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January 14, 1985

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

Dear Dr. Snyder:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Defueling Water Cleanup System Technical Evaluation Report

Attached for your review and approval is the Technical Evaluation Report (TER) for the Defueling Water Cleanup System (DWCS). The DWCS is designed to remove radioactive ions and particulate matter from the fuel transfer canal, Spent Fuel Pool "A", and the reactor vessel. To assist in your review, the System Descriptions for the Defueling Water Cleanup (DWC) Reactor Vessel Cleanup System, the DWC Fuel Transfer Canal/Spent Fuel Pool Cleanup System, and the applicable drawings for the DWCS are included.

Pursuant to the requirements of 10 CFR 170, enclosed is a check for $150.00 for the application fee required for review of this submittal.

Sincerely,

F. R. Standerfer
Vice President/Director, TMI-2

w/check 00014053
$150.00

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License Card

FRS/RDW/jep

Attachments

cc: Deputy Program Director - TMI Program Office, Dr. W. D. Travers

Drawings To:
TMI PO Cm

GPU Nuclear

TER 15737-2-G03-106 REV. 3

ISSUE DATE January 10, 1985

☒ ITS

☐ NSR

☐ NITS

TMI-2

DIVISION

TECHNICAL EVALUATION REPORT

FOR

Defueling Water

Cleanup System

COG ENG Gerald K Boldt DATE 11/1/84

RTR Edward T. Smith DATE 11/1/84

COG ENG MGR. C. L. R. for R.L DATE 11/1/84

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Title	NO.
Technical Evaluation Report for Defueling Water Cleanup System	15737-2-G03-106

Rev.	SUMMARY OF CHANGE
0	Initial issue November 1, 1984
1	Revised to incorporate system design changes and comments on Revision 0
2	Revised to incorporate comments on Revision 1
3	Revised to incorporate comments on Revision 2

SHEET	LATEST REV	SHEET	LATEST REV	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.
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REVISION STATUS SHEET

BECHTEL

DOCUMENT TITLE: Technical Evaluation Report for Defueling Water Cleanup System

JOB 15737

15737-2-G03-106

REV. 3

GPD-33000-T 10/83

Table of Contents

1

Attachments

1. Division II System Design Description of the Defueling Water Cleanup Reactor Vessel Cleanup System, Doc. No. 15737-2-M72-DWC01, Rev. 2. |2

2. Division II System Design Description of the Defueling Water Cleanup Fuel Transfer Canal/Spent Fuel Pool Cleanup System, Doc. No. 15737-2-M72-DWC02, Rev. 2. |2

3. Reactor Vessel Cleanup System, Piping and Instrument Diagram, Bechtel Drawing 15737-2-M74-DWC01, Rev. 3.

4. Fuel Transfer Canal/Spent Fuel Pool Cleanup System, Piping and Instrument Diagram, Bechtel Drawing 15737-2-M74-DWC02, Rev. 3.

5. Auxiliary Systems, Piping and Instrument Diagram, Bechtel Drawing 15737-2-M74-DWC03, Rev. 3.

6. Fuel Handling Building, General Arrangement, Bechtel Drawing 15737-2-POA-6401, Rev. 0.

7. Reactor Building, General Arrangement, Bechtel Drawing 15737-2-POA-1303, Rev. 1.

1.0 Introduction

1.1 General

The defueling water cleanup (DWC) system is designed to remove radioactive ions and particulate matter from the fuel transfer canal, spent fuel pool "A" and the reactor vessel. The majority of the particulate matter is removed by processing the water through nominal 0.5 micron rated sintered metal filters. The low micron rating of the filters will assure very low turbidity as well as reducing the particulate activity in the water.

Removal of the radioactive ions (i.e., soluble fission products) will be performed by processing a portion of the filter output through 4 x 4 liners (similar to those in use for EPICOR II) containing Zeolite, or the submerged demineralizer system (SDS).

1.2 Scope

The scope of this document includes the operation of the DWC system, the components of the DWC system and its interfaces to existing systems and components. This technical evaluation report (TER) is applicable only during the recovery mode as the DWC system is a temporary system required to support recovery operations and will be removed or reevaluated prior to plant restart. Evaluation of safety concerns related to the filter canisters is not within the scope of this TER and will be addressed in Reference 8. Licensing of the ion exchangers for offsite shipments is outside the scope of this TER. |3

2.0 System Description

2.1 General

The DWC system is designed to process water from the reactor vessel, spent fuel pool, and fuel transfer canal. The system's major functions are given below.

a) The DWC system filters the water contained in the reactor vessel, the spent fuel pool, and the fuel transfer canal to remove suspended solids above a nominal 0.5 micron rating. This is done to maintain the clarity of the water to a 1 NTU (nephelometric turbidity unit) rating.

b) The DWC system removes soluble fission products from the reactor vessel, the spent fuel pool, and the fuel transfer canal (FTC) by demineralization of the water. This is done to reduce the dose contribution from the water.

The DWC system is composed of two major subsystems which allow greater processing flexibility during post plenum removal operations. These two subsystems are, the reactor vessel cleanup system and the fuel transfer canal/spent fuel pool cleanup system. Online sampling of both subsystems for turbidity, pH and boron concentration is provided by the system design. The detailed system description for the DWC reactor vessel cleanup system is provided in Attachment 1. Attachment 2 provides the detailed system description for the DWC fuel transfer canal/spent fuel pool cleanup system. Also included as Attachments 3 through 7 are the following figures:

Attachment 3 Reactor Vessel Cleanup System, Piping and Instrument Diagram

Attachment 4 Fuel Transfer Canal/Spent Fuel Pool Cleanup System, Piping and Instrument Diagram

Attachment 5 Auxiliary Systems, Piping and Instrument Diagram

Attachment 6 Fuel Handling Building, General Arrangement

Attachment 7 Reactor Building, General Arrangement

2.2 Quality Classification

The quality classification of the DWC system with exception of the filter/canister units which are not within the scope of this TER is Important to Safety. Important to Safety as used here is defined in the TMI-2 Recovery Quality Classification List. 2

3.0 Technical Evaluations

3.1 General

The DWC system is totally contained within areas that have controlled ventilation and area isolation capability. This limits the environmental impact of the system during normal or postulated accident conditions. The impact of postulated DWC system failures is provided below on a case-by-case basis.

The system failures evaluated are loss of power, loss of instrumentation/instrument air, filter media rupture, and line breaks. The design of the system is such that none of the events results in unacceptable consequences. Other safety concerns evaluated with respect to operation of the DWC system were decay heat removal, criticality, boron concentration control, heavy load drops, and radioactive releases. No unacceptable consequences were found to result from operation of the DWC system provided that proper administrative control is maintained.

3.2 Postulated System Failures

3.2.1 Reactor Vessel Cleanup System

3.2.1.1 Loss of Power

A loss of power to the entire system would simply shut the system down. A loss of power to the well pumps with an additional failure which results in simultaneous loss of level control in the ion exchangers would result in a flow mismatch. In this case, the system would be automatically shut down until power is restored. Loss of power to individual components would place that component in its safe mode for an air operated valve; for example, it would fail to a position that ensures no damage to other components. 1

Loss of power to the control panel would cause the loss of all information and fail all control and solenoid operated valves. The system would be shutdown until power is restored.

3.2.1.2 Loss of Instrumentation/Instrument Air

Loss of a single instrument channel will result in the loss of indication for that channel and, for those channels that have control features a flow mismatch. This flow mismatch will result in an automatic shutdown of the affected portion of the system.

Loss of the internals indexing fixture (IIF) level indication system (bubbler) will result in an erroneous level indication which will be noted when compared with a redundant level indication system. Since this system has no control features, no adverse system conditions will result.

Loss of instrument air will take the individual components to their fail safe position. Flow mismatches induced by loss of air will result in automatic trips. Loss of air to the IIF level monitoring system will initiate a low air supply pressure alarm.

3.2.1.3 Filter Media Rupture

A failure of the filter media in the canister could potentially release fuel fines to the ion exchange portion of the system. A post filter is located downstream of both filter trains in the line to the ion exchangers. This post-filter will trap any fuel fines which would be transported past the filter canisters in the event of filter failure. The post filter is sized to be critically safe and so that a gross rupture in a filter canister will increase the differential pressure to the alarm setpoint. Turbidity meters will aid in the detection of gross filter media rupture by detecting changes in water clarity.

Upon detection of a filter media rupture the filter trains will be isolated and the ruptured filter will be identified by observing the differential pressure versus flow for each individual canister with flow being recirculated to the reactor vessel. A lower differential pressure for a given flow will indicate which filter is ruptured. The ruptured canister or canisters and the post-filter cartridge would then be replaced as required and the system restarted.

3.2.1.4 Line Break

The principal consequence of any line, or hose break in the reactor vessel cleanup system is a loss of reactor vessel inventory. The system is designed to mitigate the consequences of such an incident to the extent possible.

To help prevent a hose rupture, all process water hoses are armoured. In case of a hose rupture or line rupture, downstream of the reactor vessel pumps, the system will trip these pumps on IIF low level and alarm at control panels in the control room and fuel handling building. This could deliver approximately 500 to 1000 gallons of reactor vessel water to the area of the break. The potential areas affected would be the Reactor Building and the Fuel Handling Building, each of which has sumps to contain the spill.

Siphoning of reactor vessel water could take place if any of the lines connected to the well pump suction or return hoses, or if the hoses themselves, are damaged or rupture. The two, 4 inch suction connections provided in the Westinghouse work platform will be provided with two, 3/4 inch holes drilled 18 inches below the water level which will act as a siphon breaker. The three 2 inch return lines will be equipped with spargers, which are holes drilled into the pipes. The first holes are drilled 18 inches below the water level which will act as a siphon breaker. The sample return line will terminate 18 inches below the water level. Also, isolation valves will be provided in the Westinghouse supplied piping which could be used to manually terminate the siphoning. Therefore, a maximum of approximately 3000 gallons of reactor vessel water would spill into the fuel transfer canal following a hose rupture. Approximately half of this water would be contained in the New Fuel Pit.

The recovery from these events would be accomplished by isolating the ruptured section and replacing the ruptured hose/pipe.

3.2.2 Fuel Transfer Canal/Spent Fuel Pool Cleanup System

3.2.2.1 Loss of Power

A loss of power to any portion of the system would shut that portion of the system down. Loss of power to individual components would place that component in its safe mode for an air operated valve, for example it would fail to a position that ensures no damage to other components.

3.2.2.2 Loss of Instrumentation/Instrument Air

Loss of a single instrument channel will result in the loss of indication for that channel and, for those channels that have control features a flow mismatch. This flow mismatch will result in an automatic shutdown of the affected portion of the system.

Loss of either the spent fuel pool or FTC level monitoring system will be noted when compared with the other. The readings should normally be the same since both water bodies are in communication via the fuel transfer tubes. Neither system has control features.

Loss of instrument air will take the individual components to their fail safe position. Flow mismatches induced by loss of air will result in automatic trips. Loss of air to the IIF level monitoring system (bubbler) will initiate a low air supply pressure alarm.

3.2.2.3 Filter Media Rupture

A failure of the filter media in the canister could potentially release fuel fines to the ion exchange portion of the system. Flow may be routed to DWC ion exchanger K-2 or to the SDS both of which have filters upstream to trap migrating fuel fines. Ion exchanger | 2
K-2 has a cartridge type filter in a critically safe

canister and SDS is equipped with two filters in series, both of which have borosilicate glass to control reactivity (see Ref 2). Differential pressure is measured across the filters to indicate ruptured filter media. The SDS filter bypass is administratively controlled to prevent inadvertent operation. | 2

Upon detection of a filter media rupture the filter trains will be isolated and the ruptured filter will be identified by observing the differential pressure versus flow for each individual canister with flow being recirculated to the fuel pool. A lower differential pressure for a given flow will indicate which filter is ruptured. The affected canister or canisters and the SDS pre-filter vessel or filter canister post filter cartridge would then be replaced as required and the system restarted. | 2

3.2.2.4 Line Break

If a rupture occurred in the FTC/spent fuel pool cleanup system, the DWC system spent fuel pool pumps could deliver fuel transfer canal and/or spent fuel pool water to the Fuel Handling Building or the Reactor Building. This action would lower the level in the canal and the pool. A drop of one inch in canal/pool level is approximately equivalent to 1250 gal. A level loss would be detected and alarmed (low level alarm 3" below normal liquid level) by at least one of the two redundant level indicating systems provided for the canal/pool. The operator would then shut the system down.

