NMC
Committed to Nuclear Excellence

Palisades Nuclear Plant
Operated by Nuclear Management Company, LLC

October 30, 2006

10 CFR 50.91(a)(5)

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

Response to Request for Additional Information Regarding License Amendment Request: Removal of TSP from Palisades Containment

By letter dated March 20, 2006, pursuant to 10 CFR 50.91(a)(5), Nuclear Management Company, LLC (NMC) requested Nuclear Regulatory Commission (NRC) review and approval of a proposed license amendment for the Palisades Nuclear Plant (PNP). NMC is proposing to remove tri-sodium phosphate (TSP) from the containment building at PNP as an interim measure until the long term resolution of GSI-191 is implemented.

By electronic email dated August 11, 2006, the NRC sent a request for additional information (RAI) regarding the proposed license amendment request. Enclosure 1 provides the response to the RAI for PNP.

A copy of this RAI response has been provided to the designated representative of the State of Michigan.

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 30, 2006.

Paul A. Harden
Site Vice-President, Palisades Nuclear Plant
Nuclear Management Company, LLC

Enclosures (2)

cc: Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

ENCLOSURE 1
RESPONSE TO RAI ON TSP AMENDMENT
PALISADES NUCLEAR PLANT

NRC Request

1. *In your response to NRC Request 2 (contained on page 11 or 13 of your July 7, 2006 letter to the NRC), you describe your plans to manually connect the NaOH injection system to the containment spray flow pathway following a LOCA. 10 CFR 50.34(f)(2)(vii) (and the criteria in Section II.B.2 of NUREG-0737) states that, following an accident, the dose to a person accessing a vital area (an area which will or may require occupancy to aid in the mitigation or recovery from an accident) must not exceed the GDC 19 dose criterion of 5 rem whole body.*

    a. *Provide plant layout drawings showing the path that an operator(s) would take to access the NaOH injection system, make the required hookups, initiate the injection of NaOH into the containment spray headers, and leave the area.*

    b. *Provide the mission doses (including doses accrued during access and egress from the vital area) to the operator(s) who will manually connect and initiate the NaOH injection system following an accident. Verify that the operator(s) can perform this vital function without exceeding the 5 rem whole body dose limit at any of the various times (from 20 hours following loss of a fuel cladding barrier to seven days post-LOCA) that this operation may be performed following a LOCA.*

    c. *If the manual connection of the NaOH injection system following an accident cannot be accomplished within the dose guidelines of GDC 19, then describe what measures you will take (such as use of additional shielding, use of multiple operators to break up the task of manually connecting the NaOH injection system, etc.) to ensure that the GDC 19 dose guidelines are not exceeded during performance of this action. (8/11/2006)*

NMC Response

1. a. A time motion analysis of the NaOH addition mission has been performed. The analysis, EA-EC976-01, "NaOH Addition Mission Dose," is provided as Enclosure 2. Plant layout drawings are provided in Attachment 1 of Enclosure 2. The paths are indicated on mark-ups of plant drawings M-2 and M-3.

    b. The mission dose to the operator has been determined in Enclosure 2. The analysis concludes that a reasonable and conservative estimate of the maximum radiological dose received by a single individual performing the NaOH addition mission is less than the 5 rem TEDE limit. Therefore, measures such as the use of additional shielding or the use of multiple operators for various tasks do not need to be explicitly developed to ensure acceptable mission doses for all required personnel. Such measures would be employed by the emergency response organization as appropriate in keeping with the principles of ALARA and the protection of the health and safety of the public.

c. N/A

ENCLOSURE 2

EA-EC976-01, "NaOH Addition Mission Dose"

24 Pages Follow

NMC Committed to Nuclear Excellence	EA-EC976-10	Revision: 0
	Date: 10/24/2006	
	Total Number of Pages: 24	
Title: **NaOH Addition Mission Dose**		
Approval: See signature page		

Objective

This calculation provides a reasonable and conservative estimate of the radiological dose to a single individual performing the NaOH addition mission. The mission is to add the required quantity of NaOH to the containment spray system following a loss of coolant accident (LOCA) that progresses to the recirculation mode of emergency core cooling system (ECCS) operation in the event that no buffering agent (e.g., TSP) exists in containment. The calculation consists of a time-motion analysis of all required tasks that comprise the mission.

The estimate of total mission dose is compared to an acceptance criterion derived from Title 10 of the Code of Federal Regulations and Item II.B.2 of the Clarification of TMI Action Plan Requirements, and is used to determine whether measures such as the use of additional shielding or the use of multiple operators for various tasks need to be developed to ensure acceptable mission doses for all required personnel.

This calculation supports engineering change EC-976, which is being implemented to remove tri-sodium phosphate (TSP) from containment in order to address the potential for sump blockage due to chemical reaction products in post-accident sump water containing TSP and calcium-silicate (Cal-Sil) insulation. EC-976 contains provisions for the addition of an alternate buffer within 20 hours post-LOCA with recirculation, which requires entry into Room 121.

Conclusions

A reasonable and conservative estimate of the maximum radiological dose received by single individual performing the NaOH addition mission is 4.113 rem TEDE. The estimate of total mission dose is less than the 5 rem TEDE limit. Therefore, measures such as the use of additional shielding or the use of multiple operators for various tasks do not need to be explicitly developed a priori to ensure acceptable mission doses for all required personnel. Such measures will be employed by the emergency response organization as appropriate in keeping with the principles of ALARA and the protection of the health and safety of the public.

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1.0 PURPOSE

This calculation provides a reasonable and conservative estimate of the radiological dose to a single individual performing the NaOH addition mission. The mission is to add the required quantity of NaOH to the containment spray system following a loss of coolant accident (LOCA) that progresses to the recirculation mode of emergency core cooling system (ECCS) operation in the event that no buffering agent (e.g., TSP) exists in containment. The calculation consists of a time-motion analysis of all required tasks that comprise the mission.

The estimate of total mission dose is compared to an acceptance criterion derived from Title 10 of the Code of Federal Regulations (Ref. [1]) and Item II.B.2 of the Clarification of TMI Action Plan Requirements (Ref. [18]), and is used to determine whether measures such as the use of additional shielding or the use of multiple operators for various tasks need to be developed to ensure acceptable mission doses for all required personnel.

This calculation supports engineering change EC-976 (Ref. [2]), which is being implemented to remove tri-sodium phosphate (TSP) from containment in order to address the potential for sump blockage due to chemical reaction products in post-accident sump water containing TSP and calcium-silicate (Cal-Sil) insulation. EC-976 contains provisions for the addition of an alternate buffer within 20 hours post-LOCA with recirculation, which requires entry into Room 121.

2.0 METHODOLOGY

2.1 Background

The purpose of TSP in containment is to control post-accident sump fluid pH to within the range 7-8. Ensuring post-accident sump pH between 7 and 8 assures that hydrogen generation, corrosion, insulation and debris dissolution, and radio-iodine retention are all acceptable and consistent with licensing basis assumptions. TSP removal is being pursued to mitigate the potential for containment sump screen blockage during the post-accident recirculation mode. By removing the TSP, reaction with dissolved calcium-silicate (Cal-Sil) insulation in the post-accident environment and subsequent precipitation is precluded. With the elimination of TSP/Cal-Sil precipitate, the predicted magnitude of sump screen blockage is reduced. This alleviates a specific NRC concern resulting from the integrated chemical effects testing performed in September 2005 (Ref. [3]).

