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December 15, 1986

TMI-2 Cleanup Project Directorate
Attn: Dr. W. O. Travers
Director
US Nuclear Regulatory Commission
c/o Three Mile Island Nuclear Station
Middletown, PA 17057

Dear Dr. Travers:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Safety Evaluation Report For The Addition Of Coagulants
To The Reactor Coolant System

Attached for your review and approval is a Safety Evaluation Report (SER) for the addition of a coagulant and body-feed material to the Reactor Coolant System (RCS) in conjunction with the operation of the Defueling Water Cleanup System (DWCS). The scope of this evaluation encompasses continuous treatment of the RCS with the coagulant and body-feed material. The coagulant addition is expected to improve the performance of the DWCS filters and enhance RCS water clarity.

We have been working for almost one year to develop the method of operating the DWCS filter system so that water clarity can be provided for defueling operations. It appears that the use of a coagulant coupled with body feed is the solution. This conclusion is based on successful laboratory tests and a successful batch experiment performed last week between reactor coolant bleed tanks. I have put top priority on making DWCS system modifications so that the approach can be used on a full scale, continuous demonstration. We now expect the modified DWCS will be ready for operation on December 23, 1986. It is very important to the TMI-2 project that we obtain NRC approval of this SER (and subsequent operating procedures) before December 23, 1986.

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The coagulant that proved successful in our tests does add a small amount of chloride to the treated water. This SER is based on maintaining reactor coolant chloride levels below the current Technical Specification limit of 5 ppm. If we find that there is an operating problem to meet this chloride limit we will review options on an expedited basis.

Per the requirements of 10 CFR 170, an application fee of $150.00 is enclosed.

Sincerely,

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

FRS/RDW/sle

Attachment

Enclosed: GPU Nuclear Corp. Check No. 000409

GPU Nuclear

SAFETY ANALYSIS

SA # 4240-3525-86-228

Rev. # 0

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TITLE

DWCS PROCESSING USING COAGULANTS

(RCS)

Originator Richard E Sheppard Date 12/12/86

CONCURRENCE

Lead Engineer/RTR [signature] Date 12/12/86 SRG [signature] Date 12/12/86

Cognizant Eng. Thomas O. [signature] Date 12/12/86 Rad Con M J Slobodien Date 12-12-86

APPROVAL

Mgr. Eng. Section D.R. Buchanan Date 12/12/86 Site Ops Director S. Levin per Telecon [signature] Date 12/12/86

FORM 4000-ENG-7310.09-1 (9/86)

Safety Analysis

For DWCS Processing Using Coagulants (RCS)

1.0 Purpose and Scope

The purpose of this safety analysis is to briefly describe the proposed addition of a coagulant and body-feed to the RCS and evaluate the safety issues which may be impacted by this activity. The scope of this analysis is the potentially continuous treatment of the RCS with the coagulant and body-feed. This treatment of the RCS is expected to improve the performance of the Defueling Water Cleanup System (DWCS) filters. Operating experience with DWCS has not achieved the desired level of RCS water clarity to support defueling operations within the reactor vessel. The DWCS filters have required change-out due to high differential pressure without the expected high filter throughput. It is suspected that the root cause of shortened filter canister life is the presence of hydrated metallic oxides in colloidal suspension within the RCS which are plugging the filter media. The addition of the coagulant with body-feed is expected to agglomerate the colloids to filterable sizes and thus form a filter cake on the filter media.