Process water hoses are employed in three services in this system; filter canister inlet/outlet, skimmers to well pumps, and downstream of penetration R-539.

If a filter canister inlet/outlet hose ruptures, that canister will be isolated and the hose replaced. Since these hoses are submerged in the SFP, this results in no net water loss.

If a hose connecting the skimmer to the well pumps breaks, then the ability to surface skim will be hampered or lost, but pump capacity will not be diminished as the hose is routed underwater to the pumps and a pump suction supply will continue to be available.

If the hose on the FTC return line downstream of penetration R-539 breaks, then process water will be lost to the Reactor Building sump. The resulting loss in level would be detected and alarmed by the canal/pool monitors. This hose is steel armored to 1
minimize accidental damage. Check valves are provided to prevent siphoning the FTC if the hose (or connecting line) breaks. Furthermore, the normal return path is to the SFP; thus this hose is not normally used. When not in use this hose should be isolated by closing valves to minimize the effect of a hose break.

A break of the fuel transfer canal pump discharge line which uses penetration R-524 would cause process water to be lost to either the Reactor Building or the Fuel Handling Building. The water loss would be detected both by a decrease in the monitored flowrate returned to the fuel pool or fuel transfer canal and also by the drop in fuel pool and/or transfer canal level. When the fuel transfer canal pumps, are not in use, the discharge valves will be closed. This will 1
prevent a syphoning of the FTC when the pumps are not in use.

3.3 Decay Heat Removal

Decay heat removal is currently performed by heat loss to ambient. No change in this mode of operation is required to operate the DWC system. The large exposed surface of the open reactor vessel and the FTC will significantly enhance the removal of decay heat.

3.4 Criticality

Subcriticality of the core is maintained by a high concentration of boron in the reactor coolant system (RCS). Subcriticality of the fuel within the filter canister will be assured by design and will be addressed in the licensing document for the canisters. The fuel transfer canal/spent fuel pool pump and the reactor vessel cleanup pumps will be evaluated to assure that the design of the pump does not allow an accumulation of a significant quantity of fuel. The system piping and the post-filter will also be designed to prevent a possible critical configuration of fuel debris. This will be accomplished by restricting the size and configuration of components. Furthermore, the post-filter will not accumulate 1
significant quantities of fuel unless filter rupture occurs (see Sections 3.2.1.3 and 3.2.2.3). Fuel accumulation in other system components will be precluded by the filtration of the water.

3.5 Boron Dilution

The only credible means of attaining criticality of the fuel contained in the vessel is through deboration of the RCS water. The approach described in References 6 and 7 for prevention of deboration will be followed for operation of the DWC system. Specific system evaluations with respect to deboration control will be performed prior to DWC system operation. Boron dilution during defueling will be addressed in a revision of the "Hazards Analysis: Potential for Boron Dilution of Reactor Coolant System".

3.6 Heavy Load Drops

In-containment load handling will consist of the transfer of the DWC filter canisters from the deep end of the FTC to the Fuel Handling Building via the fuel transfer system. The handling of these canisters will be in accordance with procedures, or unit work instructions (UWI's) which will define load paths. These load paths will be administratively controlled to ensure that a postulated drop of a canister would not compromise plant safety or the integrity of the FTC floor.

Load handling within the Fuel Handling Building will consist of the movement of SDS ion exchange liners, the reactor vessel cleanup system liners, the DWC filter canisters and transfer casks. The heavy load drop analysis for the SDS casks is given in reference 3. The reactor vessel cleanup system liners will be moved using the existing casks for the EPICOR II system. The total heavy load of the cask and liner is less than that of the shield plugs removed from spent fuel pool "A". The load path for movement of the liners, although not over the spent fuel pool, is part of the same load path used for the spent fuel pool "A" shield plug removal. The load path and heavy load drop analysis provided in the spent fuel pool "A" refurbishment SER (Ref. 5), therefore, bounds the movement of the liners and casks. The radiological concerns associated with a load drop are bound by the analysis in Reference 4 which concludes the health and safety of public is not endangered as a result of this hypothetical accident. The handling of heavy loads over the spent fuel pool is not within the scope of this document and will be addressed in the Early Defueling SER. 2

3.7 Radioactive Releases

The operation and design of the DWC system was reviewed with respect to radioactive releases. No direct radioactive release paths to the environment exists for the system. Local spillage of contaminated water from the DWC system will result in a local contamination problem. Since the specific activity of the water is essentially that of the fuel transfer canal and spent fuel pool, no significant radioactive releases above those from the open pools can occur when processing pool water. Defueling activities have the potential of significantly increasing the specific activity of the reactor vessel water. To preclude any significant releases during these periods the operating procedures associated with processing reactor vessel water shall include requirements to ensure isolation of the system should a line break or massive system leakage occur.

4.0 Radiological and Environmental Assessment

4.1 Off-Site Dose Assessment

Operation of the DWC system could reduce the off-site doses which would result if the system were not available. Without operation of the DWC system specific activity of the water in the pools would slowly increase. This could lead to an increase in the local airborne concentration available for release via the plant ventilation system. However, operation of the DWC system will maintain the reactor and fuel pool water at very low specific activity, thereby minimizing this as a potential release source. Since the source available for release from the SDS greatly exceeds that available from the DWC system, the off-site dose analysis provided in the SDS TER (Ref. 4) bounds those of the DWC system.

4.2 On-Site Dose Assessment

4.2.1 Reactor Vessel Cleanup System

The potential exists that defueling may significantly increase the specific activity in the reactor vessel water. This could possibly occur during defueling through disturbance of the core debris. Material greater than nominal 0.5 microns would be captured in underwater filter canisters. The soluble fission products, particularly cesium-137, would be removed by processing through the associated ion exchange media. The filter canisters are located underwater at a depth greater than four feet in the reactor building and therefore do not represent a radiological problem. The water to be processed is piped through a reactor building penetration to the ion exchange media at 20 to 60 gpm (max. 30 gpm/train) depending on the specific activity of the reactor vessel water. These process lines and the liners for the ion exchange media represent potential radiological hazards.

To assess the radiological hazards, the dose rates from DWCS piping and components during operation were evaluated. Sources in the water were assumed to be fuel particles and dissolved radioactive materials. The design basis concentrations of these sources are 1 ppm suspended solids and a concentration of soluble materials equivalent in dose rate to 0.02 µCi/ml of cesium-137. During operation at the design basis concentrations, the dose rate from a long 3" diameter unshielded hose is 0.2 milirem/hour at a distance of 2 feet.

During defueling operations both the solubles and suspended solids concentrations in the water may increase. To assess increases in dose rates during upset water conditions, a combination of a 20 curie cesium-137 spike and an instantaneous release of approximately 35 lb of suspendable fine debris to the reactor vessel volume is postulated. A long 3" diameter hose carrying water at the resulting concentrations would result in a dose rate of 9 millirem/hour 2 feet from the hose. Process lines which are downstream of the filters do not contain the suspended solids concentrations postulated for the upset water conditions. A 3" diameter hose downstream of the filters would produce a dose rate of 2 millirem/hour at a distance of 2 feet, due to the soluble radioactive materials remaining in the water.

Shielding of lines upstream of the filters may be used to reduce dose rates in areas of personnel occupancy.

Dose rates from solubles are based on the specific activity of cesium-137. Other isotopes which may contribute significantly to gamma dose rates are cesium-134 and antimony-125. The cesium-134 concentration is normally an order of magnitude less than that of cesium-137. Antimony-125 is not removed by the DWCS ion exchangers with a reliable decontamination factor. However, the dose rate for antimony-125 is less than that of cesium-137 for a given concentration. If antimony-125 in the DWCS becomes a significant dose contributor to workers, the reactor coolant may be processed through the EPICOR II system in a batch processing mode. Batch processing will be used because chemical adjustment of the coolant is required. EPICOR II will remove the antimony-125 with a satisfactory decontamination factor.

Three zeolite ion exchangers are needed to handle the flow from DWC system. Two are needed for the reactor vessel cleanup system to provide a 60 gpm flowrate through the ion
exchangers. One is used for FTC/spent fuel pool cleanup. SDS 2
is also to be used for FTC/spent fuel pool cleanup.

The shielding requirements for these liners will be based on a homogenized 500 Ci source in a 4 x 4 liner, similar in construction to those used for EPICOR II. Since changeout of liners will be based on radiation level, and since the 500 Ci loading is conservatively high (actual loading should be approximately 100 Ci, see Section 4.3), the calculated shielding requirement is considered acceptable.

The contact dose rate on the side of the liner for a homogenized 500 Ci source is approximately 185 R/hr. The liners will be shielded to limit the shield contact dose rate at the side and on top of the liner to a maximum of 5 millirem/hr. The concrete floor will reduce the dose rates on lower elevations to less than 5 millirem/hr.

Both dose rates represent an upper bound, and as indicated, the dose rates would not pose any undue operational constraints if actually attained.

If hoses or piping in the DWC system break, water will be released in the Reactor Building or the FHB. This water may contain suspended fuel particles and dissolved radioactive materials. The specific activity of the DWC system water will be maintained low enough that personnel access to the spill area will not be precluded. After the removal of the spilled water, the area may require decontamination to reduce loose surface contamination to acceptable levels. Thus there are no safety concerns associated with the breakage of DWC system hoses or pipes.

4.2.2 Fuel Transfer Canal/Spent Fuel Pool Cleanup System

The fuel transfer canal/spent fuel pool cleanup system processes water through the DWC ion exchanger K-2 or SDS. The water in the pools will be maintained by this system at .01 to .02 μCi/ml of cesium-137. This is significantly lower concentrations than water processed by SDS. The analysis provided in the SDS TER Reference 4 therefore bounds the doses possible from this system. |2

4.3 Occupational Exposures

Operation of the DWC system will reduce the occupational exposure during defueling operations by maintaining low specific activities in the fuel transfer canal, spent fuel pool and reactor vessel. The DWC system is designed to maintain the maximum Cesium-137 concentration in the water to between .01 and .02 μCi/ml. This will result in a contribution to general area dose rates of 10 to 20 millirem/hr from the water.

It is estimated that approximately 42, 4x4 liners each loaded with 52 curies of Cesium-137 will be required for the reactor vessel cleanup system. The occupational dose to workers during each change-out is estimated to be less 0.1 man-rem. Therefore the total accumulated dose for change out of the estimated 42, 4x4 liners is 4.2 man-rem.

The following table provides an estimate of the man-hours and man-rem associated with the installation, operation, maintenance and removal of the in-containment and fuel handling building portions of the DWCS. These estimates are based upon current man-hour projections.

IN-CONTAINMENT

Activity	Man-Hours	Dose Rate (mR/hr)	Man-Rem
Installation	505	60	30.3
Operation	40	60	2.4
Maintenance	85	60	5.1
Removal	250	60	15.0

FUEL HANDLING BUILDING

Activity	Man-Hours	Dose Rate (mR/hr)	Man-Rem
Installation	34,400	0.3	10.3
Operation	26,280	0.3	7.9
Maintenance	8,600	0.3	2.6
Removal	17,200	0.3	5.2

1

The total man rem attributable to the operation and maintenance of the DWC system, as a whole, is expected to be between 65 and 125 man-rem. This estimate is based upon a total of 80 man-rem from above increased by 20% for Health Physics coverage and allowing ± 30% due to uncertainties. 1

5.0 Safety Evaluation

5.1 Technical Specifications/Recovery Operations Plan

No additional Technical Specifications/Recovery Operations Plan changes, beyond those required for head removal, are required to install and operate the DWC system.

5.2 Safety Questions (10CFR50.59)

10CFR50, Paragraph 50.59, permits the holder of an operating license to make changes to the facility or perform a test or experiment, provided the change, test, or experiment is determined not to be an unreviewed safety question and does not involve a modification of the plant technical specifications.