However, the removal of TSP has the potential to impact post-accident sump pH which subsequently impacts iodine retention in sump water and can impact on-site and off-site doses. The impact on the radiological design basis due to the removal of TSP is evaluated in EA-EC-976-01 (Ref. [4]). This new calculation, EA-EC976-10, reasonably and conservatively determines the radiological dose to single individual performing the NaOH addition mission.

2.2 Post-Accident Radiation Field Analysis

A design review of post-accident operator actions was performed in response to NUREG-0737, Item II.B.2 (Ref. [5]). As part of this analysis, maximum post-accident dose rates for all areas that require access for the NaOH addition mission were determined. The analysis relies on source terms based on Regulatory Guide 1.4 (Ref. [6]) that can be characterized as TID-14844 (Ref. [7]) source terms.

Since these source terms credit iodine spray removal and do not consider the possibility of an un-buffered containment sump with subsequent re-volatilization and evolution of iodine, the radiation fields determined in these calculations are adjusted to conservatively account for the condition of complete loss of sump pH control.

First, an examination of the details of the source terms used for the NUREG-0737 response is performed. Then, the impact of the loss of sump pH control is determined and adjustments made to the radiation fields such that they are applicable to the un-buffered sump configuration.

The NUREG-0737 response considered dose from the following sources:

- Shine from ECCS piping outside containment
- Shine from airborne activity inside containment through the containment wall
- Shine from airborne activity inside containment through penetrations

Sources not considered are:

- Immersion and inhalation doses due to entering room containing containment atmosphere leakage or ECCS recirculation water leakage

Based on the expected conservative design of the modification, there is a low potential for the NaOH injection process (after multiple failures) to lead to filling the sensing line with ECCS recirculation water and/or potentially leaking, therefore the sensing line and sensing line leakage dose is excluded. Liquid or airborne leakage into rooms requiring access for the NaOH addition mission are not considered since leakage into these rooms is not expected, based on the barriers between the rooms and other ECCS recirculation piping and containment penetrations.

The radiation fields are combined with mission task information (see Section 2.3) and used to determine mission doses relative to the acceptance criterion (see Section 3.0).

2.3 NaOH Addition Mission Time-Motion Analysis

The addition of NaOH to the primary coolant system to ultimately buffer the pH of the re-circulating sump fluid is controlled by Palisades emergency operations procedure EOP Supplement 42 (Ref. [8]), which defines pre- and post- RAS actions.

Each required task from this procedure is identified and associated with a specific plant location. Estimates of the time required for each task have been obtained from an operations crew (Ref. [9]). These estimates were derived from an in-plant walk-down of the procedure with simulations of task performance where possible.

2.4 Software Codes

No shielding calculations are performed for this analysis. Adjustments to the results from previous analyses are calculated with spreadsheets. The previous analyses relied upon QAD P-52 code for shielding calculations.

2.4.1 Microsoft™ Excel

The commercial spreadsheet application is used for source term computations and to compute the final integrated dose.

3.0 ACCEPTANCE CRITERIA

The calculation of post-accident mission doses was required to respond to NUREG-0737 II.B.2 concerning post-accident operator doses. Given the large degree of uncertainty associated with severe accident magnitude and progression, and uncertainty with the timing and duration of the alternate buffer addition mission activities, the specific acceptance criteria cited below are meant to provide confidence that mission activities can be completed safely with regard to personnel dose.

Sound radiation protection principles and the principle of "As Low As is Reasonably Achievable" are applicable to the NaOH mission irrespective of the demonstration of an acceptable single individual dose as per the criterion below. In any actual event, measures such as the use of additional shielding or the use of multiple operators for various tasks are available to emergency response organization personnel. However, the demonstration of an acceptable single individual dose obviates the need to formally develop such measures prior to the occurrence of the event.

Limits for personnel performing the alternate buffer addition mission are derived from 10-CFR-20, Subpart C (20.1201(a)(1)(i)), 10-CFR-50, Section 50.34(f)(2)(vii) and NUREG-0737 Item II.B.2.

All doses considered in this calculation are external whole body gamma doses. As such, the deep dose equivalent (DDE) typically calculated in shielding codes is equivalent to the TEDE.

The acceptance criterion is as follows:

- A reasonable and conservative estimate of the radiological dose to a single individual performing the NaOH addition mission following a LOCA with recirculation shall be less than 5 rem TEDE.

It is noted that this acceptance criterion is only ½ of the EPA-400 guidance of 10 rem for workers performing emergency services to protect valuable property (Ref. [17]). Therefore, the acceptance criterion above ensures that the EPA-400 limit can be met for an individual performing the mission whose cumulative annual dose is at the 5 rem TEDE limit at the time of the event.

4.0 INPUTS

4.1 NUREG-0737 response dose rates calculated for points inside the iso-dose-rate lines should be added to the dose rate from containment shine within the iso-dose-rate lines.

Source: NUREG-0373 response (Ref. [5]), Figure 19, Note 1.

4.2 NUREG-0737 response dose rates from different source locations at the same dose point should be added to determine the total dose rate.

Source: NUREG-0373 response (Ref. [5]), Figure 19, Note 1.

4.3 Dose rates and source term type from the following NUREG-0737 response calculations are:

Calculation	Dose Rate (mrem/hr)	Source Type
570-13	3.3×10^3	Liquid
570-15	5.0×10^2	Liquid
570-23	2.2×10^4	Liquid
590-4	1.3×10^4	Liquid
602-5	$<10^0$	Gaseous
602-9	$<10^0$	Gaseous
602-10	$<10^0$	Gaseous
602-11	$<10^0$	Gaseous
602-13	$<10^0$	Gaseous
602-14	1.9×10^1	Gaseous
611-5	9.0×10^4	Gaseous
611-6	6.7×10^4	Gaseous
611-7	1.2×10^3	Gaseous
611-8	7.7×10^2	Gaseous
611-11	3.8×10^1	Gaseous
611-12	2.6×10^1	Gaseous

Source: NUREG-0373 response (Ref. [5]), Table 6, Figures 19 and 22.

4.4 The core fission product inventory from the NUREG-0737 response is given in Attachment 2.

Source: NUREG-0737 response (Ref. [5]), Table 1.

4.5 The liquid fission product source term from the NUREG-0737 response is given in Attachment 3.

Source: NUREG-0737 response (Ref. [5]), Table 1, Assumption III.B.1 and Assumption III.C.

4.6 The gaseous fission product source term from the NUREG-0737 response is given in Attachment 4.

Source: NUREG-0737 response (Ref. [5]), Table 1, Assumption III.B.2 and Assumption III.C.