2.0 System Operations

The addition of coagulant and body-feed to the RCS may be performed in one of two modes; either as a "batch-type" or an "on-line" process. The "batch-type" process involves the use of two reactor coolant bleed tanks (RCBT's), the existing waste transfer pumps, a coagulant addition unit, a booster pump, the existing body-feed addition unit, the DWCS filters, and associated piping, valves, and instrumentation. This processing mode is intended as an interim mode to improve reactor vessel water clarity to the extent that defueling can proceed without DWCS operation while the necessary changes are made for the "on-line" processing mode. This interim mode would be a continuous "bleed and feed" operation. Reactor vessel water would be letdown to a RCBT, treated with coagulant and body-feed, filtered, then returned to feed reactor vessel while the reactor vessel water is bled to a second RCBT. After processing the water in the first RCBT, the water in the second RCBT is treated, filtered, and fed to the reactor vessel while letting down the reactor vessel to the first RCBT; then the cycle is repeated. The "on-line" processing mode involves placing the coagulant addition unit into the reactor building and using the DWCS pump. The coagulant addition unit would be tied-in at the discharge of the DWCS pump P-2A. The treated RCS water then follows the existing DWCS flow path to the DWCS filters F-1 and/or F-2. The body-feed is injected upstream of the DWCS filters using the existing body-feed addition unit. The filtered water is then returned to the reactor vessel. In both modes of operation the DWCS ion exchangers may be used to reduce the radionuclide concentration in the RCS. The processing flow rate in the "batch-type" mode would be limited by the RCS bleed rate which is expected to be approximately 30 gpm. The "on-line" processing mode could be at the maximum DWCS flow rate of 200 gpm. System operating pressure, in either mode, will not exceed the DWCS design limit.

The coagulant addition unit is electronically operated with an undiluted coagulant mixing/activation rate up to 0.2 gallons per hour (gph) and a solution injection rate of 4 to 40 gph. This product is a strongly cationic, high molecular weight, liquid flocculent/coagulant, which is approximately 20 w/o $C_8H_{16}NCl$ and 80 w/o unborated water when undiluted.

The "batch-type" processing mode requires a booster pump downstream of the coagulant injection point to maintain the required head for filtration. A 10-hp centrifugal pump is planned to be used to meet the needs of this processing mode. The "on-line" processing mode requires a coagulant addition pump. A 3/4 hp progressing cavity pump is planned to be used to meet the needs of this processing mode. Static mixers are employed near the coagulant injection and the body-feed injection points to facilitate coagulant and body-feed mixing. The body-feed material will be diatomaceous earth (d.e.). The body-feed addition unit has been previously used as a filter aid system (see reference 1). Both the coagulant/water mixture and the coagulant/body-feed/water mixture require specified contact or dwell times for optimum performance of the coagulant. To accommodate the required dwell time for the coagulant/water mixture, the piping flow path used in the "batchtype" mode is expected to give the required residence time; and, for the "on-line" mode, approximately 650 feet of 3" hose will be installed downstream of the coagulant injection point to obtain the required residence time. To accommodate the required dwell time for the coagulant/-body-feed/water mixture approximately 300 feet of 2" hose will be installed downstream of the static mixer and upstream of the filter canisters. All of the additional hose required for this activity will be unarmored, unlike existing DWCS hose which are armored, to facilitate hose handling.

3.0 Safety Evaluation

The performance of this activity may impact the following safety issues:

- o Criticality Prevention
- o Compliance to RCS Requirements
- o Spill Consequences
- o Canister Shipping Requirements

Each of these safety issues are addressed below.

3.1 Criticality Prevention

Criticality prevention must be ensured where fuel may be accumulated. Fuel locations include the reactor vessel, defueling canisters, the RCBT's and the various piping systems. For fuel located in the reactor vessel subcriticality is ensured by the presence of water borated to at least 4350 ppm. For fuel located outside the reactor vessel criticality prevention is attained by either limiting the accumulation of fuel to less than the safe fuel mass of 70 Kg (~ 75% of the minimum critical mass of TMI-2 fuel) or, for greater fuel mass, having the fuel mass confined within a geometrically safe configuration or poisoned to preclude criticality.

3.1.1 Reactor Vessel

Subcriticality in the reactor vessel (RV) is maintained by the presence of water borated to at least 4350 ppm. Administrative procedures require that the RCS be borated to at least 4950 ppm. Inadvertent introduction of under-borated or unborated water into the RCS is minimized by the adherence of the "double barrier" concept of reference 2.

During OWCS processing (in either mode) two barriers isolate each identified potential boron dilution pathway. The water source for the coagulant mixing and body-feed mixing will be borated to at least 4950 ppm. As a further precaution, the unarmored hose added will be uniquely identified or labeled to indicate their intended application.

The addition of coagulant and d.e. to the RCS is evaluated with respect to boron concentration and neutron moderating ability. Laboratory testing of RCS grade water at various concentrations of coagulant has shown that the presence of the coagulant in the water will not cause the precipitation of boron nor the inclusion of boron in the coagulant polymer that is removed during filtration. Recent testing involving the processing of water in the RCBT's has verified the laboratory testing results. The RCS boron concentration is monitored and corrective actions can be employed if the RCS boron concentration is reduced below 4950 ppm. RCS boron concentration monitoring capabilities are addressed in Section 3.2.