A proposed change involves an unreviewed safety question if:

a) The possibility of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report may be increased; or 1

b) The possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report may be created; or

c) The margin of safety, as defined in the basis for any technical specification, is reduced.

The DWC system does not increase the probability of occurence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in a safety analysis report. The system failures evaluated are presented in section 3.2 of this report. No failures of the DWC system were found which would increase the probability of occurence or the consequenses of an accident or malfunction of equipment important to safety. In addition, operation of the DWC system will be performed under strict administrative procedural control to further ensure safe operation. The procedures used for operation of the DWC system will be reviewed and approved prior to use in accordance with Technical Specification 6.8.1.

The possibility of an accident or malfunction of a different type than previously evaluated in the safety analysis report is not created by the existence of the DWC system. The DWC system is essentially a liquid radwaste system utilized to maintain clarity and low specific activity in the reactor vessel, fuel transfer canal, and spent fuel pool water. As such, the possibility of an accident or malfunction is of the same type as previously evaluated for other liquid radwaste systems.

Operation of the DWC system does not result in a reduction in the margin of safety as defined in the bases for the Technical Specifications. Liquid effluents will not be released to the environment directly from DWC system operations. The effluents from operation of the DWC will be returned to the sources in order to maintain proper water levels. Any gaseous effluents resulting from DWC system operations will traverse existing gaseous effluent flow paths. The gaseous effluents will be less than those generated during processing of the water from the reactor building basement by SDS. The results of the radioactive release analysis presented in the SDS Technical Evaluation Report therefore bound the releases from the DWC. Since no change in the maximum permissible concentrations or the instrument configuration or setpoints specified in Appendix B of the Technical Specifications was required for SDS operation, and since the DWC system operation is bounded by the SDS operation, no changes are required for DWC system operation.

Based on the above, the installation and operation of the DWC system does not present an unreviewed safety question as defined in 10 CFR 50.59.

6.0 References

1. Recovery Program System Description, Auxiliary Building Emergency Liquid Clean-up System (EPICOR II), GPUNC Letter 4410-84-L-0023, Feb. 24, 1984.

2. Technical Evaluation Report (TER) for the Submerged Demineralizer System, GPUNC Letter 4410-84-L-109 dated July 19, 1984. 1

3. Letter from G. K. Hovey, GPU, to B. J. Snyder, NRC, dated September 30, 1981, "Control of Heavy Loads". GPU letter No. LL2-81-0277. 1

4. Same as Reference 2. 1

5. Safety Evaluation Report (SER) for the Refurbishment of Fuel Pool "A", Revision 1, June 1983, GPUNC Letter 4410-83-L-0156, July 29. 1983. 1

6. SER for Removal of the TMI-2 Reactor Vessel Head, Revision 5, February 1984.

7. SER for the Operation of the IIF Processing System, Revision 1, May 1984. 1

8. TER for Defueling Canisters

GPU Nuclear

S D 15737-2-M72-DWC01 REV 2

ISSUE DATE

☐ ITS
☒ NSR
☐ NITS

TMI-2

DIVISION

SYSTEM DESCRIPTION

FOR

Defueling Water Cleanup

Reactor Vessel Cleanup System

(ECA 3525-84-0041)

COG ENG E K Boldt DATE 8/27/84

RTR R L Mays DATE 8/27/84

COG ENG MGR. G K Boldt for R.L. Rider DATE 8/27/84

NO	DATE	REVISIONS	BY	CHECKED	GROUP SUPERVISOR	MGR DESIGN ENGINEERING
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FORM 4000-ENG-7310.06-1 (5/84)

GPU Nuclear	No. 15737-2-M72-DWC01
Title Division System Description for Defueling Water Cleanup Reactor Vessel Cleanup System	Page 2 of 23

Rev.	SUMMARY OF CHANGE
1	Incorporated changes to add third 4 x 4 Ion Exchanger to allow two ion exchangers to be dedicated to this system and separate system from FTC/SFP System; revised references; revised setpoints (Section 2.2); revised initial fill and draining to reflect addition of ion exchanger level switch disable, added valve numbers.
2	Changed Dwg. No., item 22.b, p.7; added note p.7; deleted sentence p.8; added "V084 (FV-10)", p.8; deleted parentheses around "p-6 or 8", p.9; added "by EPICOR-II from a RCBT as required," p.9; changed EPICOR to "Nuclear Packaging 50 ft^3 ENVIRALLOY Demineralizer/HIC," p.10 changed later to "4850," p.16; added note p.16.

TABLE OF CONTENTS

1.0 DESIGN DESCRIPTION

1.1 Summary

The reactor vessel cleanup system is a temporary liquid processing system which is designed to process water contained in the reactor vessel. The system's major functions are:

a) to filter the water contained in the reactor vessel to remove suspended solids above a nominal .5 micron rating. This is done to maintain the clarity of the water to a 1 NTU rating.

b) to remove soluble fission products from the reactor vessel contamination barrier by demineralization of the water. This is done to keep the equivalent Cs-137 concentration less than .02 µci/ml and thus reduce the dose rate contribution of the water. Also, Sb-125 concentration can be controlled by batch processing of reactor vessel water at the RCBTs.

1.2 References

1. Planning Study, Defueling Water Cleanup System Doc. No. TPO/TMI-046

2. Technical Plan, Defueling Water Cleanup System Doc. No. TPO/TMI-047

3. Division I, System Design Description, Defueling Water Cleanup System Doc. No. 2-R72-DWC01

4. Bechtel Drawing 2-M74-DWC01, Defueling Water Cleanup (DWC) Reactor Vessel Cleanup System

5. Bechtel Drawing 2-M74-DWC02, Defueling Water Cleanup (DWC) Fuel Transfer Canal/Spent Fuel Pool Cleanup System

6. Bechtel Drawing 2-M74-DWC03, Defueling Water Cleanup (DWC) Auxiliary Systems

7. Bechtel Drawing 2-POA-6401, General Arrangement Fuel Handling Building Plan El. 347'-6"

8. Bechtel Drawing 2-POA-1303, General Arrangement Plenum Removal Reactor Building

9. DCN No. 2026-30-2, Flow Diagram Spent Fuel Cooling and Decay Heat Removal

10. Burns & Roe Drawing No. 2026, Flow Diagram Spent Fuel Cooling and Decay Heat Removal

11. GPU Drawing No. 2R-950-21-001 P&ID Composite Submerged Demineralizer System

12. TMI-2 Recovery Division System Design Description for Submerged Demineralizer System, Doc. No. SD 3527-005

13. Division System Design Description for Spent Fuel Pool/Fuel Transfer Canal Cleanup System, Doc. No. 15737-2-M72-DWC02

14. Instrument Index, Doc. No. 15737-2-J16-001

15. Design Engineering Valve List, Doc. No. 2-P16-001

16. Standard for Piping Line Specifications for GPU Nuclear Corp. TMI-Unit 2 Standard 15737-2-P-001

17. TMI-2 Recovery Mechanical Equipment List Bechtel North American Power Corp. Job 15737

18. Bechtel Piping Isometrics

    a. 2-P60-DWC01-DWCS - Pumps P-2A&B, P-3A&B, P-4A&B, and Miscellaneous Details
    b. 2-P60-DWC02-DWCS - Reactor Vessel Filter Trains A & B - Inlet Manifold Piping
    c. 2-P60-DWC03-DWCS - Reactor Vessel Filter Trains A & B - Outlet Manifold Piping
    d. 2-P60-DWC04-DWCS - Transfer Canal/Fuel Pool Filter Trains A & B - Inlet Manifold Piping
    e. 2-P60-DWC05-DWCS - Reactor Vessel Filter Train Sample Lines
    f. 2-P60-DWC06-DWCS - Discharge Piping from Sample Boxes No. 1 & No. 2 to Penetration R-537
    g. 2-P60-DWC07-DWCS - Samples Lines Upstream & Downstream of Ion Exchangers
    h. 2-P60-DWC08-DWCS - Forwarding Pumps P-6 and P-7, Suction & Discharge Piping
    i. 2-P60-DWC09-DWCS - Forwarding Pumps P-6 and P-7 Discharge Piping
    j. 2-P60-DWC10-DWCS - Supply Piping to Ion Exchangers K-1 & K-2, Supply & Discharge Piping for Post Filter F-8
    k. 2-P60-DWC11-DWCS - Supply Piping to Ion Exchangers K-1 & K-2
    l. 2-P60-DWC12-DWCS - Borated Water Flush Piping from SPC-T-4

m. 2-P60-DWC13-DWCS - Transfer Canal/Fuel Pool Filter Trains "A" & "B" Outlet Manifold Piping
n. 2-P60-DWC14-DWCS - Transfer Canal/Fuel Pool Filter Trains "A" & "B" Outlet Manifold Discharge Piping, Supply & Discharge to Booster Pump P-5
o. 2-P60-DWC15-DWCS - Nitrogen Supply Piping to SPC-T-4 and Drying Station
p. 2-P60-DWC16-DWCS - Discharge Piping from DWC Booster Pump P-5
q. 2-P60-DWC17 DWC Miscellaneous Piping Details

19. ECA No. 3525-84-0041, Definition of the Defueling Water Cleanup System.

20. ECA No. 3245-84-0034, Defueling Water Cleanup System Penetration Modifications.

21. ECA No. 3527-84-0042, SDS Tie-in to DWCS.

22. Bechtel Area Piping Drawings

a. 2-P70-DWC03 DWCS Hose Network Reactor Bldg. Plan El. 347'-6"
b. 2-P70-DWC04 DWCS Hose Network Fuel Handling Bldg. Plan El. 347'-6" 2

1.3 Detailed System Description

1.3.1 Description

The reactor vessel cleanup system is a liquid processing system which will process water from the reactor vessel. The system is shown schematically on Dwg. 2-M74-DWC01, and its associated Dwgs. 2-M74-DWC02 and 2-M74-DWC03. (Note, some valves identified herein have been given an instrument designator as well as a valve number. When this occurs, the instrument designator is shown in parentheses after the valve number.) 2

The system has two submersible type pumps (deep well pumps), P-2A and 2B, which are housed in wells and located in the fuel storage pit in the shallow end of the fuel transfer canal in the Reactor Building. Each pump has a 220 gpm capacity and will process 200 gpm from the reactor vessel and recirculate 20 gpm. The suction from the reactor vessel is through the Westinghouse work platform via hoses which connect the nozzles provided on the work platform to the wells.

The system has four particulate filters, F-1, 2, 3 and 4, each capable of filtering a flow of 100 gpm. The filters are composed of sintered metal filter media which is contained in modified fuel canisters. These filters are capable of removing debris, mainly fuel fines (UO_2) and core debris (ZrO_2), down to a 0.5 micron rating. Since the canisters contain fuel fines, they are designed to prevent a criticality condition from existing when they have been loaded. Also, the filters are submersed in the transfer canal to provide the appropriate radiation shielding.

The two pumps and four filters are arranged so that one pump discharges to two filters. Therefore, the filtration portion of the system is divided into two trains, each train contains one pump which feeds two filter canisters. This allows the system to filter 200 or 400 gpm from the Reactor Vessel. Normally, the system will process 400 gpm of Reactor Vessel water. The two pump arrangement allows for greater flexibility in system operations and provides redundancy to allow system operation during maintenance.

A filter is used continuously until the differential pressure reaches a predetermined setpoint. At this point the system is shutdown and then, after a waiting period (approximately 5 min.), it is restarted. The differential pressure is noted and if it returns to a low value the system will be run again to the pressure setpoint. This process is repeated until the differential pressure at restart reaches a value near the shutdown setpoint. When this occurs within one hour, the train is shutdown and the filters are replaced.

Once the water has been filtered, all, or a portion of, the flow can be returned to the Reactor Vessel. The amount of water returned is controlled by remotely adjusted valves VO15A & B (HV30A&B). Each of these lines | 2
will connect, via flexible hoses, to the separate inlet nozzles on the work platform. A sparger has been placed on each return line to maintain a positive pressure in the attached hoses.

