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August 23, 1982
4400-82-L-0115

TMI Program Office
Attn: Dr. B. J. Snyder, Program Director
US Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Makeup and Purification System Demineralizers

The purpose of this letter is to provide information developed to date on the Makeup and Purification Demineralizers while performing DOE Task Order referred to in GPU letter 4400-82-L-0063. The information collected provides an operating history of the demineralizer system and baseline information from the vendor on the resins loaded in these demineralizers. In order to characterize the current contents of the demineralizers, several analyses have been performed based on available information. These analyses include estimates of the curie loading and the gas generation in each demineralizer as well as estimates of the radiation dose, thermal damage, and radiation damage to the demineralizer resins. An analysis estimating the amount of fuel in each demineralizer has indicated that criticality is not a concern.

In addition, GPU has made an assessment of the feasibility of making a radiation profile of the demineralizers' exteriors and of sampling the vent gas, the demineralizer cubicle gas, and the resin inside of each demineralizers. Consideration of the technical approach to obtaining these samples is included in this assessment.

Attached is a summary of the information compiled to date concerning the Makeup and Purification Demineralizers.

Sincerely,

B. K. Kanga
Director, TMI-2

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BKK/JJB/jep
Attachment

CC: L. H. Barrett, Deputy Program Director - TMI Program Office

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SUMMARY

1. Description of Resin

Fifty cubic feet of Rohm and Haas Amberlite IRN-217 was originally loaded into each of the two Makeup & Purification Demineralizers (MU-K-1A & MU-K-1B).

This resin is a 2:3 mixture of Amberlite IRN-218 and Amberlite IRN-78.

Amberlite IRN-218 is a strongly acidic cation exchange resin with a minimum of 99% of its exchange sites in the lithium⁷ form. The minimum total exchange capacity of Amberlite IRN-218 is 38.4 kilograins (as CaCO_3) per cubic foot or 1.76 milliequivalents per milliliter in the lithium form. Amberlite IRN-78 is a strongly basic anion exchange resin with a minimum of 80% of its resin exchange sites in the hydroxide form, a maximum of 5% of its exchange sites in the chloride form and a maximum of 15% of its exchange sites in the carbonate form. The minimum total exchange capacity of Amberlite IRN-78 is 17.0 kilograins (as CaCO_3) per cubic foot or 0.78 milliequivalents per milliliter in the hydroxide form.

2. Operating History of Makeup & Purification Filters & Demineralizers

The operating history of the makeup & Purification Filters and Demineralizers has been determined by examining operators' logs, alarm histories of the accident, and strip charts of the letdown section of the Makeup & Purification System. Both the filters and the demineralizers were relatively clean before the accident of March 28, 1979. Demineralizer resins were changed approximately two to three months before the accident and the Makeup Filters were changed on Feb. 27, 1979.

Attachment I provides a sequence of events pertinent to the Purification Filters & Demineralizers during the accident. The exact time that these components were isolated cannot be obtained from existing plant records nor from operator recollection. It is assumed the demineralizers were in operation at least up to the time letdown flow was lost at 18 hours and 35 minutes (2235) after the start of the accident at 4:00 a.m. The best assessment to date is that these filters and demineralizers were bypassed some time after 2235 in an effort by the plant operators to regain letdown flow. These filters and demineralizers were probably bypassed by the time letdown flow was regained at 0631 on March 29, 1979 and they have been isolated since then.

On March 24, 1982, both of the Makeup & Purification Filters were removed from the plant. They have since been sent to EG&G for isotopic & fuel content analyses.

The strip chart of the letdown coolers' outlet temperature was examined to determine the water temperatures to which the resins were exposed. The temperature of the water flowing through the demineralizers rarely exceeded the alarm setpoints of 135°F except for the following times after the start of the accident: The first high temperature condition, at 6 minutes and 54 seconds, lasted about 3 1/2 minutes with a maximum temperature peak of 139°F. The second high temperature occurred at 4 hours and 26 minutes. It lasted about 10 minutes with a maximum temperature of 160°F to 165°F. The third high temperature condition occurred at 8 hours and 45 minutes. It lasted

approximately 1 hour with a maximum temperature of 140°F to 150°F. On March 30, 1979 another high temperature condition occurred at 4:50 pm. The alarm lasted for 10 minutes with a maximum temperature of 150°F. However, this alarm is not considered relevant since the filters and demineralizers were, based on the assessment discussed above, bypassed by this time.

Several analyses have been performed to characterize the contents of the Purification Demineralizers. These analyses consist of estimates of the curie loading, the amount of fuel and the gas generation in each demineralizer and an estimate of the radiation dose received by the demineralizer resins.