With respect to RCS boron dilution, for a boron concentration in the RCS of 4950 ppm and a total RCS volume of 39,000 gallons, more than 5,300 gallons of coagulant would need to be added to the RCS to reduce the boron concentration to 4350 ppm. The instantaneous introduction of more than a thousand gallons of undiluted coagulant into the RCS is non-credible.

The moderating ability of the coagulant is currently under evaluation. Should the coagulant be found to be a better moderator than water the addition of coagulant in the RCS would not impact previous core criticality calculations since the concentration of the coagulant in the RCS is orders of magnitude less than the boron concentration in the RCS. In addition, the accumulation of a non-borated mass of insoluble coagulant in the RV, which might cause a boron displacement, is not credible. The coagulant dose rates are small and the coagulant passing through the DWCS filter media is substantially smaller in particle size than the filtered polymer. Since the active polymer is soluble with an average molecular weight of 200,000 to 400,000 a.m.u., then the particles which pass through the filter would also be soluble as the monomeric structure is the same and the molecular weight is much less. The DWCS filters will not be bypassed during normal operation of coagulant addition. Further, the migration of filter cake to the RV from filter breakthrough is minimized by early detection of filter breakthrough via reduction of filter differential pressure and the increase of turbidity measured from the nephelometer located downstream of the filters, and corrective actions which would terminate system operation. The addition of d.e. to the RCS would not affect the boron concentration in the RCS since the d.e. is not water soluble. As previously stated in reference 1, the moderating ability of d.e. has been found to be significantly less than that of water and, therefore, the use of d.e. would not impact previous core criticality calculations.

3.1.2 Defueling Canisters

Criticality prevention in the defueling canisters is achieved by the poison material placed in the canisters. As stated above, d.e. has less moderating ability than water; thus, the criticality evaluations for the defueling canisters, performed assuming optimally moderated fuel with unborated water, will not be adversely affected by the addition of d.e. in the canisters. The accumulation of coagulant in the filter canister is being evaluated for its impact on canister subcriticality. While the canisters are stored at TMI-2 the borated water in and between the canisters would compensate for the addition of the coagulant and thus would not adversely impact the subcriticality of the canisters. Off-site shipping of the canisters is addressed in Section 3.4.

3.1.3 RCBT's and Piping

Criticality prevention in the RCBT's and the piping systems are achieved by the small quantity of fuel mass, geometry, and boration. Significant quantities of fuel are not expected to accumulate in the RCBT's or the piping or pumps because of the movement of water within the flow path. The piping system is comprised mostly of 2" and 3" pipe or hose. The largest diameter pipe used in the flow path for the "batch-type" mode is a 10" nominal pipe. The largest diameter pipe used in the flow path for the "on-line" mode is a 4" nominal pipe. It has previously been determined that an infinitely long pipe filled with TMI-2 fuel which is fully moderated and reflected with unborated water would be subcritical provided that the pipe diameter is less than 11.3 inches. No piping is used which would exceed this critical pipe diameter. Subcriticality is further ensured by the water being borated to at least 4950 ppm. Therefore, subcriticality is ensured within the piping system regardless of the fuel content of the processed water.

3.2 Compliance to RCS Chemistry Requirements

The RCS and make-up water to the RCS must meet the following requirements:

- o Boron - 4950 to 6000 ppm
- o pH - 7.5 to 8.4
- o Cl - $\leq$ 5 ppm

The treated and filtered water returning to the RV must maintain the RCS within the above requirements. Even though the addition of d.e. would not affect these RCS requirements, the quantity of d.e. which could be introduced is minimized since the water is filtered prior to its return to the RV. The addition of the coagulant, however, may impact these RCS requirements. The extent of impact is dependent on the quantity of coagulant added to the RCS and subsequent removal by filtration.

