the rate of sodium-alcohol reaction rate.

Off-Gas System

The off-gas system vents inerting gas (nitrogen) and hydrogen from the alcohol holding tanks and the large component cleaning tank to the atmosphere outside of the High Bay. Both off-gas systems contain a water-cooled condenser for condensing the alcohol vapors in the off-gas. The small radioactive component cleaning system also contains a HEPA filter for removing radioactive particulates from the off-gas and a moisture separator to remove entrained moisture to prevent plugging of the HEPA filter.

Alcohol Storage System

Alcohol used in the SCMS is stored in outside above-ground storage tanks on a concrete alcohol storage pad. Tanks are provided for the separate storage of unused alcohol, used radioactive alcohol, and used nonradioactive alcohol. Each tank is blanketed with inert gas.

Figure 1 shows the location of the alcohol storage pad and the general arrangement of the storage tanks. The storage pad is a 9.8 m x 9.8 m concrete pad with an 0.46 m high surrounding wall to contain all alcohol that would be released if the largest tank failed.

Alcohol storage includes:

1. A 3800 L tank and a 22,700 L tank for storing unused alcohol.

2. A 22,700 L tank for storing used radioactive alcohol.

3. Two 1900 L holding tanks - one for storing used nonradioactive alcohol and one for storing used radioactive alcohol.

4. A 1900 L holding tank for storing reprocessed alcohol.

Each storage tank is provided with a conservation vent to reduce evaporation losses and to allow the tank to breathe while being filled or emptied. Each tank is also provided with an emergency vent containing a safety valve to relieve excessive internal pressure.

Two pumps on the storage pad transfer alcohol to the cleaning systems. A 57 L/min canned pump transfers alcohol to the Small Component Cleaning System, and a 190 L/min canned pump transfers alcohol to the Large Component Cleaning System or the Small Radioactive Component Cleaning Systems. There is also a pump for transferring alcohol to the ARF and a pump to transfer reprocessed alcohol to either clean or contaminated storage.

Inerting Gas System

A liquid nitrogen system with a vaporizer provides gaseous nitrogen for inerting the alcohol cleaning systems and the alcohol storage tanks. A gaseous nitrogen blanket is maintained on each alcohol storage tank to prevent the formation of an explosive mixture of alcohol and oxygen and to keep the fresh alcohol pure.

Prior to filling with alcohol, the tanks and cleaning module are inerted to reduce the oxygen concentration to less than 1%. After filling, inerting is maintained to keep the oxygen concentrations less than 1% and to sweep hydrogen from the tanks and cleaning module through the off-gas system.

Gas Sampling System

A gas sampling system is provided to monitor the oxygen and hydrogen in the off-gas. A hydrogen meter, oxygen analyzer, and a gas chromatograph are located in the SCMS alcohol instrument and control panel. The oxygen meter is used to monitor the oxygen concentration in the alcohol holding tanks or large component cleaning tank. The on-line hydrogen meter and the gas chromatograph are used to monitor the hydrogen that is evolved during the alcohol-sodium reaction.

ALCOHOL RECOVERY FACILITY

The waste sodium-alcohol solution generated by SCMS operations is processed by the Alcohol Recovery Facility (ARF) to convert the waste to sodium carbonate, to recover the alcohol for reuse and to reduce the volume of sodium waste for disposal in the Radioactive Waste Management Complex (RWMC).[1]

The equipment used in the ARF consists of a process tank, a wiped-film evaporator, a molecular sieve, alcohol holding tanks, pumps, and 208 L barrels for collection of the solid waste. Storage tanks and pumps located on the alcohol storage pad are used as needed for the process. A flow diagram of the process is shown on Fig. 3. Contaminated alcohol is pumped from the alcohol waste tank to the process tank where water is added to the alcohol to convert the sodium ethoxide to sodium hydroxide. The alcohol is pumped to the wiped-film evaporator which is maintained under a carbon dioxide atmosphere to convert the sodium hydroxide to sodium carbonate. In the wiped-film evaporator the alcohol is boiled off, condensed to a liquid in a condenser, and collected in a 380 L holding tank. The waste product, a sodium carbonate powder is collected in a 208 L waste drum. The condensed alcohol is then pumped through the molecular sieve dryer to remove water and is collected in the 1900 L reprocessed alcohol holding tank.

Wiped-Film Evaporator

The evaporator is of the wiped-film, rotary vane type with a water cooled condenser. The wiped film evaporator is a .46 m^2 unit and is rated at 57 L/h. The vane which is enclosed in a steam jacketed chamber rotates at 750 rpm where the alcohol is thrown against the heated walls to form a thin film and is then evaporated. The alcohol vapor is condensed in a 2.8 m^2 water-cooled condenser. The solids are forced to the end of the evaporator by the rotating vane and are discharged through a bottom opening into a 208 L drum.