Curie Loading

In order to calculate the total number of curies deposited on the demineralizer resins in the course of the accident, the flow rate of the water through the demineralizers and the specific activity of the RCS water was determined. According to plant operating records, the total volume of water to flow to the demineralizers in the 16 hr. and 25 min. time period following the initiation of core damage was estimated at 46000 gallons. The average flow rate was approximately 46.5 gallons per minute. A gross beta-gamma activity of 140.7 mci/ml. in the RCS water was obtained from Plant Chemistry Sample analyses taken 2 hrs. and 45 min. after the start of the accident. An estimate of the total activity contained in the resins at the time the demineralizers were isolated revealed that the resin in each demineralizer contained up to 4×10^6 curies of mixed fission products with the isotopes of iodine predominating. After more than three years of radioactive decay,

Cs-134 and Cs-137 are the most significant remaining gamma-emitting isotopes. Attachment No. II provides a table of each fission product's estimated activity at 18 hours and 35 minutes after the start of the accident when the demineralizers were isolated.

Radiation Dose

Using these curie loading estimates, the integrated radiation dose to the demineralizer resins was calculated to be above 8×10^8 Rads as of January 1, 1982. This dose includes both beta and gamma radiation.

It is believed that the curie loading estimate, and therefore the above radiation dose estimate may be high by a factor of 1.8 to 3, based on measured (60 - 100 Rem/Hr) and calculated (180 Rem/Hr) dose rate values in the demineralizer cubicles. The discrepancy between the calculated and measured dose rates could possibly be due to exhaustion of the beds resulting from the depletion of the demineralizer resins by loading with sodium during the accident. Sodium was injected into the reactor coolant system during the accident in the form of sodium hydroxide when the safety injection pumps were activated.

Fuel Loading

A calculation has been performed to determine the total amount of fuel which may be present in each demineralizer. A sample taken of the RCS one day after the accident indicated a fuel concentration of 68.24 milligrams per liter. This fuel had the following size distribution: 33.33 milligrams per liter of

particles greater than 5 microns, 14.28 mg/l of particles in the 1.2 to 5 micron range, and 20.63 mg/l of particles in the 0.45 to 1.2 micron range. It is assumed that this distribution was present during the accident before the demineralizers were isolated. Vendor data on the filters located upstream of the demineralizers indicates that they are 98% effective for 1 micron particles. If particles greater than 5 microns were completely removed and those less than 5 microns were 98% removed, the total mass of fuel in both demineralizers is about 120 gms. Since ANSI N16.1 specifies that the minimum critical mass for fuel with an enrichment of 3% is 70 kilograms, criticality is not a concern with the demineralizers.

Gas Generation

The gas generation in the demineralizers has been estimated. It is assumed that the demineralizer vessels were water solid at shutdown, that the relief valve is located on the bottom of the tank and is set at 150 psig, that the information on the originally installed resin is correct and that the total dose to the resins after three years is approximately 8×10^8 Rads. The possibility of dissolution of the gas into the water in the demineralizer is disregarded because the water was already at a high hydrogen concentration due to the accident. Gas volumes at 150 psig were calculated which represent the material lost from the system by means of the pressure relief valve. Since this valve is located on the bottom of the tank, water is lost first. Attachment III provides a summary of the estimated hydrogen production based on the original radiation dose estimates of $1-5 \times 10^9$ Rads which were based on initial estimates of the flowrate through the demineralizers. (This

radiation dose estimate has since been changed to 8×10^8 Rads based on more accurate flowrate data.) Estimates for the current three year time frame indicate that all of the water and some of the gas has been ejected from the demineralizers.

The calculation was based only on hydrogen production, however, it is expected that 7.5% of the amount of hydrogen will also be produced as carbon dioxide.

With the set point on the relief valve at 150 psi and assuming a 15 psi blowdown prior to resetting, it is estimated that venting should have occurred twice since the first two months for the low estimate and 25 times since the first two months for the high estimate.

Demineralizer Resin Characterization

The demineralizer resins have undergone significant thermal damage by two sources. The first source was the hot water flowing through the resin from the letdown line. The resulting thermal damage is considered to be minor since the resin temperature remained under 130°F with the exception of three high temperature occurrences discussed previously. Even so, these high temperature conditions never lasted longer than an hour at a time nor did the temperatures exceed 165°F. According to Rohm & Haas, the vendor, the cation resins in the mixed bed remain stable to 300°F and therefore were not thermally damaged during the three temperature peaks. Above 150°F the anion resins begin to lose functional groups, therefore they may have been slightly damaged during the 165°F temperature peak which lasted 10 minutes. These

functional groups, consisting of tri-methanol amine and other similar compounds would have been carried out of the resin beds during the accident since the high temperature condition occurred 14 hours before the demineralizers were isolated.

