GPU Nuclear

DC 3255-86-0004 REV 1
SUB / YEAR / SEQ

DATE July 1987

☒ ITS
☐ NSR
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☐ SITE ENGINEERING
☐ PLANT ENGINEERING
☒ DEFUELING ENGINEERING

TMI-2
DESIGN CRITERIA
FOR

PRESSURIZER
DEFUELING
SYSTEM

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FORM 4000-ENG-7310.01 (03/86)

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FIGURES

1.0 PURPOSE AND SCOPE

The purpose of the Pressurizer Defueling System is to remove fuel debris from inside the pressurizer in a systematic and safe manner. This system will agitate and pump out the estimated 11 kg of fuel debris existing within the pressurizer and any fuel debris which may be flushed into the pressurizer from other ex-vessel defueling operations, such as pressurizer spray line defueling.

This design criteria is applicable to the following items which comprise the Pressurizer Defueling System:

- Pressurizer Vacuuming Pump
- An agitation water supply line
- Supporting accessories which are needed to complete the system such as long handled tools, controls, piping, fittings, flexible hosing, etc.
- The existing Defueling Water Cleanup System (DWCS).

2.0 REFERENCES/CODES/STANDARDS

2.1 References

a. Bechtel P&ID 2-M74-DWC01, Defueling Water Cleanup System

b. Burns & Roe Flow Diagram Drawing 2024, Reactor Coolant Make-Up & Purification

c. Babcock & Wilcox Drawing, Pressurizer General Arrangement, GPU File #07-00-0110

d. TMI-2 Technical Bulletin TB 85-10a Rev. 1, A Reevaluation of Fuel in the Pressurizer.

e. TMI-2 Technical Bulletin TB 86-02 Rev. 0, Physical/Radiological Inspection and Sampling of the Pressurizer

f. TMI-2 Technical Bulletin TB 86-13 Rev. 0, Gamma Analysis of Pressurizer Sample

g. Babcock & Wilcox Pressurizer Instruction Manual

h. TER 15737-2-G03-106 Rev. 10, "TMI-2 Division Technical Evaluation Report for Defueling Water Clean-up System" |⚠

i. SD 15737-2-M72-DWC01 Rev. 0, "TMI-2 Division System Description for Defueling Water Clean-up Reactor Vessel Clean-up System"

2.2 CODES/STANDARDS

2.2.1 The following codes and standards are specifically referenced and shall be applied as required by this document.

ANSI N45.2 (1977)	Quality Assurance Program Requirements for Nuclear Facilities
ANSI B16.34 (1981)	American National Standards Institute, Valves - Flanged and Buttwelding Ends
ANSI B1.20.1 (1983)	American National Standards Institute, Pipe Threads - General Purpose
ANSI B31.1 (1983 with Winter 1984 addenda)	American National Standards Institute, Power Piping Code
ANSI B16.5 (1981)	American National Standards Institute, Pipe Flanges and Flanged Fittings
ANSI B16.11 (1980)	American National Standards Institute, Forged Steel Fittings, Socket Welding and Threaded
ANSI ASME NQA-1 (1979) Supplement 17S-1 and Appendix 17A-1 (including Addenda NQA-1a-1981)	Quality Assurance Program Requirements for Nuclear Power Plants, Supplementary Requirements for Quality Assurance Records
ASTM A36-1981	American Society of Testing and Materials, Structural Steel
ASTM A312/A312M-1985	Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A500-1984	American Society of Testing and Materials, Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

10 CFR 50, Appendix B, 1982	General Design Criteria for Nuclear Power Plants
OSHA	Occupational Safety and Health Standards, Part 1910, Section 1910.179, 1977.
OSHA	Occupational Safety and Health Standards, Part 1926, Section 1926.550, July 1980.

2.2.2 Should any requirements of this document conflict with those of the Code or applicable standards, the more stringent requirement shall govern.

3.0 FUNCTIONS AND DESIGN REQUIREMENTS

Refer to Figure 1 for a schematic representation of this system.

3.1 Functions

3.1.1 Pressurizer Vacuuming Pump

The pump will draw suction from the water inside the pressurizer. This water will contain suspended particles of fuel debris which the pump is capable of handling during suction. The pump, along with its discharge piping, will be located within the pressurizer. In order to ensure that the heavier debris is drawn into the pump, the pump unit will be lowered as close as possible to the lower head of the pressurizer.

3.1.2 Agitation Water Supply Line

The agitation water supply line with a nozzle shall be used to suspend debris particles in the pressurizer by using water from the DWCS. The position of the nozzle can be maneuvered using long handled tools. Since this is a closed system, the volume of water entering the agitation supply line is the same volume as being discharged by the submersible pump. Therefore the volume of water in the pressurizer remains unchanged.

