CASK NAC-1D

SURFACE CONTAMINATION EVALUATION

September 1981

Prepared by

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Introduction

During the period from August 1980 to early September 1981 there were seven instances of excessive removable radioactive surface contamination on the NAC-1D cask on arrival at its destination. In four of the seven cases, the cask had been used to transport spent nuclear fuel. In the other three cases the cask was transported empty. Survey data from these shipments are charted and listed in Figure 1.

U. S. Federal regulation 49 CFR 173 places a limit on removable surface contamination of 22,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2). It is normal practice to decontaminate the outside surfaces of the cask before release from the shipping site to 10% or less of the removable contamination limit. If the measured activity per square centimeter does not exceed 10 percent of the level described above (or 2200 dpm/100 cm^2), it may be assumed that those levels have not been exceeded. The margin is desired to compensate for variations in counting methods and equipment and to allow for some release of fixed or semifixed contamination during transport.

As a result of the recent history of violations of surface contamination limits and in particular the contamination levels reached during the Midwest Storage Facility (MSF) to Lacrosse Boiling Water Reactor (LAC BWR) shipping campaign, the NRC Office of Nuclear Material Safety and Safeguards issued an order prohibiting the use of Cask NAC-1D outside the confines of a licensed facility. The suspension is to remain in effect until the USNRC finds there is reasonable assurance that surface contamination levels will not exceed the requirements of 49 CFR 173 during future shipments.

In an effort to reach an understanding of the cause of the contamination problems, a review has been made of spent fuel shipments, decontamination agents used, and decontamination results over the past year as well as survey results and experience on earlier shipping programs. Discussions were held with supervisory and safety personnel at the facilities involved with the cask contamination difficulties as to their procedures, experience, and observations on decontamination and shipment of the NAC-1D cask. Copies of the licensee contamination survey reports were obtained, the average contamination levels were calculated, and the distribution or location for the highest surface contamination spots were reviewed.

Subsequent to the receipt of the "Show Cause" order, the NAC-1D cask has been utilized on-site at the Turkey Point Nuclear Station for movement of fuel assemblies between the Unit 3 and Unit 4 spent fuel pools. A program for survey measurements on the cask was performed

using a number of decontamination agents to determine their effectiveness. The results showed a negligible increase or change of the removable contamination or surface equivalent radiation dose rates with time and usage during the fuel transfer operations at the Turkey Point Nuclear Station. However, there were significant differences noted in the effectiveness of the various decontamination agents in reducing the surface equivalent beta radiation dose rates.

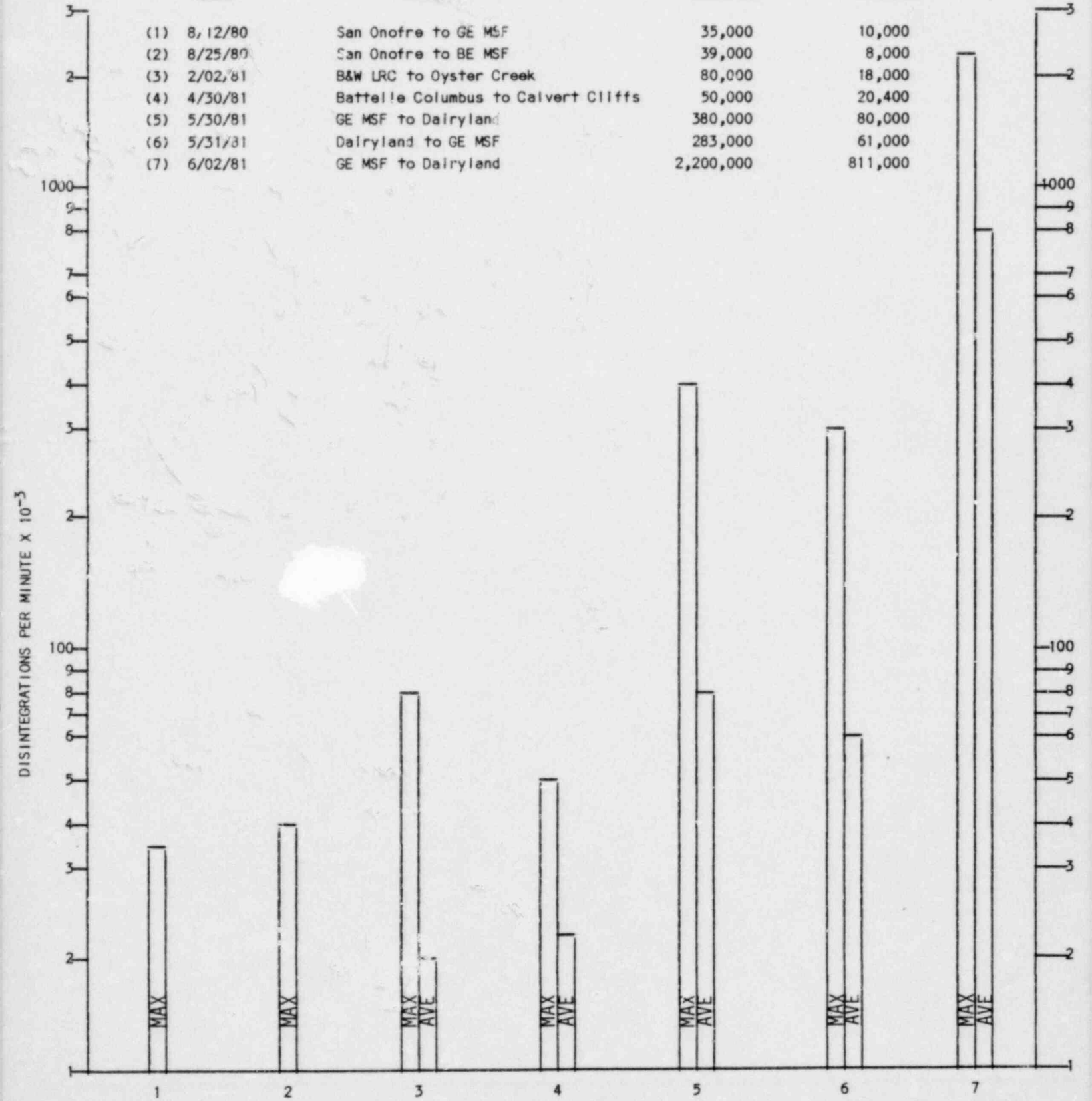
This study analyzes the results of the reviews and the more controlled survey at Turkey Point and presents recommendations for action to provide assurance that surface contamination limits will not be exceeded during future shipping programs.