The second and most significant source of thermal damage to the resins was the energy absorbed from curies deposited on the resins. Prior to isolation, the heat generated by the curie loading in the demineralizer would have caused temperatures sufficiently high enough to boil the available water inside the vessel. Consequently, the vessel probably became steam filled, causing the water present in the interstitial voids of the demineralizer to be blown out under pressure through the demineralizer effluent isolation valves. These stop check valves were not closed until 2 days after the accident. Based on the calculated curie loadings, it is most likely that the resin bed centerline temperature became high enough for some of the resin beads at the center of the resin bed to melt. For a strong acid resin, this would result in a release of sulfates from the resins. The sulfates were probably released along with the water to the makeup system via the demineralizer effluent isolation valves. This would account for the presence of sulfates detected in the RCS after the accident. This action was probably terminated by the isolation of the demineralizers or the removal of the heat source by radioactive decay.

Upon isolation, the vessel became pressurized and the resins contained there in were heated even further with the only heat removal being that lost to ambient air. The heat source in the resins has since decreased due to radioactive decay.

It is probable that as a result of radiation damage to the resins, the resin beads have become soft and packed down and probably will not permit a high flowrate of water through them. It has further been determined that the resin beads may become gouged, pitted and cracked with the possibility of the final products of the degradation being soluble in water.

During the accident, the RCS chemistry was altered by the injection of water from the borated water tank and sodium hydroxide storage tanks and by reactions which took place within the reactor core area. These chemicals and the resin degradation products would have altered the chemistry of the demineralizers. The sulfate radicals produced by the increasing degradation of the cation resins combined with the sodium on the cation resins to form sodium sulfate, which is soluble in water. The breakdown of this compound in the water combined with the borate radical, which is present on the anion resins, results in the formation of a buffered sodium borate solution. Therefore, the pH of any water which may exist in the demineralizers is estimated to be about 5.0 to 5.5. However, as discussed previously, it is believed that most of the water has been removed from the demineralizers.

Demineralizer Sampling

In order to determine an appropriate method for the removal of the demineralizer resins from TMI, a radiation profile of the demineralizer exterior, a vent gas sample, a demineralizer resin sample and a demineralizer cubicle gas sample are desirable. An assessment of the feasibility and technical approach to obtaining these data is discussed below in the order of need and feasibility of performance.

1. Demineralizer Cubicle Gas Sample

Prior to any work in and around the demineralizer cubicles, it will be necessary to obtain combustible gas measurements in the working areas outside the cubicles (in the Hayes Gas Analyzer room), in and around the door entryways, and in the upper and lower portions of the cubicles themselves. One method for obtaining a local combustible gas sample in the work spaces outside the demineralizer cubicles and around the door entryways is by using an Edmont Combustible Gas Analyzer. This instrument would be used to detect the presence of methane gas along the floor and hydrogen gas at higher elevations. It detects combustible gases in terms of percent of the lower flammability limit for combustible gas (4%) and the percent of oxygen in the air.

An alternative method which may be more reliable is being considered for use in detecting very low concentrations of potentially combustible gases inside the cubicles. This method would involve using carbon absorption tubes to collect air samples for 8-10 hours inside the cubicles. The readings would be

in the parts per million range, providing a more accurate, qualitative sampling. However, methane may not be detected using the carbon absorption tubes.

Due to the high radiation levels, a remote method of sampling for combustible gases will be required for combustible gas samples inside the demineralizer cubicles. This method for remote sampling is shown in Attachment IV. As shown, tubing will be placed under the door entryways to obtain air samples to detect the presence of gases along the floor. Tubing will also be installed through other higher penetrations into the demineralizer cubicles to sample for the presence of hydrogen gas. The most probable penetration for this purpose is the resin inlet pipe penetration located in the cubicle wall directly over the top of each demineralizer. This tubing will be connected via flexible tubing to a gas sampling package located in the work area next to the demineralizer cubicle. This package will consist of the following items: an air particulate filter used for radiological control purposes and characterization of the particulates in the air; a gas sampling device such as a Marinelli beaker to be connected to a gas chromatograph or a combustible gas detector; a calibrated portable air pump which will be used to pull air through the particulate filter and the gas sampler. These samples will supplement the combustible gas samples taken on May 13, 1982 and reported via GPU Letter 4400-82-L-0088 dated June 2, 1982.

2. Vent Gas Sample

A vent gas sample would provide information on the pressure and chemical composition of the gas in the demineralizer. This in turn would provide a measure of the resin degradation and the integrity of the system with regard to leaks. It is also desirable to obtain a water/liquid sample if in fact water/liquid is present in the demineralizers. This sample would provide information on the chemical and radiological characteristics of the water/liquid for future safety analyses. These liquid samples from the effluent pipe of each demineralizer may also provide an indication of resin degradation.