3.1.3 Supporting Accessories

Hose shall be used for the agitation water supply line and for the pump discharge. Valves and associated fittings shall be used to control the flow of water into and out of the pressurizer. Instrumentation such as pressure and flow indicators shall be used to monitor the flow of water in and out of the pressurizer. Long handled tools shall be used to maneuver the agitation nozzle as required and to position the pump where necessary for effective vacuuming. To the extent practical, valves, instrumentation and pump controls shall all be centrally located and within easy reach of the operator.

3.1.4 The existing Defueling Water Cleanup System (DWCS)

The Pressurizer Defueling System utilizes a portion of the DWC System to provide a flow path back to the reactor vessel. Inherent in the design of the DWC System, is the capability to use filter canisters and/or knockout canisters as part of the process stream to filter and remove fuel debris. Although this debris separation capability exists, and may be used if defueling conditions warrant, present baseline plans are to bypass the filter canisters and return the process stream directly to the reactor vessel.

The DWCS can also be configured as described below

The existing DWCS train "B" shall be used to filter the water from the submersible pump discharge prior to returning it to the pressurizer via the agitation supply line. Water from the pressurizer will enter a knockout canister prior to returning to the reactor vessel or being filtered. This knockout canister will retain those particles exceeding 800 microns in size. The water will then be routed to the reactor vessel or to a DWCS filter canister. The filter canisters for DWCS are capable of removing debris down to 0.5 micron in size. This would ensure that water entering the pressurizer through the agitation supply line is sufficiently clean to prevent fuel debris from returning to the water inside the pressurizer.

During operation of the Pressurizer Defueling System, Train B of DWCS will not be in operation except for the Train B filter canisters (F3 & F4). The remaining DWCS can be isolated by closing valves V004B and V007B and opening V003B (if filter canister F-3 is to be used), or by closing valves V004B and V003B and opening V007B (if filter canister F-4 is to be used). This will ensure that DPIT-5B will monitor the differential pressure across the filters. Valve V356 will also be closed and V357 will be open. This will create a flowpath from the submersible pump back to the agitation supply line.

During operation of Train B the Pressurizer Defueling System will not be in operation. The Pressurizer Defueling System can be isolated from DWCS by closing valves DWC-V357 and V501.

Allowing the ability to operate either DWCS or the Pressurizer Defueling System by valve alignment will maintain body feed/precoat on the DWCS filters.

3.2 Design Requirements

3.2.1 Pressurizer Vacuuming Pump

The pump shall be a vertical submersible pump. The pump shall operate at 100 gpm which will ensure sufficient velocity to transport fuel debris solids. The pump shall operate at approximately 300 feet total head, with a shutoff head of approximately 450 feet. The pump shall be furnished and delivered completely assembled. The pump shall be powered by an electric motor rated for 460 volts, 3 phase, 60 Hz and have an integral cooling system. The pump shall be capable of handling particle sizes up to 1/4" in size. A minimum of 50 feet of power cable shall be supplied with the pump. The pump will be handling radioactive, borated, reactor vessel water with the chemistry described in Section 3.3. The pump shall be capable of being operated in air without damage. The overall dimensions of the pump shall be such that it can be placed down to the lower head of the pressurizer.

3.2.2 Agitation water supply line

Water will be introduced into the pressurizer using a hose with a nozzle at one end. The hose diameter will be sized to accommodate the flow of the submersible pump.

The nozzle will have sufficient discharge velocity to promote agitation of debris in the pressurizer. The configuration of the nozzle shall be such that agitation occurs in all directions with a minimum of manual manipulation. The nozzle shall be stainless steel, shall have a full cone spray pattern with uniform distribution, and shall be of sufficient size to avoid clogging.

3.2.3 Supporting Accessories

Hose for the pump discharge and agitation supply line shall be rated for the maximum discharge pressure of the submersible pump. The hose shall be as continuous as practical to minimize connections. Hose fittings to adapt to steel pipe shall be provided. Valves used to control flow shall be stainless steel conforming to ANSI Standards. Valves shall be temporarily supported as required. Flow indicators shall be installed on the supply and discharge lines. A pressure indicator shall be used on the discharge line. Minimum tap sizes for flow and pressure indicators shall be 3/8" in order to prevent clogging by fuel debris. These same instruments shall be located on the top of horizontal pipe to avoid being plugged from settlement of debris during no flow conditions. An On/Off switch for the submersible pump shall be provided. Existing long handled tools shall be utilized to the greatest extent possible. Design of special tools shall be minimized.

Hose and piping will be hydrostatically pressure tested prior to use to ensure against any potential line break or failure. In the unlikely event of a hose rupture or line rupture upstream or downstream of the submersible pump the system will trip the pump on IIF low level and alarm at the control panel located on the pressurizer missile shield. The pump will trip on IIF low level because it will be electrically interlocked with the reactor vessel cleanup pump which would trip on IIF low level (Reference h). This event could deliver approximately 500 to 1000 gallons of reactor vessel water to the area of the break.