4.7 The gamma energy per disintegration for the gaseous source term nuclides is given in Attachment 4.

Source: FGR 12 (Ref. [16]), Table A.1.

5.0 REFERENCES

[1] Title 10, Code of Federal Regulations: Part 20 – Standards for Protection Against Radiation, Subpart C - Subpart C--Occupational Dose Limits, Section 20.1201 – Occupational Dose Limits for Adults; and Part 50 – Domestic Licensing of Production and Utilization Facilities, Section 50.34 – Contents of applications; technical information.

[2] EC-976, Remove Trisodium Phosphate from Containment in Response to NRC Information Notice 05-26, Engineering Change - Modification, February 2006.

[3] Information Notice 2005-26, Results of Chemical Effects Head Loss Tests in a Simulated PWR Sump Pool Environment, USNRC, Office of Nuclear Reactor Regulation, September 16, 2005.

[4] EA-EC-976-01, Revision 0, Impact on Radiological Consequences Due to Removal of Trisodium Phosphate from Containment, March 2006.

[5] Report entitled "NUREG-0578 Design Review Study of Plant Shielding for Post-Accident Operations," Revision 1, Commonwealth Associates Inc., January 15, 1982. (2687/1277)

[6] Regulatory Guide 1.4, Revision 2, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors", U.S. Atomic Energy Commission, Directorate of Regulatory Standards, June 1974. (ML003739614)

[7] TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites", J.J. DiNunno et al., U.S. Atomic Energy Commission, 1962.

[8] EOP Supplement 42, Revision 6, Pre and Post RAS Actions, Palisades Nuclear Plant Emergency Operating Procedure, (pending).

[9] WWK0637OPSTV1 through WWK0637OPSTV4, Perform "Time Validation" for selected EOP Supplement 42 (Pre / Post RAS) Actions, September 2006.

[10] NUREG/CR-5950, Iodine Evolution and pH Control, Oak Ridge National Laboratory, December 1992

[11] ANL Report, Chemical Effects/Head–Loss Testing, Quick Look Report, Tests ICET-3-4 to 11, Argonne National Laboratory, ADAMS Ascension Number ML060190713, January 20, 2006.

[12] NWT Report 729, Part 1, Palisades Calcium Silicate Insulation Behavior, Laboratory Evaluations, October 2005.

[13] Letter from Paul A. Harden (NMC) to Document Control Desk (NRC), License Amendment Request: Removal of TSP from Palisades Containment, March 20, 2006.

[14] M-2, Revision 28, Equipment Location – Aux. Bldg., Radwaste Modifications, Plan of EL. 590'-0", Palisades Drawing, July 2005.

[15] M-3, Revision 23, Equipment Location – Auxiliary and, Reactor Bldg. Radwaste Modification, Plan of EL. 607'-6", Palisades Drawing, July 2005.

[16] Federal Guidance Report No. 12, "External Exposure to Radionuclides in Air, Water, and Soil", K. F. Eckerman, J. C. Ryman, Oak Ridge National Laboratory, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, 1993.

[17] EPA-400, "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", Office of Radiation Programs, U. S. Environmental Protection Agency, 1991.

[18] NUREG-0737, "Clarification of TMI Action Plan Requirements", Division of Licensing, Office of Nuclear Reactor Regulation, U. S. Nuclear Regulatory Commission, November 1980.

6.0 ASSUMPTIONS

6.1 Verified Assumptions

6.1.1 It is assumed that the removal of TSP results in a complete loss of post-accident sump pH control for the duration of the NaOH addition mission.

Basis: This is a conservative assumption since complete loss of sump pH control results in worst-case radiological consequences and sump pH is not expected to be completely uncontrolled even in the absence of TSP. Also, during the NaOH addition mission, sump pH is becoming more and more controlled. See the discussion in Section 7.

6.1.2 It is assumed that a complete loss of post-accident sump pH control results in complete, instantaneous re-evolution of the iodine scrubbed from the atmosphere by containment sprays. The impact of the instantaneous re-evolution can be modeled by eliminating radiological credit for containment sprays.

Basis: This is a conservative assumption since 100% re-evolution is not expected to occur, and a time delay would exist between scrubbing and re-evolution that would reduce the early atmosphere iodine concentrations.

6.1.3 It is assumed that the liquid source terms of the NUREG-0737 response conservatively represent the liquid source terms with a complete loss of post-accident sump pH control.

Basis: The removal of TSP would result in increased re-evolution of iodine from ECCS water prior to transport to ECCS components. No credit for reducing iodine concentration in the liquid source term due to re-evolution prior to leakage is taken. In addition, the assumption of 100% noble gas retention in the liquid source term is very conservative since noble gases are expected to evolve out of the recirculation fluid prior to transport out of containment. The liquid source terms of the NUREG-0737 response conservatively bound the impact of TSP removal.

6.1.4 It is assumed that the gaseous source terms of the NUREG-0737 response conservatively represent the gaseous source terms with a complete loss of post-accident sump pH control provided the halogen release fraction is increased by a factor of 2 from 25% to 50% to eliminate credit for containment spray removal.

Basis: The removal of TSP would result in increased evolution of iodine from sump water. Halogen release fractions are increased to 50% to account for re-evolution due to the potential for lower pH with TSP removed. No wash-out, plate-out or settlement of halogens or particulates is assumed – all initially released nuclides are assumed to remain airborne. The gaseous source terms of the NUREG-0737 response as adjusted conservatively bound the impact of TSP removal.

6.1.5 It is assumed that an increase of 50% in the gaseous source term dose rates of the NUREG-0737 response conservatively represents the impact of the TSP removal on the NUREG-0737 response dose rates.

Basis: From Assumption 6.1.3, the liquid source terms of the NUREG-0737 response conservatively bound TSP removal. From Assumption 6.1.4, the gaseous source terms of the NUREG-0737 response with the halogen concentrations increased by a factor of 2 conservatively bounds TSP removal. The component of the gaseous source term dose rate due to halogens is estimated by determining the ratio of the activity-energy of the halogens to the total activity-energy of the halogen and non-halogen nuclides in the source term. This is reasonable since dose rates are proportional to both the activity and average energy per disintegration of the source. Note that only gamma energy is used in the weighting since beta radiation will not contribute to the dose rates outside containment. Attachment 4 determines the halogen ratio to be 44.3% of the total, i.e., halogens contribute 44.3% to the gaseous source term dose rates. Conservatively rounding the halogen ratio to 50% and increasing the halogen contribution by a factor of 2 results in an increase of 50% in the gaseous source term dose rates of the NUREG-0737 response. Dose rates derived in this manner conservatively bound the impact of TSP removal.

6.1.6 It is assumed that dose from the following potential contributors can be ignored:

- Shine from the sensing lines associated with flow transmitters FT-0301 and FT-0302 in the event the lines are backfilled with ECCS recirculation water
- Immersion and inhalation dose from ECCS recirculation water leakage in the event of sensing line or valve failure associated with the sodium hydroxide addition mission
- Immersion and inhalation dose from ECCS recirculation water leakage or containment atmosphere leakage from any other sources

Basis: Based on the expected conservative design, there is a low potential for the alternate buffer injection process (after multiple failures) to lead to filling of the sensing line with ECCS recirculation water and/or potentially leaking, therefore the sensing line and sensing line leakage dose is excluded. Liquid or airborne leakage is not considered since leakage is not expected in the mission areas and compensatory measures are available (such as KI ingestion or SCBA donning) to mitigate the impact of these doses to mission personnel.