Figure 1

MAXIMUM AND AVERAGE REMOVABLE SURFACE CONTAMINATION
ON CASK NAC-1-D AFTER TRANSPORT

dpm/100 cm^2

	Date	Trip	Maximum	Average
(1)	8/12/80	San Onofre to GE MSF	35,000	10,000
(2)	8/25/80	San Onofre to BE MSF	39,000	8,000
(3)	2/02/81	B&W LRC to Oyster Creek	80,000	18,000
(4)	4/30/81	Battelle Columbus to Calvert Cliffs	50,000	20,400
(5)	5/30/81	GE MSF to Dairyland	380,000	80,000
(6)	5/31/81	Dairyland to GE MSF	283,000	61,000
(7)	6/02/81	GE MSF to Dairyland	2,200,000	811,000



Discussion

The NAC-1D spent fuel shipping cask is one of five casks of the same design that have been used by the Nuclear Assurance Corporation (NAC). These casks have smooth stainless steel surfaces and are designed to be immersed in fuel pools for loading and unloading the radioactive spent fuel.

Commonly, spent fuel pools will contain various levels of fission products and radioactive corrosion products. During removal of the cask from the pool, the cask is normally rinsed with deionized water and decontaminated by manually wiping with a decontaminating agent.

Decontamination usually generates some liquid and solid low level radioactive waste. Because of handling and disposal problems, utilities and others who decontaminate casks have a high incentive to minimize these wastes. Consequently, we have observed a general trend to use cleaning agents and procedures that preclude liquid wastes. We have also observed that casks occasionally arrive at their destinations with removable contamination exceeding the regulatory limits. The frequency of these violations with cask NAC-1D increased considerably in late 1980 and early 1981, particularly after the cask had been immersed in pools with relatively high levels of fission product contamination.

Available contamination survey data covering shipments in NAC-1 casks during the years 1976 and 1977 have been compiled and are listed

in Appendix A. Appendix B is a record of surface contamination data on shipments arriving in 1980 at the MSF from San Onofre. As noted in the Appendices, there were occasional incidents of excessive contamination on arriving casks. During May and June 1980 when San Onofre was not shipping, cask NAC-1D was used for two shipments of fuel from Connecticut Yankee to Battelle Columbus Laboratories (BCL). These shipments were made with no reported incidents of excessive contamination. When San Onofre resumed shipments in August, however, the first two shipments arrived at MSF with reportable contamination.

Appendix C is a tabulation of the contamination survey results on all cask shipments made during the current 1981 calendar year. Included in the total are the remaining five incidents reported in the NRC "Show Cause" order for NAC-1D. Some shipments were made during this period without exceeding the DOT limit of 22,000 dpm/100 cm^2; however, excessive contamination was detected with increasing frequency up through the shipments to LAC BWR. After the third shipment to LAC BWR, and in response to an Immediate Action letter from NRC Region III to LAC BWR, a temporary amendment to the cask certificate of compliance was obtained authorizing the cask to be covered with plastic during shipment of the low-heat-rate fuel. All subsequent (through August 1981) cask movements were made, after decontamination of the cask surface to less than the DOT limit, with a cover of polyethelene plastic over the entire cask surface.