Three alternatives for obtaining a gas sample have been considered. The first approach examined is through the existing demineralizer differential pressure (D/P) switch valve manifold. This has been determined to be the most viable approach for obtaining a gas and liquid sample in the demineralizer. The advantages of this route are: an existing high integrity system is used; a minimum amount of new piping and equipment is required; samples will be removed at one controlled location; no additional valve operations are required; influent and effluent demineralizer gas samples can be obtained as close as possible to the demineralizer thereby providing representative samples. The other two approaches considered are through the existing plant Waste Gas Disposal System or through the existing Nuclear Sample System. The following sections provide a description of the feasibility and technical approach for the three methods considered in order of preference.

2.1 D/P Switch Valve Manifold

The D/P switch valve manifold is a five valve manifold consisting of valved connections to influent and effluent piping of the demineralizer, a valved bypass and valved test taps on the influent and effluent sides of the D/P switch. The manifold is installed on the instrument racks in the Hayes Gas Analyzer Room. A water and gas sample system consisting of a pressure gauge, a pump and sample cylinders with the appropriate tubing and isolation valves will be attached to the test taps. A preliminary design of this system is shown in Attachment V.

Two preliminary technical approaches for drawing gas and/or liquid samples via the D/P switch valve manifold are outlined below.

1. The D/P switch shall be isolated by closing the influent and effluent isolation valves in the five valve manifold.
2. The valve manifolds shall be drained and the test tap plugs removed.
3. The sample system shall be installed under the D/P switch instrument racks in the Hayes Gas analyzer room and then attached to the test taps. Vent lines to the plant HVAC system will be connected.
4. Radiation Shielding shall be provided for the D/P switch instrument lines to the demineralizer and to the sample system. This shielding will be designed to accommodate the possibility of degraded demineralizer resin being drawn into the lines.

5. Sampling of the demineralizer will not begin until the newly installed sample system has been hydrostatically tested to ensure no leakage.
6. The pressure of the demineralizer shall be determined by opening the influent side demineralizer valves to the pressure gauge.
7. After sampling the residual water in the D/P switch instrument tubing to the valve manifold, a gas sample in the influent leg shall be taken.
8. Radiation instruments shall be used to determine the presence of radioactive fluid in the tubing. The pump may be used as necessary to obtain the samples.
9. A sample of the demineralizer effluent shall be taken next. Radiation instruments shall be used to detect the possible degraded demineralizer resin.
10. When sampling has been terminated, the demineralizer should be vented slowly and completely to the Auxiliary Building HVAC system in order to depressurize the vessel. The demineralizers, like the SDS demineralizers, should then remain on a permanent vent to the HVAC system to eliminate the safety concern of having an isolated demineralizer containing hydrogen gas in the Auxiliary Building. Alternatively, if gas generation rate studies are deemed necessary, the demineralizer vessels would be closed with the pressure monitored and additional samples obtained as necessary.

The second possible method of obtaining liquid and gas samples requires the pressure reading off the D/P switch to indicate a positive pressure inside the vessel, this would mean that the isolation and relief valves are not leaking. In that case, the vessel could in turn be pressurized with argon (or a similar carrier gas for analysis which is deemed appropriate). Pressurizing the vessels would force gas and liquid samples off the top and the bottom of the demineralizers.

2.2 Waste Gas Disposal System.

The Waste Gas System is also a desirable approach to obtaining a vent gas sample since the Waste Gas Vent is attached to the top of each demineralizer vent. These vents are controlled by a manual valve operated by a reach rod in a low radiation area.

The following procedure is a preliminary technical approach for drawing gas samples from the demineralizers through the Waste Gas System.

1. All portions of the Waste Gas System connected to the vent header of the demineralizers shall be isolated.
2. This portion of the Waste Gas System shall be pneumatically tested to detect leaks which shall be repaired prior to sampling.
3. The gas sample system shall be installed in the Waste Gas Decay Tank "A" cubicle and connected to the Waste Gas System and the plant HVAC system.
4. The entire assembly shall then be pneumatically leak tested.

5. A sample shall be drawn from either demineralizer by opening the appropriate gas vent valve.
6. Following sampling, both demineralizers should be placed on vent. It is desirable to attach a vent at the D/P switch valve manifolds to the plant HVAC system rather than continually using the Waste Gas System to vent the demineralizers.

The Waste Gas System approach presents several drawbacks which are discussed below:

1. There is no convenient point at which to tap into the vent header after the piping leaves the demineralizers because it is either located in inaccessible high radiation areas or embedded in the concrete floors of the Auxiliary Building. The nearest possible convenient point for drawing a sample is in the Waste Gas Decay Tank "A" cubicle.
2. There are many other pieces of equipment which vent into this vent header that would require isolation before a sample could be drawn.
3. A pressure check of this system would be required prior to sampling. This check, however, may not be possible since this part of the Waste Gas System was a source of radioactive gas leaks during the accident. In addition, many of the isolation valves for this part of the system are located in high radiation areas and therefore are not repairable if leaks are identified.