6.1.7 It is assumed that the alternate buffer addition mission will be accomplished between 1 and 20 hours following a LOCA with recirculation.

Basis: Given the severity of the postulated LOCA, many other actions and concerns would be addressed prior to execution of the alternate buffer addition mission. This would result in a certain delay allowing decay of the source terms before mission doses begin accumulating. A 1 hour delay is a conservatively short decay time assumption, given the expected post-accident priorities. The 20 hour time frame was committed to in the license amendment request TSP removal (Ref. [13]).

In this calculation, the sooner post-accident that the mission is attempted the greater the potential dose. However, except for decay, this result is an artifact of the calculation in that it follows from assumptions about the instantaneous failure of the fuel and mixture with ECCS recirculation water and instantaneous transport of the ECCS recirculation fluid leakage into the ESF piping. In an actual event, there may be significant time delays for any or all of the instantaneous assumptions, making earlier entry more favorable. For example, ECCS piping may not develop significant leakage until well into the 30 day mission time or fuel melting might take hours to develop. Therefore, the assumption that the alternate buffer addition mission is not performed prior to 1 hour post-event is not a condition of the mission. The assumption is understood in the context of establishing that the mission can be accomplished with acceptable personnel dose. In an actual event, dose rates in mission areas would be assessed prior to sending in personnel. This calculation is meant to show that the mission can be achieved with acceptable personnel doses.

6.2 Unverified Assumptions

6.2.1 None.

7.0 ANALYSIS

An examination of NaOH addition mission tasks in EOP Supplement 42 (Ref. [8]) indicates that the following areas in the auxiliary building require access to complete the mission:

Mission Area	Description
1	El. 611 - near caustic tank M-66 and chemistry hot lab
2	El. 611 - corridor to stairwell
3	El. 611 - stairwell
4	El. 590 - stairwell
5	El. 590 - corridor to jib crane
6	El. 590 - jib crane room
7	El. 590 - west end of C-40 panel room

These areas are indicated in the marked-up plant drawings in Attachment 1 from Refs. [14] and [15]. Note that the location of the pre-staged equipment may not be exact within mission area 1 but that all pre-staged equipment will be located in mission area 1 or a lower dose area.

Post-accident dose rates from the NUREG-0737 response (Ref. [5]) for all areas that require access for the NaOH addition mission are determined below and are summarized in Attachment 5.

7.1 Post-Accident Radiation Field Analysis

As noted in Section 2.2, the NUREG-0737 response analysis relied on source terms crediting iodine spray removal and do not consider the possibility of an un-buffered containment sump with subsequent re-volatilization and evolution of iodine. Therefore, the radiation fields determined in these calculations must be adjusted to conservatively account for the condition of complete loss of sump pH control.

7.1.1 NUREG-0737 Response Source Term Characterization

The Reference [5] core fission product inventory consists of 35 nuclides, comprised of noble gases, halogens and particulates as indicated in Attachment 2. Releases of this inventory are assumed to be partitioned between the containment atmosphere (gaseous source term) and the containment sump (liquid source term). The liquid source term is assumed to contain 100% of the noble gases, 50% of the halogens and 1% of the particulates. The gaseous source term is assumed to contain 100% of the noble gases and 25% of the halogens and no particulates. The partitioning of noble gases obviously involves a conservative double counting. The partitioning of halogens represents a 50% release fraction to the containment atmosphere and after the operation of sprays, a removal ½ of the gaseous halogens. The partitioning to the sump can be thought of as a 0% release fraction to sump initially that increases instantaneously to 50% (all gaseous halogens are transported to sump). The partitioning of halogens also involves a conservative double counting. The partitioning of particulates does not involve a double counting.

7.1.2 Impact of TSP Removal on NUREG-0737 Response Source Terms

The removal of all TSP from containment is assumed to result in the complete loss of the ability to control post-accident sump water pH to between 7-8. In an actual large break LOCA event with significant fuel failure, fission products (primarily cesium in the form of cesium hydroxide, cesium borate, and cesium iodide) and concrete reaction products are likely to control pH to pH>7 for time periods on the order of 24 hours in the absence of pH control additives such as TSP (Ref. [10]). Additionally, regardless of the initial pH or the presence of TSP, the pH of the sump water is expected to rise to about 7, primarily because Cal–Sil contains sodium silicate as an impurity (Ref. [11]). The sodium silicate is very soluble and as it dissolves the dissolved sodium (Na) causes the pH of the initial boric acid/LiOH solution to increase. Moreover, Palisades specific testing indicates that post-accident sump water pH would be increased by the dissolved Cal-Sil (Ref. [12]). In addition, the NaOH mission itself is designed to restore sump pH control prior to 20 hours after a LOCA with recirculation. The partial control of sump pH during the injection mission would be beneficial with regard to mission dose. However, no credit for these phenomena will be taken in determining NaOH mission dose.

The assumed complete loss of sump pH control impacts the containment atmosphere halogen chemical form distribution, since re-evolved iodine is preferentially elemental. However, since the spray removal process modeled in Reference [5] does not differentiate between chemical forms, this phenomenon has no impact on calculated dose rates.

The assumed loss of sump pH control impacts iodine scrubbing of the containment atmosphere. Re-evolution of iodine limits the effectiveness of the containment sprays since long-term retention of halogens cannot be assured. Therefore, the assumed loss of sump pH control is assumed to result in no removal of halogens from the containment atmosphere. This results in the initial 50% halogen release to containment remaining in the containment atmosphere.

Loss of sump pH control impacts retention of iodine in the sump. Re-evolution will occur in containment and could occur after transport outside of containment. Re-evolution in containment will reduce the iodine in the liquid source term. However, no credit is taken for a reduction in liquid halogen source term that would result if complete re-evolution were to occur. For conservatism, the liquid source term is assumed to be unaffected by the loss of sump pH control.

Therefore, the impact of the assumed complete loss of sump pH control on the Reference [5] source terms is a reduction in halogen inventory for liquid source terms (conservatively not credited) and an increase from 25% to 50% of core halogen inventory for gaseous source terms.

7.1.3 Impact of TSP Removal on NUREG-0737 Response Radiation Fields

No adjustment to the radiation fields from liquid source terms is needed since the liquid source terms bound the condition of TSP removal and are not altered as discussed above. To account for the impact of the altered gaseous source term on the dose rates calculated in Reference [5], the gaseous source term dose rates are increased by 50%. The component of the dose rate due to halogens is estimated by determining the ratio of the total activity-energy of the halogens to the total halogen and non-halogen source term. This calculation is performed in Attachment 4 and it is seen that the halogens contribute an estimated 44.3% to the total dose rate. For conservatism, this estimate is rounded up to 50%.