The impact on boron concentration in the RCS from the addition of coagulant has been addressed in section 3.1.1. Existing boronometers will monitor the RCS boron concentration. The RCS sample pump SNS-P-7 can draw RCS samples from either the 322'-6" elevation within the IIF or the 315'-6" elevation within the annulus of the RV to the boronometer SNS-AT-203. If the filtered water is further processed by the DWCS ion exchangers the "in-line" boronometer DWCS-AE-17 will also monitor boron concentration. At least weekly chemical analysis of the RCS samples will also monitor the boron concentration. Thus, adequate means are implemented to ensure that water returning to tl RV will not reduce the boron concentration in the RCS below the allowable limit. Testing has shown that the boron concentration in water treated with coagulant and body-feed is not impacted by filtration, ion exchange, or processing through activated charcoal for TOC removal.

Laboratory testing has shown that the addition of coagulant may reduce the pH of the treated water. This reduction has been shown to be slight (less than 2%) even at coagulant concentrations of 50 ppm. At lower coagulant concentrations the affect on pH is even less. The pH of the water treated with coagulant and body-feed has also been shown by testing to be unaffected by filtration.

Testing has shown that the addition of the coagulant increases the chloride concentration in the treated water. This increase is dependent on the concentration of the coagulant in the treated water. From the laboratory analyses it is observed that the chloride concentration increases by approximately 0.05 ppm for a 1 ppm concentration of coagulant. Repeated RCS treatments will build-up the chloride in the RCS. The coagulant addition to the RCS will be terminated prior to the RCS chloride concentration exceeding the 5 ppm concentration limit.

3.3 Spill Consequences

A postulated rupture of a pipe or hose during DWCS processing would result in spillage within the AFHB or the RB. The quantity of spillage would be dependent on the size of the rupture and the time required to detect, identify, and terminate the leakage. A leakage could be detected during the "batch-type" mode by a reduction in the discharge pressure of either the waste transfer pump or the booster pump, increases in sump level, increasing airborne activity, unanticipated water level changes in the IIF, or a mismatch in the hourly level checks in the RCBT's. Considering the hourly level checks in the RCBT's, it is unlikely that system leakage would continue undetected for more than one hour. Operator actions to secure system operation and to terminate the leakage is conservatively assumed to require another hour. Thus, with the expected operating flow rate of 30 gpm, approximately 3,600 gallons of RCS water could be released to the AFHB or the RB from a postulated rupture during the "batch-type" mode of processing. For the "on-line" processing mode the RCS is being processed as a "closed loop" system; thus, level changes within the IIF would indicate a system leakage. An observed reduction in discharge pressure of the DWCS pump would also indicate a system leakage.

Reference 3 has shown that a line break, which could cause a siphon of the RCS water in the RV, would limit the resulting leakage to 4,000 gallons due to the siphon breakers located approximately two feet below the normal operating water level in the IIF.

To estimate the off-site radiological consequences from a postulated rupture the quantity of spillage is assumed to be 4,000 gallons and the airborne release fractions are assumed to be 0.001 for particulates and one (1) for tritium. Since the spillage occurs in either the AFHB or the RB, the effluent to the environment is first filtered via the HEPA filtration units. Each unit consists of two (2) HEPA filters with each filter having a removal efficiency of at least 99.9%. Taking credit for only one of the two HEPA filters and assuming a filter efficiency of only 99% for particulates (zero for tritium), a conservative assessment of the quantity of radionuclides released to the environment is obtained. Using the accident atmospheric dispersion factor of 6.1 E-4 sec/M^3 (given in Appendix 2D of the TMI-2 FSAR) and the maximum radionuclide concentration in the RCS observed during core drilling operations (see Table 1), the dose to the maximally exposed off-site individual is less than 4 mrems to the bone. This estimated dose is much less than the dose limits given in 10 CFR 100. The radionuclide concentrations in the RCS during DWCS processing are not expected to be greater than assumed in this assessment. However, the conservatisms employed in this assessment would more than compensate for any potentially higher radionuclide concentrations in the RCS.

TABLE 1

Assumed RCS Concentrations for Assessment of Spill Consequences

Isotope	Concentration (μ Ci/cc)
H-3	9.3 E-2
Co-60	2.8 E-2
Sr-90	6.7 E 0
Cs-134	3.5 E-2
Cs-137	1.7 E 0
Sb-125	1.0 E-1
Ce-144	1.4 E-2
Gross Alpha*	9.3 E-3

*For off-site dose assessment total gross alpha is assumed to be Pu-239.