4. The atmosphere in the demineralizers is almost pure hydrogen gas and it is not desirable for this hydrogen gas to leak uncontrollably during sampling at identified locations in the Auxiliary Building.

2.3 Nuclear Sampling System

The existing Nuclear Sampling System would allow samples to be taken on the influent and effluent tubing of the demineralizer. The following presents an outline of the preliminary approach for using this method of obtaining samples.

1. A new sample system would be required since the original sample ties to Unit I have been severed.
2. A new isolation valve would be required as close as possible to the demineralizer since the original remotely operated isolation valve is presently inaccessible in a high radiation area.
3. A pressure check of the new sample system would be required.
4. Demineralizer water or nitrogen gas would be used to force the sample into the new sample system.

A review of this final method for vent gas sampling reveals numerous drawbacks which are the following:

1. The nearest viable location for the new sample system is the Model Room in the Fuel Handling Building which is a long way from the demineralizers.
2. A large amount of liquid waste would be required to move the sample to the new sample system due to the long piping runs in between.

3. The addition of extra fluid such as water or nitrogen to force a sample to the sample system may create a non-representative sample.
4. The installation of a new isolation valve to serve as a backup for the existing isolation valve would involve a large radiation dose to personnel installing the valve.

3. Demineralizer Resin Sample

It is desirable to obtain a resin grab sample to provide information on the state of the resin degradation in each demineralizer. The data obtained will in turn be used to determine the method for removal of the resins. There are only two means of entry into the demineralizer for obtaining a resin core sample. One is through the 3" diameter resin fill line from a location outside the demineralizer cubicles. The other is through the demineralizer manway by using special remote tooling, however, this is not considered viable due to the extensive remote tooling which would be necessary to open the manway in a high radiation area at this time.

The following is an outline of a preliminary technical approach for obtaining a resin sample from each demineralizer if the resin fill lines are to be used as the path for obtaining a sample.

1. A resin addition line is attached to the top of each demineralizer and is isolated by a pneumatically operated diaphragm valve located above the demineralizer. The resin fill lines exit the demineralizer cubicles into the Hayes Gas Analyzer where they are routed to the resin addition station located at the 328' elevation of the Auxiliary Building.

2. The diaphragm valve mentioned above is a spring closed - pneumatically operated valve. It is believed that the polymer diaphragm has been irradiated to between 1×10^7 to 1×10^8 Rads and is currently degraded. This valve cannot be manually opened in a slow controlled manner to prevent diaphragm rupture.
3. The demineralizer should be vented to reduce the hydrogen gas over pressure in the vessel through a venting system such as the gas sampling system described earlier. This would permit a controlled release of hydrogen gas to the Auxiliary Building HVAC. After the pressure has been reduced to atmospheric, the demineralizer should remain on vent to the HVAC system. The current gas generation rate is estimated to be 10 cc of hydrogen gas per minute and the flow rate through the HVAC duct is 19130 CFM.
4. The resin fill line shall be sampled for hydrogen gas up to the resin addition station in case the resin fill line has leaked above the diaphragm. The resin fill lines, which are capped at the resin addition station, should be sampled and purged as necessary prior to severing the resin fill pipe in the Hayes Gas Analyzer Room.
5. The resin fill pipe will be severed in the Hayes Gas Analyzer Room, a new isolation valve installed and a sampling tool inserted in the line. The sampling tool should have visual capability, the ability to take a grab sample of the resin, and a containment to prevent contamination from spreading into the Hayes Gas Analyzer Room.

6. Upon insertion of the sampling tool, the valve should be opened by controlled use of air pressure. Valve actuation may be observed via the visual capabilities of the sampling tool and a verification of valve actuation may be obtained using mirrors or periscopes through the demineralizer cubicle walls. After the valve is opened, a wedge should be inserted to prevent closure.
7. The sampling tool shall be pushed into the demineralizer to observe the resins and take a grab resin sample.
8. After sampling, the tool shall be removed and the resin fill line sealed with the new valve. A leak check of the seal should be performed.

There are several problems which may be encountered with this method of resin sampling. The resin fill valve may fail to open. There may be obstructions in the demineralizers such as the influent water distribution header. The sample may be unable to fit through the resin fill valve. The sample tool may fail to penetrate the resin and obtain a sample since it is possible that the resin has become hardened. These problems will need to be addressed prior to attempting to obtain a resin sample.

In order to simplify the resin sampling and to eliminate a number of the problems associated with the resin fill line approach, the possibility of cutting a hole directly in the side of the demineralizer vessel is being studied. A machine which would drill a hole in the side of the vessel, back the drill out, and install a valve is presently used in the oil industry.