Therefore, the gaseous source term dose rates from Reference [5] are increased by 50% to conservatively account for the additional halogens present in the containment atmosphere when complete loss of sump pH control is assumed.

7.1.4 Mission Area Doses

Mission Area 1

From Figure 22 of Reference [5], a representative dose rate for mission area 1 is 26 mrem/hr, based on dose point 611-12. Point 611-12 is near coordinate line 26 in the El. 611' corridor. This point is closer to containment than the caustic tank/chemistry lab area and represents a conservative shine geometry through the personnel air lock penetration. This dose point can be used as a conservative surrogate for the dose in mission area 1. Since there is only a single calculation for this point and it is outside the iso-dose-rate lines the contribution of containment shine and other dose calculations should not be separately added. Since the dose is due to a gaseous source term, the dose rate is increased by 50% to 39 mrem/hr to account for TSP removal.

Mission Area 2

From Figure 22 of Reference [5], a representative dose rate for mission area 2 is 50 mrem/hr, based on dose points 611-11 and 611-12. These points are closer to containment than the most of the corridor area and represent a conservative shine geometry through the personnel air lock penetration. The maximum of these dose points can be used as a conservative surrogate for the dose in mission area 2. Since there are only single calculations for these points and both are outside the iso-dose-rate lines the contribution of containment shine and other dose calculations should not be separately added. Points 611-7 and 570-15 are in the stairwell and are included in mission area 3. Point 611-8 is significantly higher than 50 mrem/hr (770 mrem/hr) but represents a small area of the corridor in which only a very small fraction of the time is estimated to be spent relative to the time in other parts of mission area 2. Since the dose is due to a gaseous source term, the dose rate is increased by 50% to 75 mrem/hr to account for TSP removal.

Mission Area 3

From Figure 22 of Reference [5], a representative dose rate for mission area 3 is 10,000 mrem/hr, based on dose points 570-15, 611-5, 611-6 and 611-7. Doses for these points range from 500 mrem/hr to 90,000 mrem/hr. 10,000 mrem/hr is chosen as representative even though dose rates as high as 90,000 mrem/hr may exist in localized areas due to containment shine through the personnel air lock. The 10,000 mrem/hr value can be used as a reasonable surrogate for the average dose considering: (1) doses in the stairwell behind the shield wall would be orders of magnitude lower, (2) once descended lower than the 611' elevation, the flooring provides significant additional shielding, and (3) the overall mission time in area 3 (2 minutes) is very conservative (an actual traverse would only take a few tens of seconds). Since there are only single calculations for these points and both are outside the iso-dose-rate lines the contribution of containment shine and other dose calculations should not be separately added. Since the limiting doses are due to a gaseous source term, the dose rate is increased by 50% to 15,000 mrem/hr to account for TSP removal.

Mission Area 4

From Figure 19 of Reference [5], a representative dose rate for mission area 4 is 3,300 mrem/hr, based on dose points 570-13, 602-11, 602-13, and 602-14. Doses for these points range from <1 mrem/hr to 3,300 mrem/hr. The maximum value can be used as a conservative surrogate for the dose in mission area 4. Since there are only single calculations for these points and both are outside the iso-dose-rate lines the contribution of containment shine and other dose calculations should not be separately added. Since the limiting doses are due to a liquid source term, the dose rate bounds TSP removal and is not increased.

Mission Area 5

From Figure 19 of Reference [5], a representative dose rate for mission area 5 is 10 mrem/hr, based on dose points 602-9 and 602-10. Doses for these points are all <1 mrem/hr. The 10 mrem/hr value can be used as a conservative surrogate for the dose in mission area 5. Since there are only single calculations for these points and both are outside the iso-dose-rate lines the contribution of containment shine and other dose calculations should not be separately added. Since the dose is due to a gaseous source term, the dose rate is increased by 50% to 15 mrem/hr to account for TSP removal.

Mission Area 6

From Figure 19 of Reference [5], a representative dose rate for mission area 6 is 10,000 mrem/hr, based on dose points from mission areas 5 and 7. There are no dose rates available for this mission area but rates can be expected to be between those of mission areas 5 and 7. The 10,000 mrem/hr value can be used as a conservative surrogate for the dose in mission area 6, given the shielding and distance differences from mission areas 5 and 7. Since the majority of the dose is due to a liquid source term (as estimated from mission area 7), the dose rate bounds TSP removal and is not increased.

Mission Area 7

From Figure 19 of Reference [5], a representative dose rate for mission area 7 is 35,000 mrem/hr, based on dose points 570-23, 590-4, and 602-5. Doses for these points sum to 35,000 mrem/hr and the value can be used as a conservative surrogate for the dose in mission area 7. Since there are multiple calculations for these points the doses are added. Since the points are outside the iso-dose-rate lines the contribution of containment shine should not be separately added. Note that this value is consistent with the value quoted for this area in item b) on page 12 of Reference [5]. Since the limiting doses are due to a liquid source term, the dose rate bounds TSP removal and is not increased.

Adjusted post-accident dose rates for mission areas are summarized in Attachment 5.

7.2 NaOH Addition Mission Time-Motion Analysis

The addition of NaOH to the primary coolant system to ultimately buffer the pH of the re-circulating sump fluid is controlled by Palisades emergency operations procedure EOP Supplement 42 (Ref. [8]), which defines pre- and post- RAS actions. Section 5 of EOP Supplement 42 contains the steps required to perform the NaOH addition:

- Step 5.1 does not contain actions but lists required equipment and locations.
- Step 5.2 is to fill caustic addition tank M-66 with 25% NaOH solution. Both the tank and NaOH are in mission area 1 and the task is estimated to take 2 hours.
- Step 5.3 is to notify the control room that various fire doors will be blocked open and can be performed from mission area 1 by companion phone in 2 minutes.
- Step 5.4 is to place the portable injection pump near tank M-66 and is performed in mission area 1 in 2 minutes.
- Step 5.5 is to connect the hose to the suction of portable injection suction and is performed in mission area 1 in 5 minutes.
- Step 5.6 is to route the suction hose to the caustic tank and is performed in mission area 1 in 2 minutes.
- Step 5.7 is to assemble the discharge hose segments and is performed in mission area 1 in 10 minutes, mission area 2 in 15 minutes, and in mission areas 3, 4, 5, and 6 in a total of 11 minutes.
- Step 5.8 is to identify the in-service containment spray header and can be performed in a low dose pre-job brief area. It is therefore not included in the mission dose.
- Step 5.9 or 5.10 is to prepare either flow transmitter FT-0301 or FT-0302 for injection by closing the isolation valves, opening the bypass valve, removing the check valve plug, and installing the discharge hose onto the check valve. This is performed in mission area 7 in 5 minutes.
- Step 5.11 is to connect suction hose to desired suction drain and is performed in mission area 1 in 10 minutes.
- Step 5.12 is to provide power to the portable injection pump and is performed primarily in mission area 1 (or lower dose areas) in 20 minutes. Verification of breaker 52-855 is in mission area 7 and has been included in the 5 minutes of Steps 5.9 and 5.10. Note that access to the 590' elevation is needed to complete power cable connection and this has been included in the times for Step 5.7.
- Steps 5.13, 5.14 and 5.15 are to ensure proper valve alignment and are performed in mission area 1 in 2 minutes.