That portion of the flow not returned to the vessel can be further processed to remove soluble fission products. The flow from the pumps, which passes through a single line to the ion exchangers, is automatically controlled by remotely adjusted flow control valve V084 (FV-10). There | 2
is a post filter, F-5, located in that line to ensure that, in case of a failure of a filter canister, no fuel fines can reach the ion exchangers. The loading on the post filter is expected to be minimal and, as such, they will be standard disposable cartridge type filters.

Two ion exchangers, K-1 and K-3, are dedicated for use in this system. Each of these ion exchangers can handle the normal 30 gpm flow. The ion exchange media is a bed of zeolite resin which will remove the Cs-137. The two ion exchangers provide flexibility in operation so that one can be taken out of service without interrupting normal flow. The ion exchange media is contained in a 4 x 4 liner which is similar to those in use for the EPICOR II system.

The level in each ion exchanger is maintained by regulating the flow out of the ion exchanger to match the inflow. The outflow is regulated by a throttling control valve V029 or V266 (LV 45 or 72), which is located downstream of an air driven reciprocating diaphragm pump P-6 or 8. This valve automatically throttles in response to changing level in the ion exchanger. The maximum system flow rate is 30 gpm per 4 x 4 liner. The pumps head-flow characteristics can be changed by adjusting the air pressure to the pumps. Post filter F-6 is located downstream of these pumps to prevent the migration of any resin fines. The water is returned from here to the reactor vessel via flexible hoses.

Sampling points are provided at various locations in the system. The samples are routed to two sample glove boxes which are located in the Fuel Handling Building. This system provides the operator with the capability to periodically monitor the effectiveness of the system. Also, the turbidity of the effluent from the filters is constantly monitored by nephelometers and displayed at the local control panel. The radiation levels of the ion exchange influent and the boron concentration and pH of the ion exchange effluent are also constantly monitored and displayed at the local control panel.

Several inlets have been provided on the DWC system through which borated water can be gravity fed from the standby reactor pressure control system storage tank to backflush the system. The system will be backflushed when radiation levels in the piping are determined to be excessive and prior to maintainence.

A path to allow flow to the reactor coolant bleed tanks is provided to allow for system inventory reduction. Also, batch processing to remove Sb-125 will be performed by EPICOR-II from a RCBT as required. This flow path uses a portion of the submerged demineralizer system. This path is located downstream of the DWC ion exchangers, and, as such, this flow does not pass through the SDS ion exchange vessels. 2

1.3.2 System Components

P-2 A/B Reactor Vessel Cleanup Pumps

Type: Vertical Submersible Deep Well Pump
Model: Goulds VIS 9AHC/2
Material: Stainless Steel Bowl and shaft with a bronze impeller
Motor: Franklin Electric 25 hp, 460 Volt, 3 phase
Rating: 264 FT TDH at 220 gpm
Minimum Flow: 20 gpm

F-1/2/3/4 Reactor Vessel Filters

Type: Pleated Sintered metal media
Model: Pall Trinity special product contained in a crictically safe canister
Rating: 0.5 micron Nominal Removal Rating
Flow: 100 gpm

F-5/6 Filter Canister Post Filter and DWC Post Filter

Type: Disposable Cartridge
Model: Filterite No. 921273 Type 18M503C-304-2-FADB-C150
Rating: 0.45 micron nominal removal rating
Flow: 20 to 60 gpm

K-1/3 Ion Exchangers

Type: Zeolite resin contained in a 4'x4' HIC
Model: Nuclear Packaging 50 ft^3 Enviralloy Demineralizer/HIC 2
Flow: 30 gpm

P-6/8 Forwarding Pumps

Type: Air driven double diaphragm pump
Model: B.A. Bromley Heavy Metal Pump Model No. H25
Material: Stainless Steel with Viton diaphragms
Rating: 60 feet TDH at 60 gpm

For instrumentation, valves, piping. and equipment details, see references 14, 15, 16 and 17, respectively.

1.4 System Performance Characteristics

The system is designed to function in any of the modes of operation shown in table 1 below.

FILTER FLOW (GPM) [Return to Reactor Vessel]	ION EXCHANGER FLOW (GPM) [Return to Reactor Vessel]
400 [200]	0
370 [170]	30
340 [140]	60

(Numbers in brackets indicate flow if only one train is in operation.)

Table 1

Reactor Vessel Cleanup System Operational Configurations

The operational mode is determined based upon the solids loading in the reactor vessel. Normally, 400 gpm from the reactor vessel is filtered, and 30 to 60 gpm from the reactor vessel is demineralized. The 30 to 60 gpm is chosen based on the equivalent Cs-137 concentration in the reactor vessel.

As the filters load up, the pressure differential across the filter train increases. As the differential pressure increases, the flow rate is maintained constant by manually adjusting remote valves V015A and V015B (HV-30A and 30B).

1.5 System Arrangement

Well pumps P-2A and 2B are located in the fuel storage pit of the Unit 2 Reactor Bldg. These pumps are housed in wells which are located in this pit. The wells are connected by hose to the Westinghouse work platform. The pump discharge is routed to the filter canisters via a skid mounted manifold which is located above the water level of the canal. The filter isolation valves are also located on the skid. The filter canisters are in racks which are submersed in the fuel transfer canal. The manifold is connected to the inlet and outlet of the filters via coded, armoured hose. The inlet and outlet connections are coded to prevent mis-connection of the hoses. The outlets from the filters return to the manifold from where the water is routed back to the vessel or to the ion exchange system for further processing.

The ion exchangers are located behind appropriate shielding in the Fuel Handling Building. The water that has been demineralized is pumped back to its source by air driven pumps which are located near the ion exchangers.

The system uses the following existing penetrations which have been modified for their temporary function.

Penetration No.	System	Modified Function
R-542	Decay Heat	Backflush
R-546	Radwaste Disposal Gas	Flow to Ion Exchangers
R-553	Radwaste Disposal Reactor Coolant Liquid	Return from Ion Exchangers

Penetration No.	System	Modified Function
R-537	R.B. Emergency Spray and Core Flooding	Sampling Return
R-545B&C	Spares	Sampling

For further location and arrangement information, see references 7, 8 and 18.

1.6 Instrumentation and Control

1.6.1 Controls

The majority of system control is handled remotely from a control panel which is located in the Fuel Handling Building. This is due to the fact that much of the system is located in the Reactor Building which has limited access. The reactor vessel cleanup pumps do have local hand switches to shut the pumps down.

Filtered water flow back to the reactor vessel is monitored by the operator and adjusted by remotely controlled valves V015A and V015B (HV30A&B). The flow to the ion exchangers is controlled automatically by flow control valve V084 (FV-10), which seeks to maintain flow to the ion exchangers at the selected setpoint.

The ion exchangers are located behind appropriate shielding in the Fuel Handling Building. The water that has been demineralized is pumped back to its source by air driven pumps which are located near the ion exchangers.

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Return flow to the reactor vessel from the ion exchangers is controlled automatically by control valves V029 and V266 (LV 45 and 72). Each valve responds to a changing level in its associated ion exchanger, which is sensed by a "bubbler" type of level measuring device. This level is maintained between a high and low setpoint in the ion exchanger. The forwarding pumps' head-flow characteristics can be changed as needed by manually adjusting the air pressure to the pumps. This control scheme maintains the inflow equal to the outflow in the ion exchanger.

For further information on the instrumentation, refer to the Instrument Index (Ref. 14).

1.6.2 Power

The pump motors are supplied with 480V power through a motor control center which is energized by an existing unit substation located in the Auxiliary Building. 120 VAC power will be supplied from the control panel or local sources.

1.6.3 Monitoring

Monitoring equipment is provided to evaluate the performance of the system and to aid in proper operation of the system.

The discharge pressure of the submersible well pumps is monitored (PI-4A & 4B) to determine if the pump is operating correctly and also to provide another indication that the pump is operating.

In order to determine the degree of filter loading, the primary filter canisters and the secondary post filters are equipped with remote indication of differential pressure across the filters (DPI-5A & 5B). The differential pressure across the canisters will be used to determine when the filters are loaded to capacity.

Flow in the filter train and the ion exchanger loop is monitored (FI-7A, 7B and 10) to ensure that inflow to the reactor vessel equals the outflow. This is important to insure that the level in the reactor vessel remains constant. Also, the flow to each ion exchanger is integrated by a local device (FQI76 & 77) to determine the loading on each ion exchanger.

The process fluid conditions are monitored to determine the effectiveness of the system. The turbidity level in the fluid is monitored (AI 43A & 43B) prior to its return to the source. Also, the capability to obtain grab samples of process fluid has been provided for at several locations in the system. The radiation levels in the process fluid are continuously monitored upstream of the ion exchangers (RE-9). A high radiation alarm (RAH-9) is also provided. This will alert the operator to the need of processing at a higher rate. The pH and boron concentration are monitored downstream of the ion exchangers (AE 11 & 12). This assures the operator that the proper boron concentration is maintained in the return flow.

The high and low level trip conditions in the ion exchangers alarm to the local control panel located in the Fuel Handling Building. This is done to ensure that the operator is aware of this condition so that the proper evaluation of the system condition that caused the level mismatch can be made. The operator will disolute the ion exchanger portion of the system during this event.

1.6.4 Trips and Interlocks

The reactor vessel cleanup well pumps, P-2A/B, are provided with low level setpoint trips to ensure that the pumps do not operate under potential cavitation conditions. Also, a low level in an ion exchanger will trip its forwarding pump and terminate flow to that ion exchanger. Additionally, a high level in the ion exchanger would terminate flow to that ion exchanger by closing its inlet valve, and also would stop its forwarding pump. These trips are taken from a conductivity level probe in the ion exchangers. A low level in the IIF will trip pumps P-2A and P-2B.

Locally mounted toggle switches are provided near the ion exchanger to disable the level switches to allow for filling and draining of the ion exchangers. An alarm at the local control panel alerts the operator when the level switches are disabled.

The reactor vessel cleanup well pumps, P-2A/B are equipped with interlocks to prevent them from being started during a low level condition. Additionally, either a high or a low level in the ion exchangers prevents the valve upstream of the ion exchangers from being opened and prevents the restart of the air driven forwarding pumps. This will ensure that the exchangers are not overfilled and also that any flow mismatch condition is properly evaluated by the operator prior to restart of the system.

For trip setpoints, see section 2.2.

1.7 System Interfaces

Those systems interfacing with the DWC are as follows:

a) Standby Reactor Pressure Control System (existing)
Use: Provide a source of borated water for backflushing
Tie-in: A single connection from SPC-T-4 downstream of SPC-VI to several points in system

b) Submerged Demineralizer System (existing)
Use: Provide a path to the reactor coolant bleed tanks
Tie-in: Downstream of CN-V-IX-32 near 1 1/2" jumper from downstream of ion exchanger post filters.

c) Instrument Air System (existing)
Use: Provide source of instrument air to equipment in the Reactor Building.
Tie-in: From existing Instrument Air supply to LOCA dampers.

d) Instrument Air System (existing)
Use: Provide source of instrument air to equipment located in the Fuel Handling Building.
Tie-in: From existing Instrument Air supply to Spent Fuel Pool gate seals

e) Service Air System (existing)
Use: Provide a source of service air to the Forwarding Pumps P-6 and P-8.
Tie-in: Service Station 87 plus another station if needed

1.8 QUALITY ASSURANCE

The defueling water cleanup system is classified according to the safety functions of its parts. There are three classifications in this system:

a. Portions of the system associated with ion exchange processing are considered to be a radioactive waste processing system; therefore, these portions of the system shall be subject to the quality assurance guidelines contained in NRC Regulatory Guide 1.143.

b. The filter canisters are classified as nuclear safety related and are designed to prevent a condition that could result in a return to nuclear criticality of the fuel retained in the filters.

c. The remaining portions of the system are subject to the BNAPC non-safety-related quality assurance program.

The TMI-2 Recovery QA Plan will be applicable for work performed on site.

2.0 SYSTEM LIMITATIONS, SETPOINTS AND PRECAUTIONS

2.1 Limitations

The system is flow limited to 200 gpm through each filter train, 400 gpm total, and 30 gpm through each ion exchanger, 60 gpm through the ion exchanger loop.