This is a more desirable method than removing the manhole on the demineralizer because it can be performed without loss of containment for a significant period of time. More information on the drilling machine and the feasibility of using it on the demineralizers is being gathered at this time.

4. Exterior Demineralizer Radiation Profile

An external demineralizer radiation profile should be obtained to determine the curie content and to provide a measure of whether or not resin slumping took place.

A gamma spectrometer system should be able to detect and quantify major gamma emitting isotopes present in the demineralizers. Collected data, when coupled with computer analysis, will establish the major isotopes and their corresponding curie levels, the amount of fuel present, the total radiation field, and the distribution of these quantities in the vessel. The detector system operates on the principle that each isotope has unique gamma emission energies. By measuring the tank gamma spectrum, the identity and relative abundance of each isotope present may be determined.

The fuel level will be determined from the amount of Ce-144 found to be present in the tank. To do this, the gamma emission of Ce-144's daughter product, Pr-144, will be monitored.

The gamma spectrometer shall consist of the following hardware:

a suitable detector (The specific type of detector to be used has not been determined at present.); a liquid nitrogen dewar; a preamplifier, amplifier and high voltage; a multichannel analyzer; data processing, storage and printout support equipment; specially designed shielding and collimator; a remote means of transporting the detector into the demineralizer cubicles.

A preliminary technical approach for obtaining an external demineralizer radiation profile has been described as follows.

1. The detector, dewar and preamplifier shall be mounted on a remotely operated transporter for moving this equipment into the demineralizer cubicles. A hydraulic or motorized lifting mechanism will be required on the transporter to move the detector up or down for the radiation profile. It must be designed such that it can scan the entire length of the tank.
 2. Combustible gas measurements inside the demineralizer cubicles will be required since the transporter will contain electrical equipment.
 3. The detector, dewar, and preamplifier shall be positioned near the demineralizer being scanned in a fashion which allows it to see direct gamma emission. The remaining hardware will be located in a low radiation area outside the demineralizer cubicle. This will require connection cables approximately 70 feet long.
- The choice of the type of detector to be used will depend on whether or not the transporter can support sufficient lead shielding if required.

4. If necessary, the detector shall be surrounded by a cylindrical, 5 in. thick lead shield containing a horizontal collimator. The collimator will have removable plugs to allow for variable collimation diameters ranging from 0 to 1/2 inches. The shield/detector arrangement, the dewar and the preamplifier should all be mounted on a suitable support which will afford positioning within the cubicle.
5. Measurements will consist of two vertical scans on each tank, one at the nominal collimator diameter and one with a solid shield. The data set using a nominal collimator diameter will establish the identities and vertical distribution of the isotopes present and the data set using a solid shield will establish the Ce-144/Pr-144 source strength (i.e. the fuel level). The solid shield data will be used to set fuel levels since only the high energy Pr-144 gamma will penetrate the shield in significant quantities.
6. A transport theory code such as "ANISN" shall be used to correlate the detector count rate to the tank source strength for each isotope. Using the nominal collimator data in conjunction with ANISN, the gamma flux on the collimator shall be determined. From this information, the gamma flux on the detector may be evaluated. Determination of the count rate will then be computer based on these gamma fluxes along with the efficiency of the detector. This approach, when coupled with a calibration of the detector/shield arrangement, should give a reasonable estimate of the curie and fuel levels.

ATTACHMENT I

PURIFICATION FILTERS AND DEMINERALIZERS HISTORY

Date	Time After Initiation Hr: Min: Sec.	Event	Remarks
03/28/79	Time Starts at 0400	Purification System Status Letdown Flow 40 GPM	
	00:00:00	Turbine Trip	Normal trip following loss of feed- water pumps. Start of accident.
	00:00:08	Letdown Flow Secured	Normal operator response to turbine trip to minimize transient.
	00:04:52	Operator Starts IC-P-1A	Operator was preparing to put the second letdown cooler on line to increase letdown flow.
	00:04:58	Letdown Flow Alarms High (160 GPM)	Operator has increased flow to maximum.
	00:06:54	Letdown Cooler High Temperature Alarm (139°F)	Due to high letdown flow rate.
	00:06:52	Letdown Flow Reduced to 71 GPM By Operator	Letdown flow remains at this level for next 2 hours.
	00:10:24	Letdown Coolers Alarm Cleared	
	01:20:00	Increase in Letdown Line Radiation Monitor Observed	Increased steadily for 45 minutes and then goes high off scale.