Siphoning of reactor vessel water from the pressurizer through the agitation supply line is prevented by the placement of a check valve in close proximity to the pressurizer. This check valve will prevent water from flowing out of the pressurizer should a hose break occur inside the pressurizer. A hose break in the submersible pump discharge line is of no concern with respect to siphoning, since all unsubmerged piping and hose outside of the pressurizer is at or above the Reactor Vessel water level.

3.2.4 The Existing Defueling Water Cleanup System (DWCS)

The preferred flowpath would provide agitation supply water from either DWC-V357 (Train "B") or DWC-V363 (Train "A"). The discharge water from the submersible pump would be routed to a knockout canister and then directly to DWC-V358 (Train "B") which would then flow into the reactor vessel.

An optional flowpath would be as follows.

Water discharging from the vacuuming pump will first be routed to the knockout canister. The water will then be directed to filter canisters F-3 and F-4 downstream of valves DWC-V003B & V007B respectively. Two new valves DWC-V360 and V361 will be installed between V003B and V007B and filter canisters F-3 and F-4. These new valves will be used to control flow to the filter canisters and will be also be used to bypass the filter canisters if required. Valve DWC-V501 will be installed to be used as an isolation valve between DWCS and the Pressurizer Vacuuming Pump discharge line. Water to the agitation supply line will enter through valve DWC-V357.

3.3 Process Requirements

The complete Pressurizer Defueling System shall be used inside the reactor building and be capable of operating continuously as required.

The design temperature for components in air (hoses, valves, etc.) is 50°F to 130°F, relative humidity of 5 to 100% and pressure of 14.7 psia atmospheric pressure to not less than 12.2 psia.

Components in the pressurizer (submersible pump, nozzles, hose, etc.) shall be designed for external pressure ranging from 0-10 psig and the following maximum water chemistry conditions:

Boric Acid	4350-6000 ppm boron
pH	7.5 - 8.4
Chloride	5 ppm
Temperature	50-200°F

Defueling performance shall be monitored as required. During the monitoring activity, the vacuuming pump shall be turned off and the water in the pressurizer shall be calm. A video camera will be used to determine the amount of debris remaining. Defueling is then resumed as necessary. Those particles which cannot be vacuumed will be removed using long handled tools as required. The flow of water from the pressurizer shall be monitored to ensure that the vacuuming pump has not clogged. The flow shall be monitored using the flow indicator on the Pressurizer Defueling System, the video camera in the pressurizer and the flow recorders on the DWC system. Since the pump is equipped with a screen it is unlikely that the pump will clog. However, should it be necessary to unclog the pump screen, a backflush can be performed.

3.4 Structural Requirements

Structural components shall be designed in accordance with the ANSI B31.1 code. Structural components shall be designed for equipment dead loads, operating loads, and containment environmental conditions given in Section 3.3. All structural welding shall be done in accordance with the ANSI B31.1 code. All piping shall be in accordance with ANSI B31.1.

3.5 System Configuration and Essential Features

The system will be handling radioactive water. The system shall be designed so that doses to personnel are limited to those which are as low as reasonably achievable (ALARA). The system will be located inside the reactor building. Figure 2 shows a general arrangement of the pressurizer.

3.6 Maintenance and In-service Inspection

Fluids and lubricants used for the vacuuming pump shall be acceptable for use in the RCS and their quantities shall be minimized. Where feasible, fluids should be miscible and/or less dense than the pressurizer vessel water to preclude boron dilution concerns.

3.7 Instrumentation and Control

The vacuuming pump shall have an On/Off switch accessible from the platform at the top of the pressurizer. Manually operated valves shall be provided or the agitation supply line and pump discharge line. These valves shall be located outside of the pressurizer. Flow indicators shall be installed on both supply and discharge lines along with a pressure indicator on the discharge line. Balancing the water flow for the Pressurizer Defueling System will be minimal since this is a closed loop system. However, valve alignment on DWCS must be performed to ensure that water leaving the pressurizer will not escape through unwanted flow paths.

3.8 Interfacing Systems

The electrical power supply that will be available is 460 volt, 25 amp, 3 phase, 60 Hertz AC for continuous service.

The Defueling Water Cleanup System is used as a means of filtering the water being removed from the pressurizer.

3.9 Testing Requirements

A functional test of the pump shall be performed prior to installation into the pressurizer.

Hydrostatic pressure testing is required of all piping and hoses. The test pressure shall be 225 psig and shall be performed in accordance with ANSI B31.1. The pressure shall be held for 10 minutes. This is compatible with the DWCS test pressure and provides enough margin to ensure that the maximum pressure delivered by the pressurizer vacuuming pump (195 psig) is within the test pressure. Testing of the hose will be performed after couplings have been attached. Pipe and hose may be tested outside of the Reactor Building.