The main filter canisters are limited to 45 psi pressure differential. At this point an alarm on the local control panel will inform the operator to stop and restart the system or change out the filter.

The post filters are limited to 10 psi pressure differential. At this point, the filters are considered fully loaded and are changed out.

2.2 Setpoints

DPSH 5 A/B trips the alarm at 45 psid across the filter canisters.

ASL 12 trips the alarm at a low Boron concentration of 4850 ppm. 2

DPSH 33 trips the alarm at 10 psid across the filter canister post filter.

RC-LIS 103 trips alarms and pumps at high IIF level of 327'-9" and a low IIF level of 327'-3".

RIS-9 trips the alarm at a high radiation reading of 0.9 mR/hr.

LSL 37/71 and LSH 37/71 trip the ion exchange loops at ± 3" from the normal operating level. (Note: Low level is 10" from top of IX, High level is 4" from top of IX.) 2

LIS 2A/B trip pumps 2 A/B at a decreasing level of 1'-0" above the suction of the pump.

For additional setpoint information, refer to Ref. 14.

2.3 Precautions

Due to the number of quick disconnect couplings, extra care should be taken to ensure that the couplings are properly connected and that they are connected in the proper locations. This precaution will help prevent a loss of reactor vessel inventory.

The portion of the startup procedures concerning the well pumps should be strictly adhered to to prevent the rapid filling of an empty manifold. This situation could cause a harmful pressure wave to develop which has the potential to damage the filter media.

The filter canisters operate by a surface filtration method, and their efficiency increases as a cake is built up on the surface of the media. Therefore, the build up of this cake is an important part of the filtration process. To prevent the migration of fines to the post filter, the ion exchange portion of the system should not be started until a cake has begun to be formed on the media. This can be verified by observing the turbidity of the filter effluent. When the filter train is started up, there will be an initial turbidity spike caused by smaller particles passing through the media. As the cake is built, these particles are stopped and the turbidity decreases. Once the turbidity reaches a level of 10 NTU or less, the ion exchange portion of the system can be started. To prevent the breakdown of the cake, the system should not be started or stopped unnecessarily.

Due to the radioactivity in the water, the system should be carefully drained and flushed prior to any maintenance work.

Double isolation has been provided for in the system design to separate borated and nonborated water supplies.

3.0 OPERATIONS

3.1 Initial Fill

The system is filled initially by borated water from the standby reactor coolant pressure system through the backflushing system provided (see section 3.7). The filters are filled to the inlet and outlet manifolds and the ion exchangers are filled until they reach their normal operating level.

To initially fill the DWC ion exchangers K-1 and K-3 the level switches must be blocked out. This is accomplished by placing the block-out toggle switch, for the ion exchanger to be filled, in the proper position. This will allow isolation valve V025 or V260 to be opened. Once the ion exchanger is filled to the operating level, the level switches are returned to operation by returning the block out toggle switch to its original position. As a reminder to the operator, an alarm is activated at the control panel when the level switches are blocked out.

3.2 Startup

Prior to startup, valve alignment must be checked to verify that the process water for each filter train and the ion exchanger loop is taken from and returned to the contamination barrier. The well pumps are isolated by the remote manual isolation valves. The ion exchanger loop is isolated by the remote isolation valves and the control valve in the ion exchanger loop. The return lines to the source are isolated by the remote control valve. The well pumps are started and placed on minimum recirculation flow. The pump isolation valve for one filter train is slowly opened to allow any trapped air to escape through the automatic vent valves. Once the isolation valve is fully opened, flow is started by slowly opening the return line to the source. Flow through this train is allowed to reach the desired flow and then the other train is brought to the desired flow by following the same procedure.

The ion exchanger is brought into service only after the filtration system is in operation. The ion exchange system is brought into service only after the initial turbidity spike, as monitored by the in line nephelometer, reaches an acceptably low level (i.e. 10 NTU).The ion exchanger should always be brought to normal operating level prior to operation of this portion of the system.

If the ion exchanger is at low level, it should be filled with borated water from the back flush system (see Section 3.1). At this time, the inlet isolation valve is opened. The air pressure to the ion exchanger forwarding pump is manually adjusted to the pressure required to maintain the flow rate chosen. The air supply solenoid valve is then opened which will start the pump and lower the level in the ion exchanger to the point where the level control valve will close. This level is above the isolation low level. Flow is slowly started to the ion exchanger by opening the flow control valve until the desired ion exchanger flow rate is obtained. The proper flow of water will be returned to the source automatically as the level control for the ion exchanger adjusts the downstream control valve to regulate the outflow.

3.3 Normal Operation

Normal operation of the system is in one of the modes shown in Table 1 of Section 1.4. The mode of operation chosen is based on the particulate and radioactivity concentrations in the Reactor Vessel.

3.4 Shutdown

The steps to bring the system to a shutdown condition are basically the reverse of the startup procedure. The ion exchanger flow would be brought to zero slowly by remote operation of the upstream flow control valve. As the level in the ion exchanger drops, flow from the forwarding pumps is terminated by the closure of the control valve downstream of the pump. Either (depending on system operation) of the isolation valves from the filtration trains to the ion exchanger is then closed, and the solenoid valve for the air supply to the forwarding pump is closed. The filtration trains are shut down one at a time by closing the flow return control valve and then shutting down the pumps and closing the pump isolation valves.

3.5 Draining

There is a low point drain which can drain both filtration train manifolds and part of the ion exhcange loops to the fuel transfer canal. A manual blockout switch is provided which will deactivate the ion exchanger level switches. This allows the ion exchangers to be pumped out to the reactor coolant bleed tanks via the connection provided.

3.6 Refilling

The fully drained system can be refilled in the same manner that the system was initially filled. A partially drained system can be refilled by using either the back flush system (see section 3.7) or the well pumps (see section 3.2).

3.7 Infrequent Operations

Flushing of the system may be performed when the internal contamination level gets high or prior to internal maintenance work. The system is shutdown (see Section 3.4) prior to flushing.

One flushing option allows a gravity flush from SPC-T-4. Borated water is stored in the charging water storage tank, SPC-T-4, located at the 347 ft. elevation in the Fuel Handling Building. This tank is connected to the DWCS. Either filter train may be flushed without stopping flow through the other.

Flushing may be accomplished by opening one of the inlet valves from the flushing system (depending on which portion of the system is to be flushed) and then opening the drain valve to the fuel transfer canal. After sufficient time has been allowed to flush the system, the drain valve is closed and then the inlet valve is closed. The system is then restarted following the procedures in Section 3.2.

System inventory can be decreased as needed by diverting the return flow from the ion exchangers through the lines provided to the Reactor Coolant Bleed Tanks. Also, water can be routed to the RCBT as required for processing to remove Sb-125.

3.8 Transient Operations

The only effects of anticipated transients (e.g., loss of pumps, valve misoperation, or loss of controls) are a mismatch of flows from and to the reactor vessel. More water can be removed from the source than is replaced by a failure to control level in the ion exchangers. In the case where level control in the ion exchangers is lost, the source outflow will exceed the inflow by a maximum of 60 gpm. This situation can be detected by flow instrumentation in the return line and by a decreasing level in the reactor vessel. This is an unlikely event since the level controls receive their signals from two separate, diverse types of level instrumentation.

4.0 CASUALTY EVENTS AND RECOVERY PROCEDURES

4.1 Loss of Power

A loss of power to the entire system would simply shut the system down. A loss of power to the well pumps with an additional failure which results in simultaneous loss of level control in the ion exchangers would result in a flow mismatch. In this case, the system would be automatically shut down until power is restored. Loss of power to individual components would place the component in its safe mode. An air operated valve, for example, would fail to a position that ensures no damage to other components.

Loss of power to the control panel would cause the loss of all information and fail all control and solenoid operated valves. The system would be shutdown until power is restored.

4.2 Loss of Instrumentation/Instrument Air

Loss of instrumentation would hamper operations but no adverse conditions would result and the system could be safely shut down until the problem is resolved.

Loss of a single instrument channel will result in the loss of indication for that channel and, for those channels that have control features a flow mismatch. This flow mismatch will result in an automatic shutdown of the affected portion of the system.

Loss of the internals indexing fixture (IIF) level indication system (bubbler) will result in an erroneous level indication which will be noted when compared with a redundant level indication system. Since this system has no control features, no adverse system conditions will result.

Loss of instrument air will take the individual components to their fail safe position. Flow mismatches induced by loss of air will result in automatic trips. Loss of air to the IIF level monitoring system will initiate a low air supply pressure alarm.

On the loss of instrument air, level control in the ion exchangers would be lost; however, the ion exchanger inlet isolation valve (V025 & V260) would fail to the closed position. Also, the level control valves, V029 and V266 (LV45 & LV72), will fail to the closed position to prevent siphoning of the ion exchanger.

4.3 Filter Media Rupture

A failure of the filter media in the canister could potentially release fuel fines to the ion exchange portion of the system. A post filter is located downstream of both filter trains in the line to the ion exchangers. This filter will trap any fuel fines which would be transported past the filter canisters in the event of filter failure. The post filter is designed to be critically safe and is sized so that a small accumulation of debris will increase the differential pressure to the alarm setpoint. Also, the nephelometers in the return line would alert the operator to a possible media rupture since the turbidity would increase rapidly.

The recovery procedure is to isolate the filter trains and find the ruptured filter by observing the differential pressure versus flow for each individual canister. Lower differential pressure for a given flow will indicate that this filter is ruptured. That canister or canisters and the post filter cartridge would be replaced and the system restarted.

4.4 Line and Hose Break

The consequences of any line and hose break is a loss of reactor vessel inventory. The system has been designed to mitigate the consequences of such an incident to the extent possible.

To help prevent a hose rupture, all process hoses are armoured. In case of a hose rupture or line rupture, downstream of the reactor vessel pumps, P-2A & 2B, the system is equipped to trip these pumps on the IIF low level and alarm to the control panel. This event could deliver approximately 500 to 1000 gallons of reactor vessel water to the area of the break. The potential areas affected would be the Reactor Building and the Fuel Handling Building, each of which has sumps or drains to the Aux. Bldg. sumps to contain the spill.

If a suction hose to the well pumps or a return hose to the reactor vessel should rupture, a siphoning of reactor vessel water would take place. The two 4 inch suction connections provided in the Westinghouse work platform are provided with two 3/4 inch holes drilled 18 inches below the water level which will act as a siphon breaker. The three 2 inch return lines are equipped with spargers, which are simply holes drilled into the pipes. The first holes are drilled 18 inches below the water level which will act as a siphon breaker. The sample return line is terminated 18 inches below the water level. Therefore, a maximum of approximately 3000 gallons of reactor vessel water would spill into the fuel transfer canal following a hose rupture. Approximately half of this water would be contained in the New Fuel Pit.

The recovery from these events would be accomplished by isolating the ruptured section and replacing the ruptured hose/pipe.

5.0 SYSTEM MAINTENANCE

The maintenance procedures are the recommended practices and intervals as described by the equipment vendors. This section will be expanded as equipment selection is finalized and vendor information becomes available.

6.0 TESTING

6.1 Hydrostatic Testing

Piping and hose will be hydrostatically pressure tested. Testing of hose will be done after couplings have been attached. Pipe will be tested outside the buildings.

6.2 Leak Testing

All accessible connections will be initial service leak tested after the piping is assembled.

6.3 Instrument Testing

All instruments will be calibrated by vendors. Complete electric/pneumatic loop verification will be done during start-up.

7.0 HUMAN FACTORS

Filter canister hoses are coded for quick identification of inlet versus outlet.

Extensive use of hoses is made, especially in the Reactor Building, allowing quick installation and use of existing radiation shielding. Hoses which are expected to be frequently disconnected are equipped with quick disconnect couplings for ease of removal and replacement.