- Step 5.16 is to vent the injection pump and is performed in mission area 1 in 5 minutes.
- Step 5.17 is to perform the NaOH injection and is performed in mission area 1 in 3 hours.
- The remaining steps are for flushing and disassembling the injection system and are not required to achieve sump pH buffering. These activities are not time critical and can be performed by other personnel as needed.

The time estimates for each task above have been obtained from an operations crew and were derived from a procedure walk-down with simulations of task performance where possible. The time estimates are summarized in Attachment 5.

The radiation fields are combined with mission task information (time and location) to determine mission doses relative to the dose acceptance criterion in Attachment 5.

7.3 Results

See Attachment 5.

8.0 CONCLUSIONS

A reasonable and conservative estimate of the maximum radiological dose received by single individual performing the NaOH addition mission is 4.113 rem TEDE. The estimate of total mission dose is less than the 5 rem TEDE limit. Therefore, measures such as the use of additional shielding or the use of multiple operators for various tasks do not need to be explicitly developed a priori to ensure acceptable mission doses for all required personnel. Such measures will be employed by the emergency response organization as appropriate in keeping with the principles of ALARA and the protection of the health and safety of the public.

9.0 ATTACHMENTS

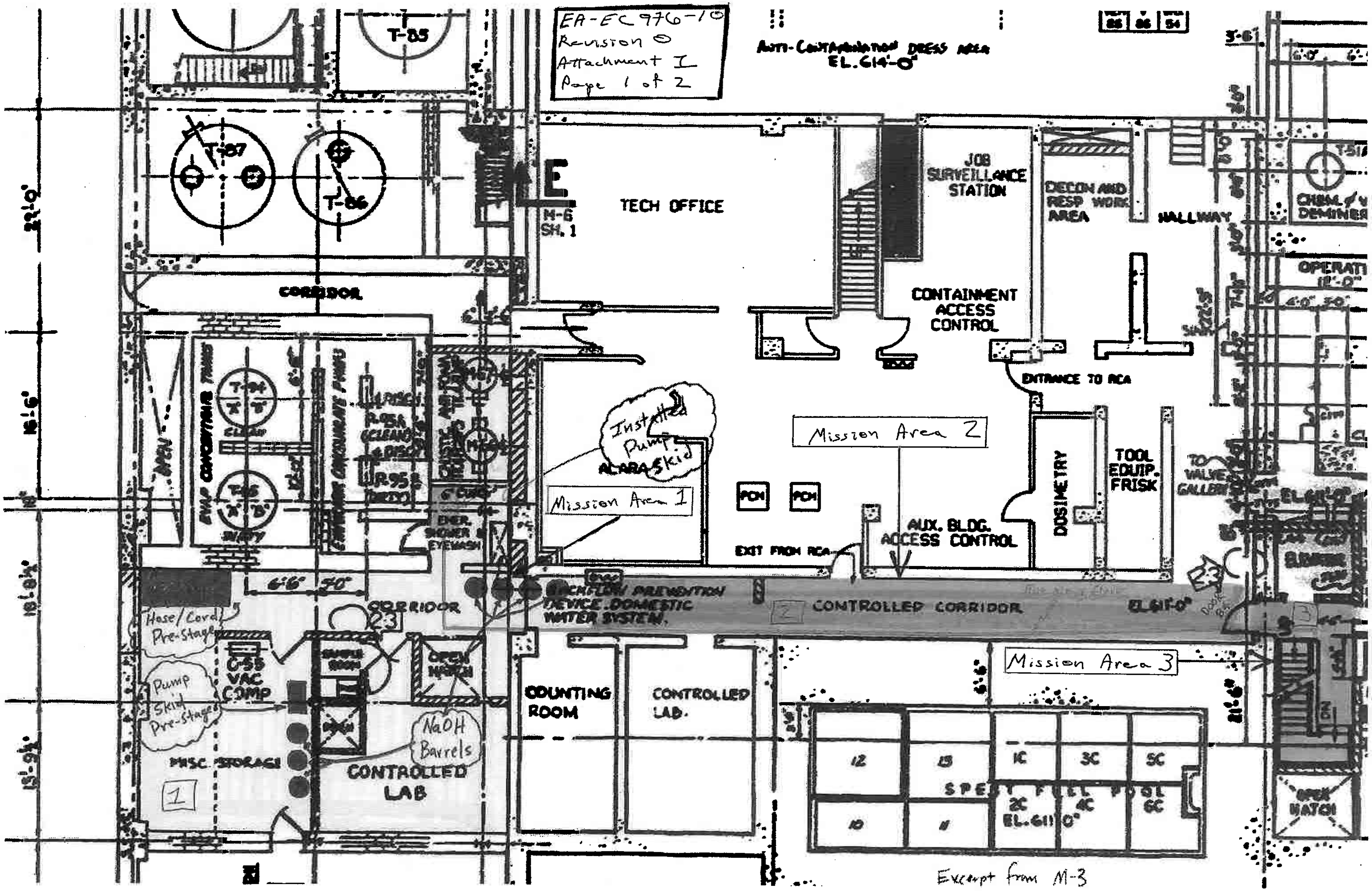
Attachment 1: NaOH Mission Path (2 pages)