All connections will be initial service leak tested after the piping and hose are assembled.

3.10 Materials

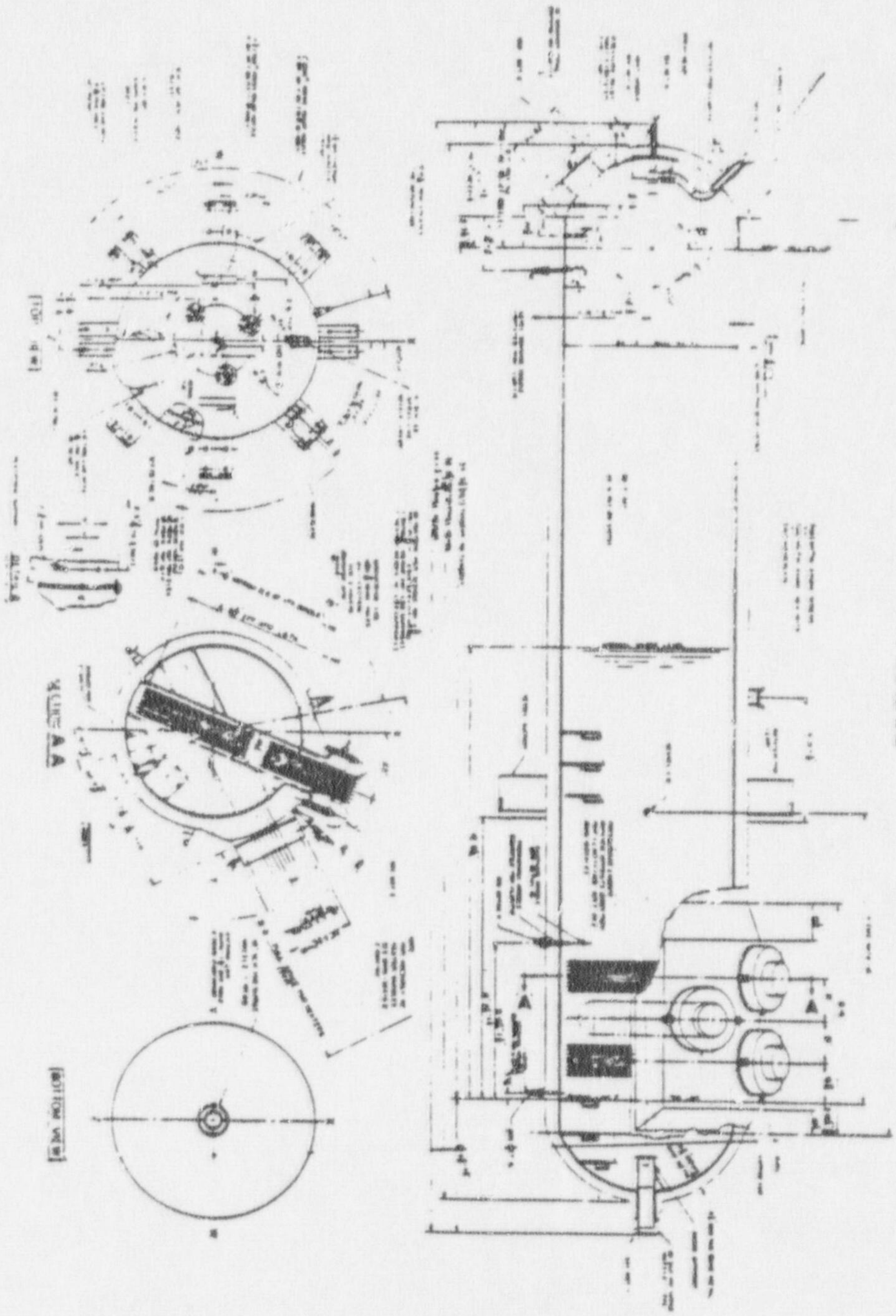
Materials selected shall be suitable for the use intended and for plant environmental conditions such as radiation, temperature and wetting with borated water. Wherever practical, 300 series stainless steel components shall be used. Hoses shall be made of rubber.

4.0 QUALITY ASSURANCE

This system is classified as important to safety.

5.0 HUMAN FACTORS

Hose shall be used to allow for quick installation and use of existing radiation shielding. Hoses and valves shall be properly identified by metal tags or banded to avoid misconnection or confusion. Quick disconnect couplings shall be used for ease of assembly and removal. "Design features" such as special fittings and color coding shall be used, if possible, to preclude any potential boron dilution or loss of Reactor Vessel inventory.



PRESSURIZER
GENERAL
ARRANGEMENT

FIGURE 2

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