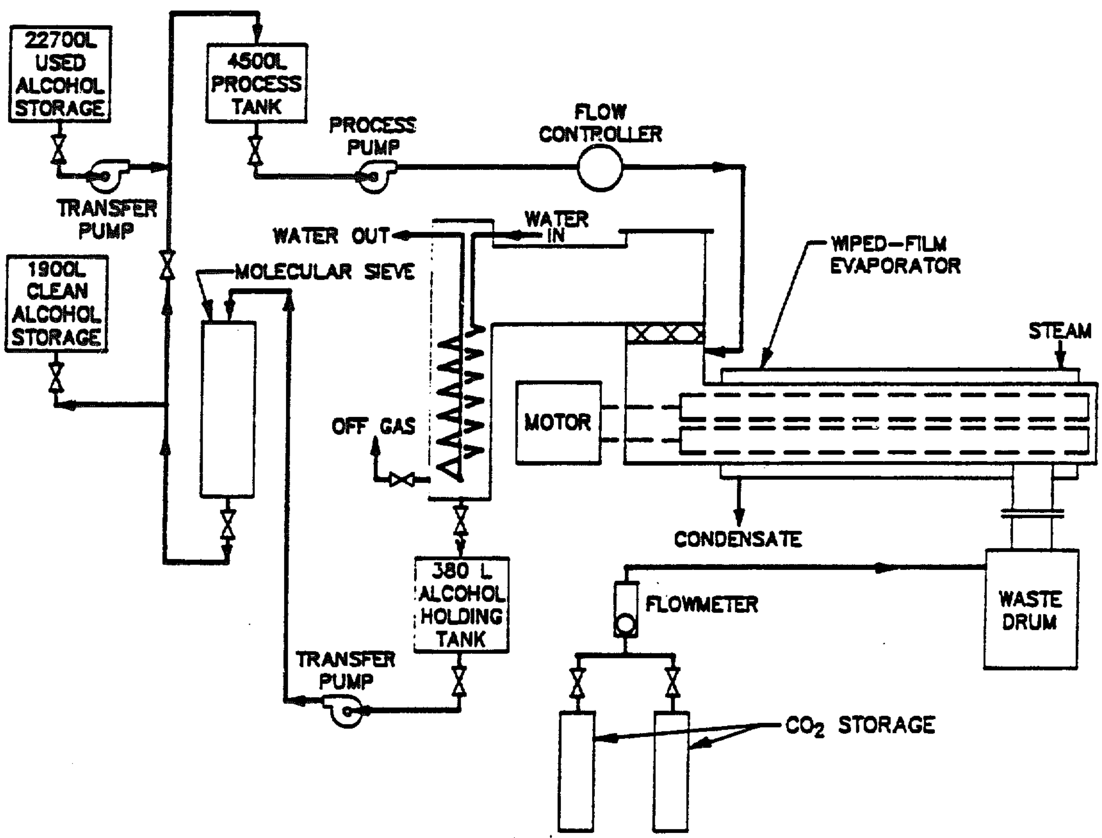

FIG. 3
SODIUM CARBONATE PROCESS FLOW DIAGRAM

Molecular Sieve

The molecular sieve consists of a tank filled with 3A molecular sieve pellets for drying ethyl alcohol so that the alcohol water concentration will not exceed acceptable levels. Four steam panel coils within the tank are used to regenerate the pellets by heating to 177°C. The four panel coils are welded into a manifold and are supplied with 1200 kPa steam and have a heat transfer surface of 9.5 m^2.

WATER-WASH SYSTEM

The Water-Wash System uses steam and/or water to remove sodium from equipment or components not intended for reuse or where the functionability will not be impaired. The water-wash system is also used for performing limited decontamination of components that may still be radioactively contaminated after sodium removal.

The Water-Wash System basically consists of a vessel and a ventilation system. The vessel contains the sodium-water reaction, thus protecting personnel from small hydrogen detonations, hot caustic and sodium, and radioactive contamination. The ventilation system consists of a venturi scrubber with liquid separator, moisture separator, air heater, HEPA filters, exhaust fan, and direct to atmosphere vent. The air is exhausted from the vessel through the scrubber, and HEPA filters before being released to the SCMS exhaust stack. The general arrangement and location of the equipment is shown on Fig. 1. A flow diagram of the ventilation system is shown on Fig. 4.

Water-Wash Vessel

The water-wash vessel is constructed of stainless steel and is approximately 3 m in diameter and 4 m high. The bottom of the vessel is dished to allow for drainage. The vessel is designed for 345 kPa to accommodate a hydrogen/air reaction but operates at or near atmospheric pressure. The top head contains openings for equipment access. A side access door is provided for equipment and personnel entry. Small sealed ports in the side of the vessel provide for insertion of steam and water lances and view ports allow for observation of cleaning operations.