The following human factors guidelines have been incorporated into the design of the DWCS control panel:

- The panel includes all controls and displays required for normal operation.
- Displays provide immediate feedback that the system has responded appropriately to an operator's action.
- Controls and displays are laid-out for a left to right flow path.
- Mimic lines are used to clarify flow paths.
- Control devices are mounted 3 to 6 feet above the floor.
- Each control device has a name plate.
- Light bulbs are replaceable from the front of the panel.
- Recorders are grouped on the right side of the panel away from the flow path.
- Adjustments to recorders and controllers can be performed from the front of the panel.

GPU Nuclear

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TMI-2

DIVISION

SYSTEM DESCRIPTION

FOR

DEFUELING WATER CLEANUP

FUEL TRANSFER CANAL/SPENT

FUEL POOL CLEANUP SYSTEM

(ECA 3525-84-0041)

COG ENG M K Boldt DATE 8/27/84

RTR R L Mays DATE 8/27/84

COG ENG MGR. M K Boldt for R.L. Rider DATE 8/27/84

NO	DATE	REVISIONS	BY	CHECKED	GROUP SUPERVISOR	MGR DESIGN ENGINEERING
2	12/27/84	See Change Summary on page 2	[illegible]	[illegible]	RLM	[illegible]
1	10/30/84	Added K-2 (see Change Summary)	MKB	[illegible]	RLM	[illegible]
0	8/27/84	Issue For Use	MKB	[illegible]	RLM	[illegible]
				CHIEF ENGR		

FORM 4000-ENG-7310.06-1 (5/84)

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PDR ADOCK 05000320
P PDR

0282Y

Rev.	SUMMARY OF CHANGE
1	DWC ion exchanger K-2 dedicated to FTC/SFP Cleanup System and made primary routing for Cs-137 removal with SDS now as a backup. Added to sections 1.3.1, 1.3.2, 1.6.3, 1.6.4, 2.1, 2.2, 3.1, 3.2, 3.4, 3.5 and 4.2 information on K-2 given previously in system description 2-M72-DWC01 (Ref. 13). Any information added to or changed from that given previously in Ref. 13 is listed below.
1	Added capability to bypass level switch on K-2 (section 3.5) for draining and filling.
1	Added low & high level set points for K-2 level switches LSL-40 and LSH-40.
1	Deleted plug valve V100. Now use V099 to isolate 4 inch hose on return line to the FTC.
1	Completed description of Ref. 18f. Added Ref. 18k through 18q, 19, 20, 21 and 22.
1	Added capability to route to K-2 & SDS simultaneously.
1	Inlet/Outlet manifolds for filter canisters are not skid mounted.
1	Normal operational mode now is 400 gpm from FTC filtered and returned to Fuel Pool A. 30 gpm is also processed in K-2.
1	Cesium concentration levels changed to read equivalent cesium concentration.
2	Deleted section 4.3; corrected ref. 22b; revised ion exchanger model, ASL-17 setpoint; made method of filling/refilling optional in sections 3.1 and 3.6; revised wording in section 4.4; corrected pump number in section 4.5; delete sentence section 2.3.

TABLE OF CONTENTS

1.0 DESIGN DESCRIPTION

1.1 Summary

The fuel transfer canal/spent fuel pool cleanup system is a temporary liquid processing system which is designed to process water contained in the spent fuel pool and/or the fuel transfer canal. The system's major functions are:

a) to filter the water contained in the spent fuel pool and/or the fuel transfer canal to remove suspended solids above a nominal .5 micron rating. This is done to maintain the clarity of the water to a 1 NTU rating.

b) to remove soluble fission products from the spent fuel pool or the fuel transfer canal by demineralization of the water. This is done to keep the equivalent Cs-137 concentration less than .02 µci/ml and thus reduce the dose rate contribution of the water. Also, a flowpath to EPICOR II via the RCBT's is provided to remove Sb-125 in the event that high Sb-125 levels are encountered.

1.2 References

1. Planning Study, Defueling Water Cleanup System Doc. No. TPO/TMI-046
2. Technical Plan, Defueling Water Cleanup System Doc. No. TPO/TMI-047
3. Division I, System Design Description, Defueling Water Cleanup System Doc. No. 2-R72-DWC01
4. Bechtel Drawing 2-M74-DWC01, Defueling Water Cleanup (DWC) Reactor Vessel Cleanup System P&ID
5. Bechtel Drawing 2-M74-DWC02, Defueling Water Cleanup (DWC) Fuel Transfer Canal/Spent Fuel Pool Cleanup System P&ID
6. Bechtel Drawing 2-M74-DWC03, Defueling Water Cleanup (DWC) Auxiliary Systems P&ID
7. Bechtel Drawing 2-POA-6401, General Arrangement Fuel Handling Building Plan El. 347'-6"
8. Bechtel Drawing 2-POA-1303, General Arrangement Plenum Removal Reactor Building
9. DCN No. 2026-30-2, Flow Diagram Spent Fuel Cooling and Decay Heat Removal
10. Burns & Roe Drawing No. 2026, Flow Diagram Spent Fuel Cooling and Decay Heat Removal

11. GPU Drawing No. 2R-950-21-001 P&ID Composite Submerged Demineralizer System

12. TMI-2 Recovery Division System Design Description for Submerged Demineralizer System, Doc. No. SD 3527-005

13. Division System Design Description for Reactor Vessel Cleanup System, Doc. No. 15737-2-M72-DWC01

14. Instrument Index, Doc. No. 15737-2-J16-001

15. Design Engineering Valve List, Doc. No. 15737-2-P16-001.

16. TMI-2 Recovery Mechanical Equipment List, Bechtel North American Power Corp., Job 15737

17. Standard For Piping Line Specifications, Doc. No. 15737-2-P-001.

18. Bechtel Piping Isometrics

    a) 2-P60-DWC01-DWCS-Pumps P-2A&B, P-3A&B, P-4A&B, and Miscellaneous Details

    b) 2-P60-DWC02-DWCS - Reactor Vessel Filter Trains A & B - Inlet Manifold Piping

    c) 2-P60-DWC03-DWCS - Reactor Vessel Filter Trains A & B - Outlet Manifold Piping

    d) 2-P60-DWC04-DWCS - Transfer Canal/Fuel Pool Filter Trains A & B - Inlet Manifold Piping

    e) 2-P60-DWC05-DWCS - Reactor Vesel Filter Train Sample Lines

    f) 2-P60-DWC06-DWCS - Discharge Piping from Sample Boxes No. 1 & No. 2 to Penetration R-537

    g) 2-P60-DWC07-DWCS - Samples Lines Upstream & Downstream of Ion Exchangers

    h) 2-P60-DWC08-DWCS - Forwarding Pumps P-6 and P-7, Suction & Discharge Piping

    i) 2-P60-DWC09-DWCS - Forwarding Pumps P-6 and P-7 Discharge Piping

    j) 2-P60-DWC10-DWCS - Supply Piping to Ion Exchangers K-1 & K-2, Supply & Discharge Piping from Post Filter F-8

    k) 2-P60-DWC11-DWCS - Supply Piping to Ion Exchangers K-1 & K-2

    l) 2-P60-DWC12-DWCS - Borated Water Flush Piping from SPC-T-4

m) 2-P60-DWC13-DWCS - Transfer Canal/Fuel Pool Filter Trains "A" & "B" Outlet Manifold Piping

n) 2-P60-DWC14-DWCS - Transfer Canal/Fuel Pool Filter Trains "A" & "B" Outlet Manifold Discharge Piping, Supply & Discharge to Booster Pump P-5

o) 2-P60-DWC15-DWCS - Nitrogen Suppy Piping to SPC-T-4 and Drying Station

p) 2-P60-DWC16-DWCS - Discharge Piping from DWC Booster Pump P-5

q. 2-P60-DWC17 DWC Miscellaneous Piping Details

19. ECA No. 3245-84-0034 - Defueling Water Cleanup System Penetration Modifications

20. ECA No. 3525-84-0041 - Definition of the Defueling Water Cleanup System (DWCS)

21. ECA No. 3527-84-0042 - SDS Tie-in to DWCS

22. Bechtel Area Piping Drawings

a. 2-P70-DWC03 DWCS Hose Network Reactor Bldg. Plan El. 347'-6"

b. 2-P70-DWC04 DWCS Hose Network Fuel Handling Bldg. Plan El. 347'-6" 2

1.3 Detailed System Description

1.3.1 Description

The fuel transfer canal/spent fuel pool cleanup system is a liquid processing system which can process water from the spent fuel pool and/or the fuel transfer canal. For the corresponding P&ID's see references 4, 5, and 6. Some valves identified herein have been given an instrumentation designator as well as a valve number. When this occurs, the instrument designator is shown in parentheses after the valve number. 2

The spent fuel pool (SFP) and the deep end of the fuel transfer canal (FTC) will be filled with water to a level of 327 ft.-8 in. A dam with top elevation 328 ft.-2 in. separates the shallow and deep ends of the FTC.

Two vertical submersible well pumps, P-3A/B, are located in the FTC. Each is capable of pumping a net 200 gpm. A 20 gpm continuous recycle protects the pump motor. P-3A/B take suction from trough-type skimmer U-7 via a 6 inch flexible hose. A secondary, 4 inch, subsurface inlet below the skimmer will prevent pump starvation due to skimmer congestion.

Pumps P-3A/B discharge to the FTC/SFP filter canisters via Reactor Building penetration R-524. The internals of check valve SF-V190 are removed to make use of existing piping connected to R-524.

Two vertical submersible well pumps, P-4A/B, identical to P-3 A/B in the FTC, are located in the SFP. P-4A/B take suction from trough-type skimmer, U-8, similar to U-7.

The system has four particulate filters, each capable of filtering a flow of 100 gpm. The filters are contained in modified fuel canisters submersed in the SFP to provide the appropriate radiation shielding. These filters are capable of removing debris, mainly fuel fines (UO_2) and core debris (ZrO_2), down to a 0.5 micron rating. Since the canisters contain fuel fines, they are designed to prevent a criticality condition from existing when they have been loaded.

The four pumps and four filters are normally manifolded so one pump from each source discharges to one pair of filters. Therefore, the filtration portion of the system is divided into two trains. Train A contains pumps P-3A and P-4A and filter canisters F-9 and F-10. Train B contains pumps P-3B and P-4B and filter canisters F-11 and F-12. In the normal mode the system filters 400 gpm from the FTC and returns the filtrate to the SFP. The system can be manifolded to filter 200 gpm from the FTC and 200 gpm from the SFP or 400 gpm from either source. This pump arrangement provides both flexibility in operations and the redundancy to permit continued operation during pump maintenance.

A filter canister is used continuously until the differential pressure reaches a set point (See section 2.2). At this point the system is shutdown and then, after a waiting period of approximately 5 minutes, it is restarted. The differential pressure is noted and if it returns to a low value the system will be run again to the pressure setpoint. This process is repeated until the differential pressure at restart reaches a value near the shutdown setpoint. When this occurs within one hour of restart, the train is shutdown and the filters are replaced.

Filter canisters are not reusable. The filter canisters are connected to inlet and outlet manifolds via 2-1/2 inch flexible hoses with cam and groove couplings.

Once the water has been filtered, all, or a portion of the flow can be returned to its source (either the SFP or the FTC). The amount of water pumped from its source is controlled by manually adjusting globe valves V097 A/B. The return path to the FTC uses Reactor Building penetration R-539. At each source the return path splits into two 2-inch returns to provide back pressure to valves V097 A/B. One two inch return is used for 200 gpm operation; both are used for 400 gpm operation.

A portion of the flow not returned directly to source can be further processed through either the DWC ion exchanger K-2 or the submerged demineralizer system (SDS). Routing to the SDS is provided as a backup to K-2 and to augment total processing capability during times of high cesium concentration in either source. The DWC ion exchanger K-2 can process 30 gpm. The ion exchange media is a bed of zeolite resin which will remove Cs-137. The resin is contained in a 4 x 4 liner, similar to those used in EPICOR II. K-2 influent is regulated by flow control valve V085 (FV-15) while K-2 effluent is regulated by level control valve V070 (LV-46). If either high or low levels occur in K-2, LSH-40 or LSL-40 will trip both isolation valve V069, halting influent, and solenoid valve V156, shutting off air supply to DWC forwarding pump P-7, thus halting effluent.