3.4 Canister Shipping Requirements

Canister shipping requirements which could be impacted from the addition of coagulant and body-feed material in the defueling canisters are criticality and gas generation and control. Canister criticality evaluations will be submitted for NRC approval prior to shipping the filter canisters. The body feed material which is essentially SiO_2 has previously been shown in reference 1 not to affect the recombiner catalyst installed in the canisters to control hydrogen and oxygen which would be generated from the radiolysis of water retained in the dewatered canisters. Radiolytic breakdown of the coagulant may generate additional hydrogen and other gases. However, the limiting gas concentration for determination of the allowable storage and shipping time for dewatered canisters would be hydrogen. The allowable storage and shipping time will be determined based on actual hydrogen appearance rates obtained from gas samples of dewatered canisters. Testing has also verified that catalyst exposed to a 50 ppm concentration of coagulant has no adverse impact on the recombiner catalyst installed in the canisters.

4.0 10 CFR 50.59 Evaluation

10 CFR 50, 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, text, or experiment is determined not to be an unreviewed safety question and does not involve a modification to the plant Technical Specifications.

A proposed change involves an unreviewed safety question if:

a. The probability 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

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

c. The margin of safety, as defined in the basis for any Technical Specifications, is reduced.

The proposed addition of coagulant and body-feed into the DWCS processing stream to improve filter performance would not increase the probability of an accident or malfunction of equipment important to safety. Analysis has shown that there is no increased probability of boron dilution given the controls over the operation and expected conditions. The coagulant addition rate and total coagulant dosage will be limited to ensure that the chloride concentration in the RCS does not exceed allowable limits. Increased chloride concentration in the RCS will not affect the filtered canisters since the chloride does not accumulate in the filter canister but rather passes through the filter canister. The addition of the coagulant and body-feed has also shown not to impact combustible gas control in the defueling canisters. The use of unarmored hose is consistent with normal cleanup practice. Various recovery systems such as the SDS sumpsucker, sediment transfer, and Reactor Building Sump Recirculation system also use unarmored hose. As a further measure of assurance of the adequacy of the unarmored hose, the hose will be hydrostatically checked prior to installation and leak checked prior to operation. The consequences of a ruptured line was determined for off-site radiological concerns and found to be very small with respect to allowable limits in 10 CFR 100. The FSAR for TMI-2 evaluated a variety of events to bound the range of possible events and their off-site dose consequences. An accident evaluated in the FSAR which is analogous to the postulated accident given in this safety analysis would be "Break in Instrument Lines or Lines from Primary System that Penetrate Containment", section 15.1.20 of the FSAR. The dose consequences from this postulated event are given in FSAR Table 15.1.20-2, and are greater than the dose consequence of the postulated line rupture given in this safety analysis.

The proposed activity would not create an accident or malfunction of a different type. Preventive measures for boron dilution concerns will be enforced so that a different boron dilution potential is not created.

The proposed activity does not reduce the margin of safety defined in the basis for any Technical Specification. The Technical specification applicable to this activity is the RCS boron concentration. The addition of coagulant and body-feed will not reduce the boron concentration margin of safety. Furthermore, the coagulant addition will be controlled to ensure compliance to the RCS limits of pH and chloride concentration given in the Recovery Operations Plan.

In conclusion, the proposed activity has been determined not to be an unreviewed safety question.

The proposed activity also does not involve any modifications to the Technical Specification.

5.0 Conclusion

This safety analysis has shown that the planned addition of coagulant and body-feed to the DWCS processing stream can be accomplished within existing procedural limits and thus not adversely impact the health and safety of the public.

6.0 References

1. Safety Evaluation for the Operation of the Filter Aid Feed System and the Use of Diatomaceous Earth as Feed Material, GPU Nuclear letter 4410-86-L-0104, F. Standerfer to W. Travers, June 30, 1986.

2. Boron Hazards Analysis, Revision 2, GPU Nuclear letter 4410-85-L-0195, F. Standerfer to B. J. Snyder, September 27, 1985.

3. Defueling Water cleanup System Technical Evaluation Report, Revision 9, GPU Nuclear letter 4410-86-L-0011, F. Standerfer to W. Travers, February 7, 1986.