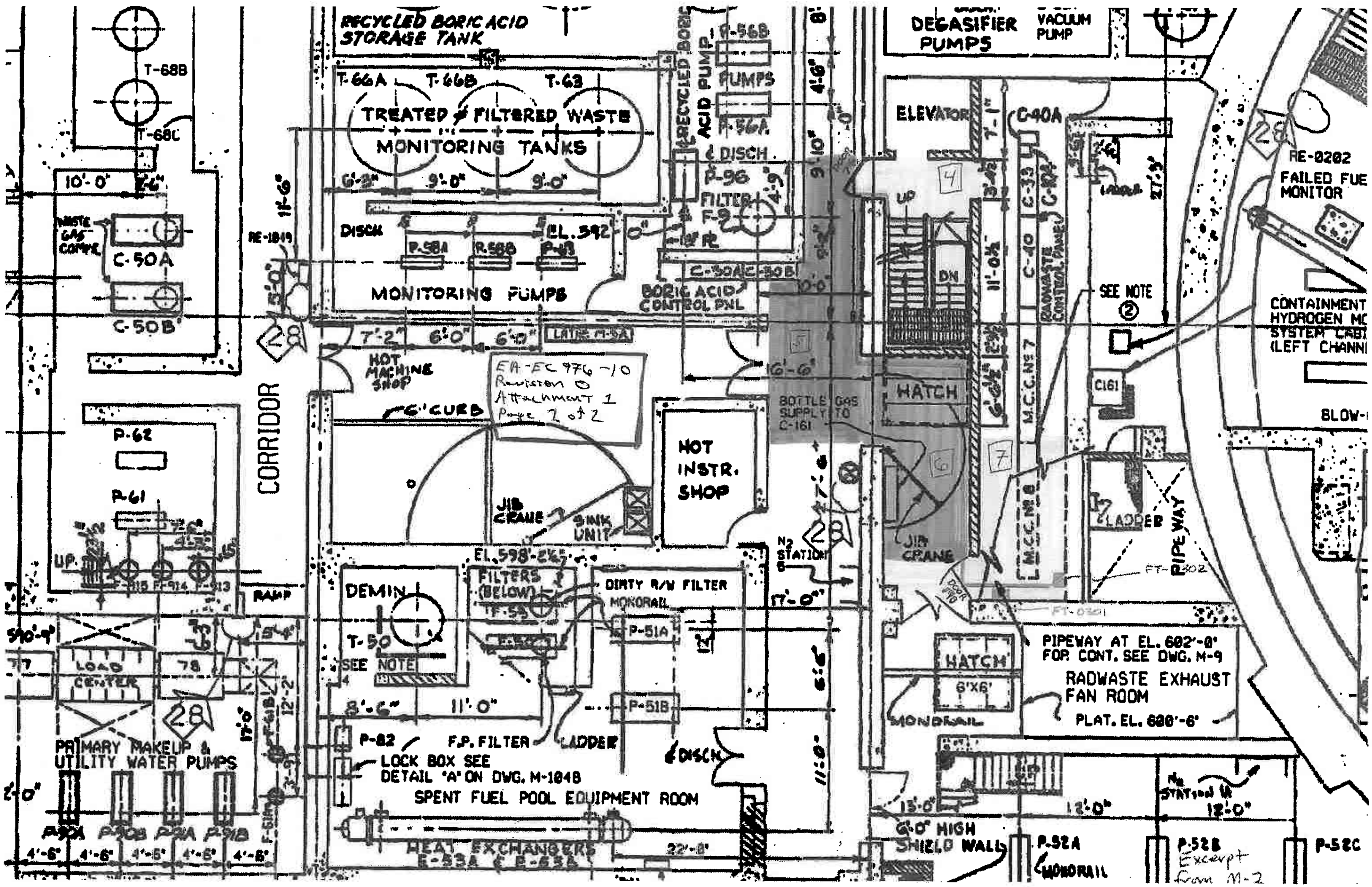
Attachment 2: Core Inventory (1 page)

Attachment 3: Liquid Source Terms (1 page)

Attachment 4: Gaseous Source Terms (2 pages)

Attachment 5: Results (1 page)


EA-EC976-10
Revision 0
Attachment I
Page 1 of 2
ANTI-CONTAMINATION DRESS AREA
EL.614'-0"
T-85
T-87
T-86
E
M-6
SH. 1
TECH OFFICE
JOB SURVEILLANCE STATION
DECON AND RESP WORK AREA
HALLWAY
CHEM. & V DEMINER
OPERATI
CORRIDOR
CONTAINMENT ACCESS CONTROL
ENTRANCE TO RCA
EVAP CONCENTRATE TANKS
T-94
T-95
EMERGENCY CONDENSATE PUMPS
Installed Pump ALARA Skid
Mission Area 1
Mission Area 2
PCM
PCM
DOSIMETRY
TOOL EQUIP. FRISK
TO VALVE GALLERY
EXIT FROM RCA
AUX. BLDG. ACCESS CONTROL
EMER. SHOWER & EYEWASH
BACKFLOW PREVENTION DEVICE DOMESTIC WATER SYSTEM
CONTROLLED CORRIDOR
EL.611'-0"
CORRIDOR
Hose/Cord Pre-stage
Pump Skid Pre-stage
C-55 VAC COMP
OPEN HATCH
NaOH Barrels
COUNTING ROOM
CONTROLLED LAB
Mission Area 3
MISC. STORAGE
CONTROLLED LAB
SPENT FUEL POOL
EL.611'-0"
OPEN HATCH
Excerpt from M-3



RECYCLED BORIC ACID STORAGE TANK
DEGASIFIER PUMPS
VACUUM PUMP
T-68B
T-68C
T-66A
T-66B
T-63
TREATED & FILTERED WASTE MONITORING TANKS
RECYCLED BORIC ACID PUMP
P-56B
PUMPS
P-56A
& DISCH
P-96
FILTER F-9
ELEVATOR
C-40A
C-39
C-104
C-40
RADWASTE CONTROL PANEL
M.C.C. No 7
M.C.C. No 8
RE-0202
FAILED FUEL MONITOR
10'-0"
WASTE GAS COMPR.
C-50A
C-50B
RE-1849
DISCH
EL. 592
P-58A
P-58B
P-58
MONITORING PUMPS
BORIC ACID CONTROL PNL
C-50A
C-50B
UP
DN
SEE NOTE ②
CONTAINMENT HYDROGEN MC SYSTEM CABI (LEFT CHANN
C161
HOT MACHINE SHOP
LATHE M-5A
EA-EC 976-10 Revision 0 Attachment 1 Page 2 of 2
6" CURB
HATCH
BOTTLE GAS SUPPLY TO C-161
BLOW-
CORRIDOR
P-62
P-61
HOT INSTR. SHOP
JIB CRANE
SINK UNIT
N2 STATION
JIB CRANE
LADDER
PIPE WAY
FT-0302
FT-0301
DOOR #10
UP
RAMP
DEMIN
T-50
SEE NOTE
EL. 598'-2½"
FILTERS (BELOW)
DIRTY R/W FILTER MONORAIL
P-51A
P-51B
17'-0"
PIPEWAY AT EL. 602'-0" FOR CONT. SEE DWG. M-9
RADWASTE EXHAUST FAN ROOM
PLAT. EL. 600'-6"
HATCH 6'X6'
MONORAIL
LOAD CENTER
78
PRIMARY MAKEUP & UTILITY WATER PUMPS
P-82
F.P. FILTER
LADDER
LOCK BOX SEE DETAIL 'A' ON DWG. M-1048
SPENT FUEL POOL EQUIPMENT ROOM
& DISCH
HEAT EXCHANGERS E-53A & E-53B
22'-8"
6'-0" HIGH SHIELD WALL
13'-0"
N2 STATION IA
12'-0"
P-52A
MONORAIL
P-52B
P-52C
Excerpt from M-2