Two post filters are provided. Filter canister post filter F-8 protects K-2 from suspended solids in the event of a canister filter media rupture. DWC post filter F-7 is located downstream of the forwarding pump to prevent the migration of resin fines. DWC forwarding pump P-7, an air driven reciprocating diaphram pump, provides the head to return flow to either source.

The SDS can process 15 gpm. The DWC Booster Pump, P-5, is provided to increase the pressure to 140 psig to overcome the high SDS differential pressure. P-5 suction pressure will vary inversely with pressure differential across the filter canisters. When the filter canisters are clean P-5 will experience maximum suction pressure. Since P-5 outlet pressure is controlled, pump flowrate varies. Pressure regulator V122 (PCV-26) controls SDS inlet pressure at 140 psig, bypassing excess flow past SDS. PSV R-1 is provided downstream of the DWC Booster Pump to prevent overpressuring the SDS due to V122 (PCV-26) failure. From the SDS, flow is routed to either the FTC or SFP.

In the event of high Sb-125 levels, the return flow from K-2 can be routed to the reactor coolant bleed tanks for batch processing through EPICOR II.

1.3.2 System Components

F-7/8 Filter Canister Post Filter and DWCS Post Filter

Type: Disposable Cartridge
Model: Filterite No. 921273 Type
18M503C-304-2-FADB-C150
Rating: 0.45 micron nominal removal rating
Flow: 20 to 30 gpm

F-9, F-10, F-11, F-12 Fuel Transfer Canal/Spent Fuel Pool Filters

Type: Pleated sintered metal media
Model: Pall Trinity special product contained in a criticality safe canister
Rating: 0.5 micron Nominal Removal Rating
Flow: 100 gpm

K-2 Ion Exchanger

Type: Zeolite resin contained in a 4' x 4' HIC
Model: Nuclear Packaging 50 ft^3, Enviralloy, Demineralizer/HIC 2
Flow: 30 gpm

P-3 A/B Fuel Transfer Canal Pumps

Type: Vertical, 2 stage, submersible pump; Goulds model VIS, size 9AHC, 5.56 in impeller
Metalurgy: Stainless steel bowl, bronze impeller, 416SS shaft
Motor: Franklin Electric 25 HP, 3550 rpm, 460V, 3 phase
Rating: 220 gpm at 264 ft
Shutoff head: 289 ft.
Min Flow: 20 gpm (recirculation)

P-4A/B Spent Fuel Pool Pumps

Identical to P-3A/B

P-5 DWC Booster Pump

Type: Regenerative turbine, 2 stage, SIHI model AEHY 3102 BN 112.42.4
Metalurgy: 316SS casing with 316SS shaft, impeller, and internals
Motor: 5 HP, 1750 rpm
Rating: 15 gpm at 250 ft
Shutoff head: 390 ft (at min flow)
Min Flow: 5 gpm
Seals: Mechanical, John Crane type 1 with tungsten carbide seal faces

P-7 Forwarding Pump

Type: Air driven double diaphragm pump
Model: B.A. Bromley Heavy Metal Pump Model No. H25
Material: Stainless Steel with Viton diaphragms
Rating: 60 feet TDH at 60 gpm

PCV-26 Pressure regulator, SDS bypass
Capacity: 25 gpm

PSV R-1 Relief Valve
Capacity: 30 gpm
Orifice: Size E, 0.196 in^2
Set Pressure: 150 psig

For further information on valves and instrumentation, refer to the valve list (Ref. 15) and the instrument index (Ref. 14). For a listing of all equipment see the TMI-2 Recovery Mechanical Equipment List (Ref. 16). For piping information see the Standard for Piping Line Specifications (Ref. 17).

1.4 System Performance Characteristics

The system is designed to function in any of the modes of operation shown in Table 1 below.

Table 1

Fuel Transfer Canal/Spent Fuel Pool Cleanup System Operational Configurations

Filter Flow (GPM)		SDS Flow (GPM)		K-2 Flow (GPM)	
From FTC	From SPA	From FTC	From SFP	From FTC	From SFP
400 (200)	0	0	0	0	0
400 (200)	0	15	0	0	0
400 (200)	0	0	0	30	0
400 (200)	0	15	0	30	0
0	400 (200)	0	0	0	0
0	400 (200)	0	15	0	0
0	400 (200)	0	0	0	30
0	400 (200)	0	15	0	30
200	200	0	0	0	0
200	200	15	0	0	0
200	200	0	15	0	0
200	200	0	0	30	0
200	200	0	0	0	30

(numbers in brackets indicate 1 pump operation)

The operational mode is determined based upon which source needs to be processed. Normally, 400 gpm from the fuel transfer canal are filtered and 30 gpm of the fitrate is processed through DWC ion exchanger K-2. The total discharge flow (400 gpm) is returned to the spent fuel pool to create an inflow to the fuel transfer canal through the open fuel transfer tubes.

The other modes of operation are chosen based on the solids and Cs-137 concentrations in the sources. The filter flow rate is chosen based on the concentration of solids in the sources. If one source experiences a high solids loading, 400 gpm from that source could be filtered to more rapidly reduce the solids loading. During this time, the other source could not be processed through this system. During periods of high Cs-137 loading, an additional 15 gpm could be processed through the SDS which would reduce the recovery time of the source.

1.5 System Arrangement

References 7 and 8 present the positioning of equipment. Well pumps P-3 A/B, are submersed in 10 inch diameter wells in the north end of the fuel transfer canal in the Reactor Building. The wells are connected by a 6" flexible hose to skimmer U-7 located at the dam separating the deep and shallow ends of the fuel transfer canal. Well pumps P-4A/B are submersed in the northeast end of spent fuel pool "A" in the Fuel Handling Building. These wells are connected by a 6" flexible hose to skimmer U-8 located at the south end of the SFP.

The discharge of pumps P-3A/B and P-4A/B is routed to the filter canisters inlet manifold near the northeast end of the SFP. The filter isolation valves, vent valves, and manual control valves V090A/B (HV-64A/E) are also located there. The filter outlet manifold is adjacent to the inlet manifold.

Filter canisters F-9, F-10, F-11, and F-12 are submersed in the SFP in the north end of the dense pack fuel rack. They are connected to the inlet and outlet manifolds by 2-1/2 inch steel guarded, flexible, coded hoses equipped with cam and groove couplings. The coupling at the fuel canister is modified for long handled tool operation.

From the filter outlet manifold the water is routed either directly back to source or to the DWC ion exchanger K-2 or SDS for further processing. The DWC ion exchangers are located behind appropriate shielding in the northwest end of the Fuel Handling Building. The forwarding pump P-7 is located near K-2.

The system uses the following existing penetrations which have been modified for their temporary function. Armored hose is used downstream of penetration R-539 to the FTC.

Penetration No.	System	Modified Function
R-524	Spent Fuel Cooling	Discharge from Fuel Transfer Canal Pumps
R-539	Decay Heat Closed Cooling Water	Return to Fuel Transfer Canal

1.6 Instrumentation and Control

1.6.1 Controls

The components of this system are located in accessible areas of the Fuel Handling Building. With the exception of the DWC ion exchanger loop, valve alignment and adjustment is performed manually to achieve the proper flows to and from the various sources.

The flow to DWC ion exchanger K-2 is regulated automatically by flow control valve V085 (FV-15). K-2 effluent is regulated automatically by level control valve V070 (LV-46).

1.6.2 Power

The pump motors are supplied with 480V power through a motor control center which is energized by an existing unit substation located in the Auxiliary Building. A stepdown transformer will provide 120 VAC for valve operation and the control panel.

1.6.3 Monitoring

Monitoring equipment is provided to evaluate the performance of the system and to aid in proper operation of the system.

PI-25 monitors the Booster Pump discharge pressure to verify the correct operation of both the pump and the bypass pressure regulator, V122 (PCV-26)

FI-15 and FQI-15 monitor the flowrate and total flow of filtered water routed to DWC ion exchanger K-2

AE-16 and AE-17 monitor pH and boron concentration in the water leaving SDS to verify these parameters were not altered during ion exchange

FI-23A and FQI-23A monitor the flowrate and total flow of filtered water returned directly to the FTC

FI-23B and FQI-23B monitor the flowrate and total flow of filtered water returned directly to the SFP

FI-60 & FQI-60 monitor flowrate and total flow to the SDS to measure system performance and to record water processed

DPI-22A/B monitor the differential pressure across the filter canisters to determine degree of loading and therefore time of replacement

LI-46 monitors the liquid level in DWC ion exchanger K-2

FCC-LI-102 and SF-LI-102 monitor the water level in the Fuel Transfer Canal and Spent Fuel Pool. They are panel mounted in the control room. The level indication system is a bubbler type system. A high or low level in the FTC and/or SFP will alarm (FCC-LAHL-103 and/or SF-LAHL-103) at the panel in the control room.

PI-81 and PI-82 monitor the pressure in the two instrument air manifolds in the Fuel Handling Building

The process fluid conditions can be sampled to determine the effectiveness of the system. The capability to obtain grab samples of process fluid has been provided at the inlet and outlet piping of the Fuel Transfer Canal/Spent Fuel Pool Filter Trains A and B. Grab samples may also be taken on the inlet/outlet lines to the DWC ion exchangers as well as several points in the SDS.

1.6.4 Trips

Low or high liquid levels in DWC ion exchanger K-2 will terminate flow to and from K-2. Both LSL-40 and LSH-40 trip closed the inlet isolation valve V069 and P-7 air supply isolation valve V156.

A locally mounted switch is provided at K-2 to override the level trips to fill and drain the ion exchanger. A signal alarm at the DWC control panel will notify the operator that the override is engaged.

1.7 System Interfaces

Those systems interfacing with the DWC are as follows:

a) Standby Reactor Pressure Control System (existing)
Use: Provide a source of borated water for backflushing
Tie-in: A single connection from SPC-T-4 downstream of SPC-V1 to the inlet manifold piping for the Fuel Transfer Canal/Spent Fuel Pool Filters, Trains A and B

b) Submerged Demineralizer System (existing)
Use: Provide a system for soluble fission product processing.
Tie-in: To downstream of pump WG-P-1 of SDS from downstream of Fuel Transfer Canal/Spent Fuel Pool Filters. From downstream of the SDS polishing filter to downstream of the DWCS manual control valves V097A/B.

c) Instrument Air System (existing)
Use: Provide source of instrument air to equipment.
Tie-in: At existing valves AH-V220 and IA-V171

d) Service Air System (existing)
Use: Provide a source of service air to the forwarding pump P-7.
Tie-in: Service Station 87 plus another station if needed

1.8 QUALITY ASSURANCE

The defueling water cleanup system is classified according to the safety functions of its parts. There are three classifications in this system:

a. Portions of the system associated with ion exchange processing are considered to be a radioactive waste processing system; therefore, these portions of the system shall be subject to the quality assurance guidelines contained in NRC Regulatory Guide 1.143.

b. The filter canisters are classified as nuclear safety related and are designed to prevent a condition that could result in a return to nuclear criticality of the fuel retained in the filters.

c. The remaining portions of the system are subject to the BNAPC non-safety-related quality assurance program.

The TMI-2 Recovery QA Plan will be applicable for work performed on site.

2.0 System Limitations, Setpoints, and Precautions

2.1 Limitations

The system is flow limited to 200 gpm through each filter train, 15 gpm through SDS and 30 gpm through the DWC ion exchanger K-2.

The filter canisters (F-9, F-10, F-11, F-12) are limited to a 45 psi pressure differential. At this point an alarm on a local panel will inform the operator of the need to stop and restart the system or to remove and replace the filter.

The post filters are limited to 10 psi pressure differential. At this point the filters are considered fully loaded and are changed out.

The system should not be started and stopped frequently since the canister filter precoat is lost during a shutdown; thus it will be necessary to reestablish a precoat on starting up before processing through SDS or K-2.

2.2 Setpoints

ASL-17 Trips alarm on a low boron concentration of 4850 ppm. 2

DPSH-22A & DPSH-22B Trip alarm at 45 psi pressure differential across the FTC/SFP filter trains A & B.