Scrubber

The venturi scrubber is designed to remove all of the reaction products resulting from burning sodium at a rate of 6 g/s. This is very conservative since less than half of the reaction products will leave the water-wash vessel. The scrubber is specified to have an efficiency of 97% for a particle size of 0.37 micron. The scrubber includes a liquid separator for separating the liquid from the exhaust air preventing liquid carry-over into the downstream HEPA filter.

A water-recirculation system is used to reduce the amount of contaminated water that will require disposal. The scrubber water holding tank and the water recirculation pumps are located in the suspect-waste-tank pit in the SCMS Equipment Annex.

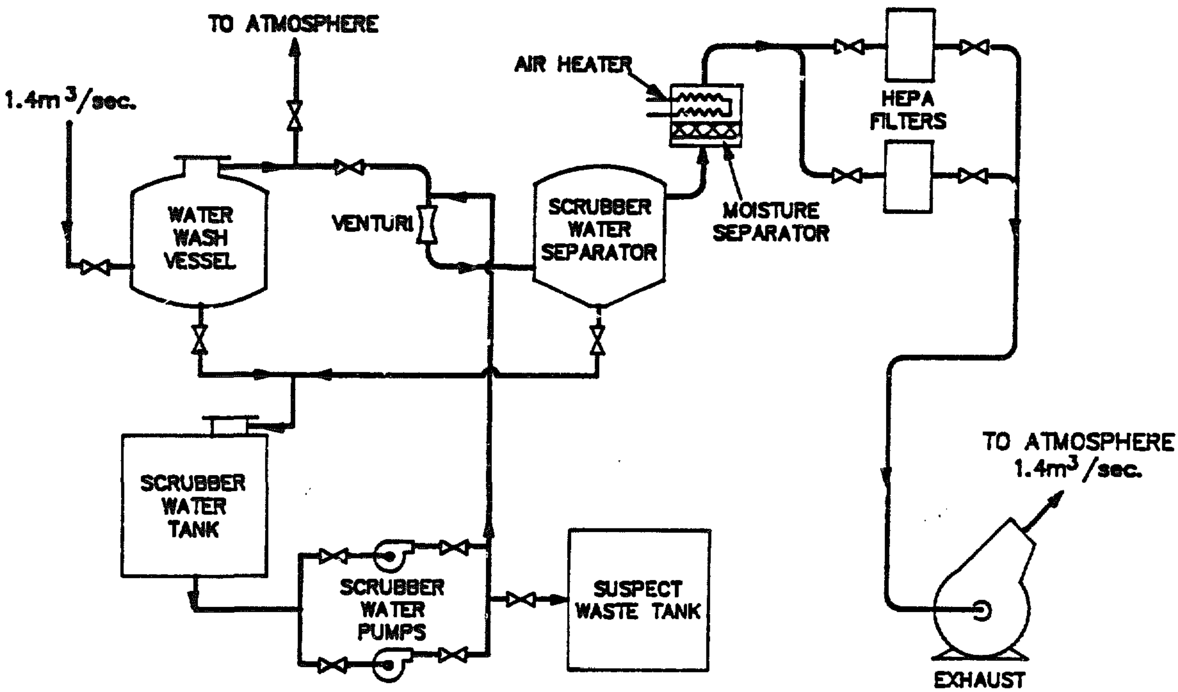

FIG. 4
SIMPLIFIED SCMS WATER–WASH FLOW DIAGRAM

Entrained Moisture Separator

A moisture separator between the scrubber liquid separator and the air heater removes the remaining entrained liquid droplets to protect the HEPA filters from moisture.

Air Heater

A steam heated air heater between the moisture separator and the HEPA filters increases the exhaust temperature a minimum of 12°C to preclude condensation of moisture in the HEPA filters.

HEPA Filters

Two banks of High Efficiency Particulate Air (HEPA) filters downstream of the air heater provides for final collection of sodium-water reaction products. Each filter bank contains four filters installed in bag-out housings. Only one filter bank is in operation at one time while the other bank is in readiness for service.

Exhaust Fan

The exhaust fan provides a ventilation flow of 1.4 m^3/sec. This allows for dilution of the sodium-water reaction products and for efficient operation of the scrubber. The exhaust fan pulls the ventilation air through the vessel, scrubber, HEPA filters and then exhausts the air to the SCMS ventilation exhaust stack.

Direct to Atmosphere Vent

The ventilation system also includes an alternative direct to atmosphere path to vent hydrogen from the vessel if the exhaust fan fails during a cleaning operation.