Nuclide [ID-Mass#]	Atomic No. [Atomic#]	Mass No. [Mass#]	NUREG-0737 Activity [Ci]
Br-84	35	84	1.60E+07
Br-85	35	85	2.23E+07
Kr-83m	36	83	9.50E+06
Kr-85m	36	85	2.23E+07
Kr-85	36	85	5.13E+05
Kr-87	36	87	4.07E+07
Kr-88	36	88	5.71E+07
Rb-88	37	88	5.75E+07
Sr-89	38	89	7.56E+07
Sr-90	38	90	3.85E+06
Sr-91	38	91	9.89E+07
Sr-92	38	92	9.76E+07
Y-90	39	90	3.83E+06
Y-91	39	91	1.00E+08
Mo-99	42	99	1.33E+08
Ru-106	44	106	2.40E+07
I-131	53	131	7.69E+07
I-132	53	132	8.92E+07
I-133	53	133	1.31E+08
I-134	53	134	1.66E+08
I-135	53	135	1.31E+08
Xe-131m	54	131	4.59E+05
Xe-133m	54	133	3.15E+06
Xe-133	54	133	1.31E+08
Xe-135m	54	135	3.34E+07
Xe-135	54	135	1.96E+07
Xe-138	54	138	1.21E+08
Cs-134	55	134	1.34E+06
Cs-136	55	136	8.79E+05
Cs-137	55	137	4.91E+06
Cs-138	55	138	1.28E+08
Ba-137m	56	137	4.60E+06
Ba-140	56	140	1.30E+08
La-140	57	140	1.31E+08
Ce-144	58	144	7.43E+07

Nuclide [ID-Mass#]	Liquid Release Fraction [unitless]	NUREG-0737 Source Term [µCi/cc]
Br-84	0.50	3.62E+04
Br-85	0.50	5.05E+04
Kr-83m	1.00	4.30E+04
Kr-85m	1.00	1.01E+05
Kr-85	1.00	2.32E+03
Kr-87	1.00	1.84E+05
Kr-88	1.00	2.59E+05
Rb-88	0.01	2.60E+03
Sr-89	0.01	3.42E+03
Sr-90	0.01	1.74E+02
Sr-91	0.01	4.48E+03
Sr-92	0.01	4.42E+03
Y-90	0.01	1.73E+02
Y-91	0.01	4.53E+03
Mo-99	0.01	6.02E+03
Ru-106	0.01	1.09E+03
I-131	0.50	1.74E+05
I-132	0.50	2.02E+05
I-133	0.50	2.97E+05
I-134	0.50	3.76E+05
I-135	0.50	2.97E+05
Xe-131m	1.00	2.08E+03
Xe-133m	1.00	1.43E+04
Xe-133	1.00	5.93E+05
Xe-135m	1.00	1.51E+05
Xe-135	1.00	8.87E+04
Xe-138	1.00	5.48E+05
Cs-134	0.01	6.07E+01
Cs-136	0.01	3.98E+01
Cs-137	0.01	2.22E+02
Cs-138	0.01	5.80E+03
Ba-137m	0.01	2.08E+02
Ba-140	0.01	5.89E+03
La-140	0.01	5.93E+03
Ce-144	0.01	3.36E+03

(PCS Volume: 7,800 ft^3)

Nuclide [ID-Mass#]	Gaseous Release Fraction [unitless]	NUREG-0737 Source Term [μCi/cc]	E_γ [MeV]	$A_i * E_{\gamma i}$ [MeV-μCi/cc]
Br-84	0.25	8.61E+01	1.788	1.54E+02
Br-85	0.25	1.20E+02	0.000	0.00E+00
Kr-83m	1.00	2.05E+02	0.003	6.14E-01
Kr-85m	1.00	4.80E+02	0.158	7.59E+01
Kr-85	1.00	1.10E+01	0.002	2.21E-02
Kr-87	1.00	8.76E+02	0.793	6.95E+02
Kr-88	1.00	1.23E+03	1.955	2.40E+03
Rb-88	0.00	0.00E+00	0.629	-
Sr-89	0.00	0.00E+00	<	-
Sr-90	0.00	0.00E+00	-	-
Sr-91	0.00	0.00E+00	0.697	-
Sr-92	0.00	0.00E+00	1.339	-
Y-90	0.00	0.00E+00	<	-
Y-91	0.00	0.00E+00	0.004	-
Mo-99	0.00	0.00E+00	0.150	-
Ru-106	0.00	0.00E+00	-	-
I-131	0.25	4.14E+02	0.382	1.58E+02
I-132	0.25	4.80E+02	2.280	1.09E+03
I-133	0.25	7.05E+02	0.607	4.28E+02
I-134	0.25	8.94E+02	2.625	2.35E+03
I-135	0.25	7.05E+02	1.576	1.11E+03
Xe-131m	1.00	9.88E+00	0.020	1.98E-01
Xe-133m	1.00	6.78E+01	0.041	2.78E+00
Xe-133	1.00	2.82E+03	0.046	1.30E+02
Xe-135m	1.00	7.19E+02	0.429	3.09E+02
Xe-135	1.00	4.22E+02	0.249	1.05E+02
Xe-138	1.00	2.61E+03	1.125	2.93E+03

Nuclide [ID-Mass#]	Gaseous Release Fraction [unitless]	NUREG-0737 Source Term [µCi/cc]	E_γ [MeV]	$A_i * E_{\gamma i}$ [MeV-µCi/cc]
Cs-134	0.00	0.00E+00	1.555	-
Cs-136	0.00	0.00E+00	2.166	-
Cs-137	0.00	0.00E+00	-	-
Cs-138	0.00	0.00E+00	2.361	-
Ba-137m	0.00	0.00E+00	0.597	-
Ba-140	0.00	0.00E+00	0.183	-
La-140	0.00	0.00E+00	2.315	-
Ce-144	0.00	0.00E+00	0.021	-

(Containment Net Free Volume: 1,640,000 ft^3)

Total Activity-Energy:	1.19E+04
Halogen Activity-Energy:	5.29E+03
Halogen Fraction:	0.4430

Estimated Maximum NaOH Addition Mission Dose
@ 1 Hour Post-LOCA during Recirculation with 100% Fuel Melt and No Sump pH Control

Task (description)	EOP Supplement 42 (step)	Location (description)	Time at Location (min)	Raw Dose Rate (R/hr)	No Buffer Dose Rate (R/hr)	Total Dose (rem TEDE)
Fill caustic tank, notify control room, place injection pump, connect suction hose to pump, route suction hose, assemble discharge hose, connect discharge hose to pump, connect suction hose to tank, align breakers, route power cord, connect power cord, align breakers, perform line-up verification, vent pump suction, inject NaOH	5-2, 5-3, 5-4, 5-5, 5-6, 5-7, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17	El. 611 - near caustic tank M-66 and chemistry hot lab	358	0.026	0.039	0.233
Assembly discharge hose, route discharge hose	5-7	El. 611 - corridor to stairwell	15	0.050	0.075	0.019
Route discharge hose, route power cord*	5-7	El. 611 - stairwell*	2	10.000	15.000	0.500
Route discharge hose, route power cord*	5-7	El. 590 - stairwell	2	3.300	3.300	0.110
Route discharge hose, route power cord*	5-7, 5-12	El. 590 - corridor to jib crane	5	0.010	0.015	0.001
Route discharge hose	5-7	El. 590 - jib crane room	2	10.000	10.000	0.333
Route discharge hose, close isolation valves, open bypass valve, remove valve plug, connect discharge hose, open isolation valves	5-7, 5-9, 5-10	El. 590 - west end of C-40 panel room	5	35.000	35.000	2.917

*power cord routing requires acess to El. 590'

Mission Time: **6.483** **hours**
Mission Dose: **4.113** **rem TEDE**