ATTACHMENT I

PURIFICATION FILTERS AND DEMINERALIZERS HISTORY

Date	Time After Initiation Hr: Min: Sec.	Event	Remarks
03/28/79	02:38:00	Letdown Cooler Radiation Monitor Goes High Off Scale	Possibility of fuel damage at this point. Reactor coolant sample is 140 Ci/cc.
	03:55:30	ESF Train "B" Actuated IC-P-1B Tripped Automatically	No cooling to MU-C-1B.
	03:55:46	ESF Train "B" Activated IC-P-1A Tripped Automatically	No cooling to MU-C-1A.
	04:00:13	IC-P-1B Started	
	04:00:19	IC-P-1A Started	
	04:10:10	IC-P-1B Stopped	
	04:19:02	IC-P-1B Stopped	
	04:19:05	ESF Train "A" Actuated IC-P-1A Tripped Automatically	High Reactor Building Pressure
	04:19:29	IC-P-1A Started	
	04:26:22	Letdown Cooler's High Temperature Alarm	Temperature goes to 160° - 165°F for about 10 minutes as shown on strip chart.

ATTACHMENT I

PURIFICATION FILTERS AND DEMINERALIZERS HISTORY

Date	Time After Initiation Hr: Min: Sec.	Event	Remarks
03/28/79	04:36:00	Letdown Cooler's High Temperature Alarm Clears	
	05:23:34	ESF Train "A" Actuated IC-P-1A Tripped Automatically	High Reactor Building Pressure
	05:23:57	IC-P-1A Started	
	09:40:00	High Letdown Cooler (MU-C-1B) High Temperature Clears	Maximum Temperature 150°F
	09:49:44	ESF Trains "A" and "B" Actuated IC-P-1A and IC-P-1B Tripped automatically	H ₂ detonation in the Reactor Building
	09:50:09	IC-P-1A Started	
	09:50:11	IC-P-1B Started	
	12:30:00	Letdown Flow 120 GPM	
	14:00:00	Letdown Flow 40 GPM	
	14:45:00	Letdown Flow 150 GPM	
	14:47:00	Letdown Flow 80 GPM	
	18:34:23	Reactor Coolant Letdown Lost	Plugging of letdown coolers

ATTACHMENT I

PURIFICATION FILTERS AND DEMINERALIZERS HISTORY

Date	Time After Initiation Hr: Min: Sec.	Event	Remarks
03/29/79	Times Start At 0000		
	00:21:00	High Δ P Alarm Across MU-F-5A and MU-F-5B	Operator silences this alarm at 00:51:00
	06:31:00	Letdown Flow Reestablished At About 25 GPM	Intermediate cooling temperature raised to clear plugging of letdown coolers
03/30/79	16:50:00	Letdown Cooler Temperature High	Alarm cleared at 1655. Temperature was 140-150°F.
03/31/79	00:00:00	Entry In Control Room Operators Log Of Plant Status That Purification Filters And Demineralizers Are Bypassed	This is the only definite that the filters and demineralizers were bypassed. It does <u>not</u> indicate when the bypass took place.