MAJOR COMPONENT HANDLING SYSTEM

A major component handling system was designed and fabricated to facilitate the removal and installation of large components from and into the EBR-II primary tank, and for the transport of large components to and from the SCMS for sodium removal and maintenance activities. The major component handling system was specifically designed to handle the primary pumps, intermediate heat exchanger, fuel storage basket, and the fuel transfer arm.

Large component removal from the primary tank is accomplished using a handling system consisting of gastight enclosures that contain the component while minimizing oxygen contamination of the primary tank cover gas. After removal, the handling system provides means for containing, handling, and transporting the large components out of the EBR-II reactor building to the SCMS for cleaning, and maintenance operations.

The major component handling system basically consists of the following components: adapters sections, pulling caissons, handling caisson, nozzle flange inspection equipment, and an argon control panel.

Adapter Section

The Adapter Section serves as a gastight transition between the primary tank nozzle and the pulling caisson. Each primary tank nozzle has a adapter section to suit its particular shape, size, and location in the top of the primary tank. Each adapter section is equipped with viewing windows, a trap door, a manhole, and argon gas connections. The viewing windows are used to observe the component during removal and insertion operations. The trap door is used to seal the vacated nozzle after the component is removed. The manhole provides personnel access for the connection of the Pulling Caisson Piston to the component. The argon gas connection provides a source of argon to maintain positive pressure in the Adapter Section and prevent air in-leakage and the escape of the primary cover gas.

Pulling Caisson

The Pulling Caisson forms a gastight enclosure to contain the component during removal or insertion operations. Two types of pulling caissons are supplied: one, a cylindrical metal enclosure for removal of the Primary Sodium Pumps, Intermediate Heat Exchanger, and Fuel Storage Basket; and the other, a flexible bag enclosure for the Fuel Transfer Arm. The cylindrical metal enclosure is about 2 m in diameter and 9 m long, and includes a metal movable piston with two inflatable seals between the piston and cylindrical metal walls, tie bars, and a bottom metal cover. The piston is connected through a load cell to the reactor building crane. The flexible bag enclosure consists of a collapsible bag 2.7 m in diameter and 9 m long, a bag clamp, and a circular bag support frame with tie bars.

Handling Caisson

The Handling Caisson is used to contain and support the major component during transport out of the reactor building to a cleanup facility. The Handling Caisson is a rectangular metal structure, 6.9 m long with approximately a 2 m square cross section. I beams are welded to the front and back rectangular side surfaces to increase the rigidity and serve as a roller support surface during handling operations. Four adapter plates with mounting holes that duplicate the primary tank nozzle hole configuration of the component to be removed are provided. Interchangeable inside support pads to support the different components in the Handling Caisson are provided. The support pads are positioned by jack screws.

Nozzle Flange Inspection Equipment

The nozzle flange inspection equipment is an assembly consisting of an adapter section cover and a nozzle cover. A particular assembly is provided for each major component nozzle. The adapter section cover of the assembly is installed on top of the adapter section after the major component has been removed. The trap door in the adapter section is then opened and the nozzle cover lowered onto the offset in the nozzle. The nozzle cover will prevent objects from falling into the reactor and provide a platform for a worker to clean the nozzle flange and gasket.

Argon Control Panel

The argon control panel performs a variety of functions for MCHS operations within the reactor building. By connecting the panel to the various MCHS components, argon gas at regulated pressure and flow can be supplied for purging and maintaining an inert atmosphere. Also, argon gas is supplied to the pulling caisson piston to activate the inflatable seals.

SUMMARY

When EBR-II was designed, a facility for maintenance of sodium components wasn't provided. Later on it was recognized that a facility was needed for maintenance of sodium components in a controlled environment. This would allow maintenance activities to be conducted under any weather condition, would allow for better control of the cleaning processes, and would allow for controlled disposal of gaseous and liquid wastes. Thus, a facility was designed and constructed for the removal of sodium from radioactive and nonradioactive component using alcohol, steam and/or water so that hands-on maintenance activities could be performed. Maintenance activities has been performed on components such as secondary sodium cold traps, FUM grippers, vapor traps, valves, piping, primary pumps, superheaters, and fuel transfer arms. The SCMS has proven to be invaluable in the support of EBR-II maintenance activities on sodium-wetted components.

ACKNOWLEDGEMENT

Work supported by the U.S. Department of Energy, Reactor Systems, Development and Technology, under Contract W-31-109-Eng-38.

REFERENCES

1. John R. Krsul and Robert A. Washburn, "Removal of Radioactive Sodium from Experimental Breeder Reactor II Components and Conversion to a Disposable Waste: Alcohol Recovery," *Nuclear Technology*, 70, 424 (1985).