LSL-40 & LSH-40 Trip alarm, trip closed inlet isolation valve V069 and trip closed P-7 air supply valve V156, shutting down P-7. Low level set point is 10 inches below top of ion exchanger. High level set point is 4 inches below top of ion exchanger (i.e., ± 3" from normal liquid level). 2

PSV-R-1 Set to relieve at 150 psig with 10% overpressure to protect SDS.

PCV-26 Regulates upstream pressure (SDS inlet pressure) at 140 psig.

SF-LIS-103 & FCC-LIS-103 Trip alarms on high or low levels in the SFP and FTC. Low level set point is 327 ft-5 in. High level set point is 327 ft-11 in.

2.3 Precautions

Due to the use of quick disconnect couplings, extra care should be taken to ensure that the couplings are properly connected and that they are connected in the proper locations.

The filter canisters operate by a surface filtration method, and their efficiency increases as a cake is built up on the surface of the media. Therefore, the build up of this cake is an important part of the filtration process. To prevent the migration of fines to the post filter, the ion exchange portion of the system should not be started until a cake has begun to be formed on the media. This can be verified by observing the turbidity of the filter effluent. When the filter train is started up, there will be an initial turbidity spike caused by smaller particles passing through the media. As the cake is built, these particles are stopped and the turbidity decreases. Once the turbidity reaches a level of 10 NTU or less, the ion exchange portion of the system can be started. Also, to prevent the breakdown of the cake, the system should not be started or stopped unnecessarily.

The portion of the startup procedures concerning the well pumps should be strictly adhered in order to prevent the rapid filling of an empty manifold. This situation could cause a harmful pressure wave to develop which might damage the canister filter media.

2

The Reactor Building penetrations R-524 at elevation 293 ft-6 in and R-539 at elevation 320 ft are both below the water level of 327 ft-0 in. When in use the connecting piping/hose should be periodically checked since a line break will cause water to be lost from the system. When not in use, the hose should be isolated by closing valves V117A/B and V-099 (see discussion in section 4.5).

3.0 OPERATIONS

3.1 Initial Fill

To initially fill the SFP & FTC borated water from the Spent Fuel Cooling System may be pumped from the borated water storage tank, DH-T-1, by the spent fuel cooling pumps, SF-P-1A/B. To fill the FTC the water may be routed through penetration R-524 and into the FTC through the 3 inch fill line downstream of the P-3A discharge check valve. To fill the SFP, V087A/B and V097B are opened and the borated water may be routed through the filter canisters and through the normal return process path to the SFP. | 2

The system is filled initially by borated water from the standby reactor coolant pressure system through the backflushing system provided (see section 3.7). The filters are filled to the inlet and outlet manifolds.

To initially fill the DWC ion exchanger K-2, the level switch LSL-40 must be overrided (see section 1.6.4) until low level is attained. At this time the override switch should be returned to normal operation for further filling.

3.2 Startup

Prior to starting the system, the suction valve alignment is verified for the mode of operation selected. The valves to the ion exchange portions of the system are also verified to be closed. The pump discharge isolation valves are closed and the cross-tie valves are closed. The pump for one train is started and allowed to operate on minimum recirculation flow. The isolation valve for this pump is slowly opended. Then the hand control valve V090 A or B (HV-64 A or B) is opened 10% and any trapped air vented through manual vent valves located on the inlet and outlet manifolds. After venting, V090 (HV-64) is opened fully. Once this has been accomplished, flow is started by slowly opening the appropriate outlet cross-tie valve(s). Once one train has been started, the other train, if desired, may be brought into service in the same manner.

Filter performance will initially increase with time as a cake forms on the filter surface. Therefore, the filtered water should be returned directly to source without further processing until this cake forms, as evidenced by a decrease in turbidity. A turbidity below 10 NTU is sufficient to route to K-2 or SDS.

The DWC ion exchanger K-2 should always be brought to normal operating liquid level prior to operation of this portion of the system. Either borated flush water or filtered water of less than 10 NTU can be used. If the liquid level is below the low level trip, the level switch trip override must be engaged until low level is established (see section 3.1). Once normal level is established, the air supply solenoid valve V156 is opened. Pressure regulator V157 (PICV-58) is then manually adjusted to the pressure required to maintain the desired flowrate. Flow is slowly started to K-2 by opening flow control valve V085 (FV-15) until the desired flowrate to K-2 is obtained. K-2 effluent is automatically controlled by level control valve V070 (LV-46).

Processing water through the SDS requires opening the isolation valves for that portion of the system and starting the DWC Booster pump. These actions will allow 15 gpm to be processed through the SDS. For a detailed description of the SDS see reference 12.

3.3 Normal Operation

Normal operation of the system is in one of the modes shown in Table 1 of Section 1.4. The mode of operation is chosen based on what source is to be processed and what the particulate and radioactivity concentrations of the sources are.

3.4 Shutdown

The steps to bring the system to a shutdown condition are basically the reverse of the startup procedure. The ion exchanger flow is brought to zero gradually by remote operation of upstream control valve V085 (FV-15). Correspondingly, level control valve V070 (LV-46) will gradually terminate flow from K-2. After termination of flow the inlet isolation valve V069 is closed and the P-7 air supply isolation valve is closed. If the SDS is in use, the booster pump is switched off and isolation valves V111, V139, and V102 are closed. Following this, the well pumps are switched off and the pump isolation valves and the cross-tie valves are closed.

3.5 Draining

The majority of the system can be drained to the spent fuel pool. The filter canisters can not be drained, since they are submerged in the SFP. The piping to/from penetrations R-524 and R-539 must be drained to the Auxiliary Building sump since the penetration elevation is below the spent fuel pool water level. The DWC ion exchanger K-2 can be pumped out to either source, FTC or SFP, or to the reactor coolant bleed tanks via a portion of the SDS. A switch is provided to override the low level switch for pumping out K-2.

3.6 Refilling

The fully drained system may be refilled in the same manner that the system was initially filled. A partially drained system may be refilled by using either the back flush system (see section 3.7) or the well pumps (see section 3.2). 2

3.7 Infrequent Operations

Flushing of the system may be performed when the internal contamination level gets high or prior to internal maintenance work. The system is shutdown (see Section 3.4) prior to flushing.

One flushing option is gravity flush from SPC-T-4. Borated water is stored in the charging water storage tank, SPC-T-4, located at the 347 ft. elevation in the Fuel Handling Building. This tank is connected to the DWCS. Either filter train may be flushed without stopping flow through the other.

Flushing may be accomplished by opening one of the inlet valves from the flushing system (depending on which portion of the system is to be flushed) and then routing the flow to the fuel transfer canal or the spent fuel pool. After sufficient time has been allowed to flush the system, the inlet valve from the flushing system is closed, and the system is then restarted following the procedures in Section 3.2.

3.8 Transient Operations

The results of loss of pumps or filter train misalignment are flows not returning to the proper source. However, since this is the normal operational mode of the system and since the sources are connected by the fuel transfer tubes, the results of these transients are negligible. Vent or drain valve misoperation would have the same effect as a line break (see section 4.5) but could be more readily rectified.

4.0 CASUALTY EVENTS AND RECOVERY PROCEDURES

4.1 Loss of Power

A loss of power to any portion of the system would shut that portion of the system down. No adverse conditions would result.

4.2 Loss of Instrumentation/Instrument Air

Loss of instrumentation would hamper operations due to loss of monitoring capability but no adverse conditions would result and the system could be safely shut down until the problem is resolved.

Loss of a single instrument channel will result in the loss of indication for that channel and, for those channels that have control features a flow mismatch. This flow mismatch will result in an automatic shutdown of the affected portion of the system.

Loss of either the spent fuel pool or FTC level monitoring system will be noted when compared with the other. The readings should normally be the same since both water bodies are in communication via the fuel transfer tubes. Neither system has control features.

Loss of instrument air will take the individual components to their fail safe position. Flow mismatches induced by loss of air will result in automatic trips.

On loss of instrument air, level control to the ion exchanger would be lost. But both the inlet isolation valve V069 and the outlet level control valve V070 (LV-46) would fail closed isolating the ion exchanger.

4.3 Deleted 2

4.4 Filter Media Rupture

A failure of the filter media in the canister could potentially release fuel fines to the ion exchange portion of the system. The SDS is equipped with a sand prefilter which has borosilicate glass to control reactivity (see ref. 12) and the DWC filter canister post filter precedes DWC ion exchanger K-2. There are differential pressure gauges supplied on the filters to determine if they are loading. Loading of the SDS prefilter or the filter canister post filter could indicate ruptured filter media. 2

The recovery procedure is to isolate the filter trains and find the ruptured filter by observing the differential pressure versus flow for each individual canister. Lower differential pressure for a given flow will indicate that this filter is ruptured. That canister or canisters and the post filter cartridge and/or SDS sand filter would be replaced and the system restarted.

4.5 Line and Hose Break

If a rupture occured in the system, the pumps could deliver fuel transfer canal and/or spent fuel pool water to the Fuel Handling Building or the Reactor Building. This action would lower the level in the canal and the pool. A drop of one inch in canal/pool level is approximately equivalent to 1250 gal. A level loss would be detected and alarmed (see setpoints section 2.2) by at least one of the two redundant level monitors provided for the canal/pool. The operator would then shut the system down.

Process water hoses are employed in three services in this system; filter canister inlet/outlet, skimmers to well pumps, and downstream of penetration R-539.

If a filter canister inlet/outlet hose ruptures, that canister will be isolated and the hose replaced. Since these hoses are submerged in the SFP, this results in no net water loss.

If a hose connecting the skimmer (U-7 or U-8) to the well pumps breaks, then the ability to surface skim will be hampered or lost, but pump capacity will not be deminished nor will there be a loss of water.

If the hose on the FTC return line downstream of penetration R-539 breaks, then process water will be lost to the Reactor Building sump. The resulting loss in level would be detected and alarmed by the canal/pool monitors. This hose is steel armored to minimize accidental damage. Check valves V-235A/B are provided to prevent siphoning the FTC if the hose (or connecting line) breaks.

Furthermore, the normal return path is to the SFP; thus this hose is not normally used. When not in use this hose will be isolated by closing valves V117A/B and V099 to minimize the effect of a hose break.

A break on the P-3A/B discharge line which uses penetration R-524 would cause process water to be lost to either the Reactor Building or the Fuel Handling Building. The water loss would be detected both by a decrease in the monitored flowrate returned to the fuel pool or fuel transfer canal and also by the drop in fuel pool and/or transfer canal level. When the fuel transfer canal pumps, P-3A/B, are not in use, the discharge valves V002A/B and valve SF-V103 should be closed. This would prevent a syphoning of the FTC when the pumps are not in use. | 2

5.0 SYSTEM MAINTENANCE

The maintenance procedures are the recommended practices and intervals as described by the equipment vendors. This section will be expanded as equipment selection is finalized.

6.0 TESTING

6.1 Hydrostatic Testing

All piping and hose will be hydrostatically pressure tested. Testing of hose will be done after couplings have been attached. Pipe will be tested outside the buildings.

6.2 Leak Testing

All accessible connections will be initial service leak tested after the piping is assembled.

6.3 Instrument Testing

All instruments will be calibrated by vendors. Complete electric/pneumatic loop verification will be done during start-up.

7.0 HUMAN FACTORS

Filter canister hoses are coded for quick identification of inlet versus outlet.

Extensive use of hoses is made, especially in the Reactor Building, allowing quick installation and use of existing radiation shielding. Hoses expected to be frequently disconnected are equipped with quick disconnect couplings for ease of removal and replacement.

The following human factors guidelines have been incorporated into the design of the DWCS control panel:

- The panel includes all controls and displays required for normal operation.
- Displays provide immediate feedback that the system has responded appropriately to an operator's action.

- Controls and displays are laid-out for a left to right flow path.

- Mimic lines are used to clarify flow paths.
- Control devices are mounted to 3 to 6 feet above the floor.

- Each control device has a nameplate.

- Light bulbs are replaceable from the front of the panel.

- Recorders are grouped on the right side of the panel away from the flow path.

- Adjustments to recorders and controllers can be performed from the front of the panel.