ATTACHMENT II

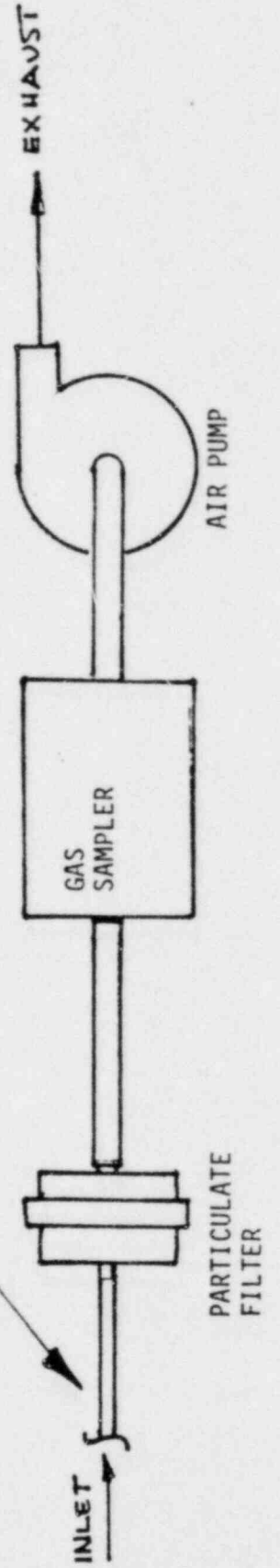
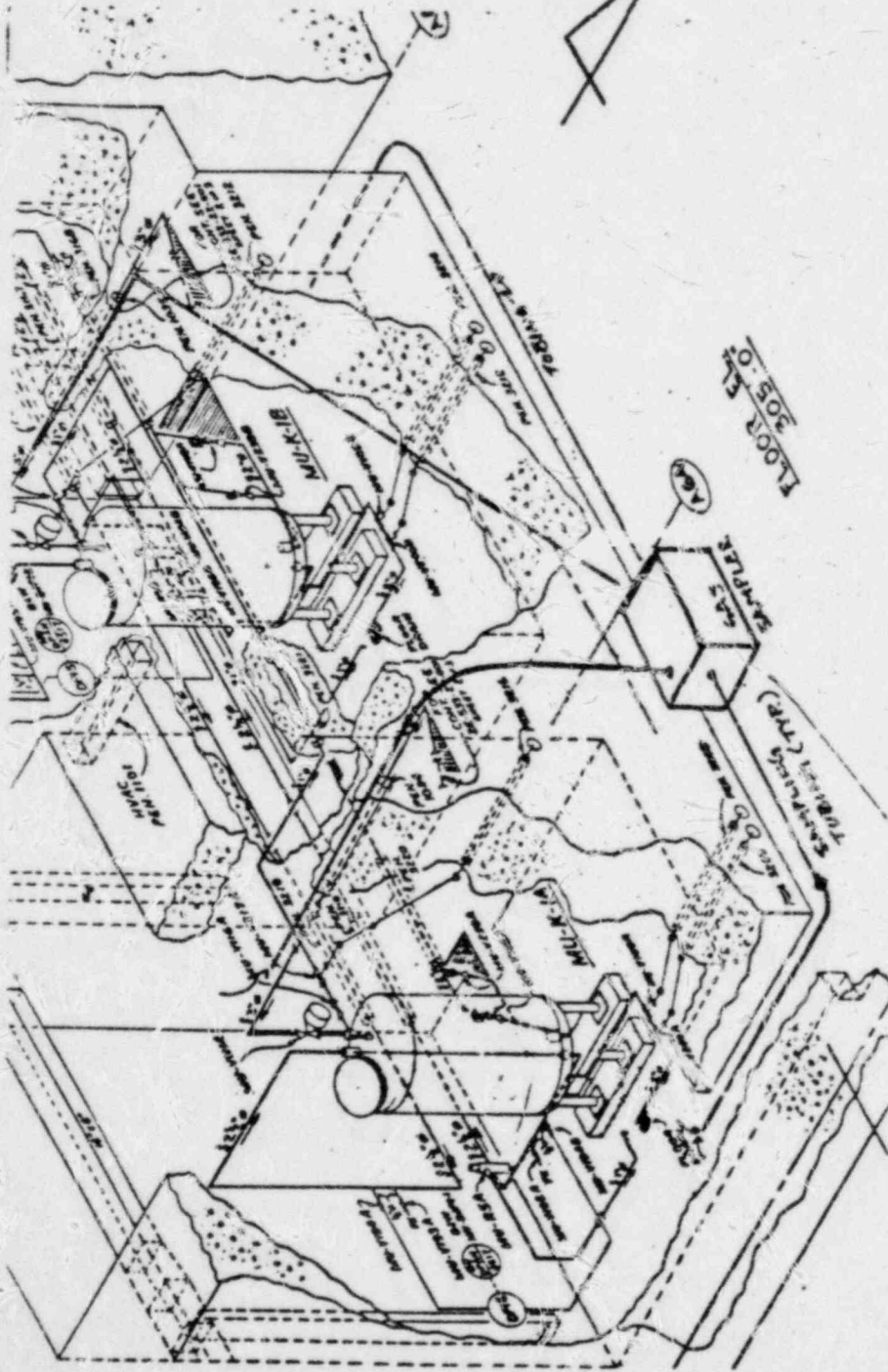
<u>Isotope</u>	<u>Activity (CI)</u>	<u>Isotope</u>	<u>Activity (CI)</u>
Kr-85	8950	I-134	57000
Sr-89	445	I-135	7550
Sr-90	30	CS-134	2650
Zr-95	9500	CS-136	12000
Nb-95	4750	CS-137	12200
Nb-98	845	CS-138	10100
I-131	1.25×10^6	Ba-140	14800
I-132	3.45×10^5	Xe-133	8220
I-133	1.93×10^6	Xe-135	3200

ATTACHMENT III

SUMMARY OF HYDROGEN PRODUCTION

<u>TIME PERIOD</u>	<u>CC/GRAM</u>	<u>CUBIC FEET AT ATM.</u>	<u>CUBIC FEET AT 150 PSIG</u>
1st month	6.637	407.43	36.66
2nd month	0.858	52.67	4.70
3rd month	0.450	27.63	2.47
4th month	0.35	21.26	1.9
3 years			
a) 10^9 Rads	10.21	626.78	55.94
b) 5×10^9 Rads	51.05	3133.91	279.71

ATTACHMENT IV
CUBICLE GAS SAMPLER



ATTACHMENT V
 CONCEPTUAL MAKEUP DEMINERALIZER SAMPLE SYSTEM