Detailed discussions were held with licensee personnel at LAC BWR. Copies of the contamination survey sheets on all shipments were reviewed and discussed. On the original shipment, for decontamination, LAC BWR used "LOOK", a commercially available glass cleaner, and "ENVY", a foaming cleanser. Following receipt of the first contaminated shipment, they included the additional decontamination agents acetone and a solution of ammonia. In spite of these efforts, the removable contamination exceeded DOT limits upon the return of the cask to MSF. After arrival of the next shipment at LAC BWR on June 2, 1981, with extremely high contamination levels, detailed measurements and analyses were made. A high level beta surface dose equivalent rate in the range of 400 to 500 mR/hr was detected. Isotopic analyses were performed and showed that the contamination was primarily Cesium-134 and Cesium-137 with a trace of Cobalt-60.

A further test was made to determine the effectiveness of the decontamination agents being used in removing surface contamination. The following results were obtained during receipt, unloading, and decontamination of the cask during the time period of June 2 through June 5, 1981, at LAC BWR:

a. Loaded Cask NAC-1D Arrived at LAC BWR from MSF.

Measurements of removable surface contamination were taken. The average of all readings was approximately 800,000 dpm/ 100 cm^2 with a high reading over 2,000,000.

Contact dose rate measurement of the cask surface upon receipt were 6 mR/hr average Gamma reading and 264 mR/hr average Beta reading.

b. Cask was Unloaded and Removed from LAC BWR Pool.

The average Beta surface dose equivalent rate was measured as 480 mR/hr.

c. Cask was Decontaminated Using "LOOK" and "ENVY".

Smearable contamination less than 2200 dpm/100 cm^2. Beta surface dose equivalent rate approximately 480 mR/hr.

d. Cask Decontaminated Using TURCO 4502 and TURCO 4521 Followed by a Demineralized Water Rinse.

Smearable contamination less than 2200 dpm/100 cm^2. Beta surface dose equivalent rate approximately 120 mR/hr.

The decontamination with the TURCO agents was repeated. Beta surface dose equivalent rate reduced to 60 mR/hr.

These results provide evidence that the mild decontamination agents "LOOK" and "ENVY", which quickly reduced smearable contamination to acceptable levels, were ineffective in removing the semi-fixed beta contamination. The stronger TURCO products proved effective in reducing both types of contamination.

General Electric personnel at MSF agree with NAC that the beta dose rate findings are important. A survey of the GE IF-300 cask on hand also showed the presence of measurable and significant beta dose rates. An analysis by General Electric confirmed the results obtained at LAC BWR showing an isotopic content of primarily Cesium-137 and Cesium-134 in the contamination. Although MSF did not have an explanation for the cause of recent contamination difficulties with NAC-1D, it was felt that the existence of the beta contamination might furnish a clue.

The MSF storage pool maintains good quality pool water with an activity level of 1×10^{-4} μCi/ml. The LAC BWR pool water had activity level of 2×10^{-2} μCi/ml.

Both LAC BWR and General Electric provided copies of cask survey documents and discussed possible implications and findings. Unfortunately there was no historical data on beta dose rates since such records have not been routinely obtained and documented. General Electric at MSF was using trisodium phosphate as their decontamination agent. This agent was effective in removing smearable contamination. At that time, however, they had no data regarding its capability to reduce the Beta contamination.

When the LAC BWR shipments were completed, Cask NAC-1D was placed in service at the Turkey Point Nuclear Station for use in shuffling fuel between the spent fuel pools of Units 3 and 4. The operation is performed by loading the cask in one pool and movement of the loaded cask by crane

to the second pool for unloading and return. This operation continued for the transfer of over 190 fuel assemblies. No cask decontamination, other than rinsedown with demineralized water, was performed during these operations.

The fuel shuffling continued at Turkey Point for approximately six weeks of multi-shift operation. It afforded an opportunity to study the cask surface contamination, to determine if there was a buildup of the surface contamination with time and use, and to explore the effectiveness of various decontamination agents used previously at other sites in cleaning the cask. A program was established and carried out limited somewhat by the time constraints imposed to minimize interference with the Turkey Point operations.

Accordingly, survey measurements were made on July 25 and again on August 10, 1981. These surveys were performed in accordance with the procedural steps presented in Appendix D; the results are attached as Appendix E. It was demonstrated that several of the common decontamination agents currently being used at nuclear installations (Tide, Alcohol, Consolve, Trisodium Phosphate, Fantastic, Easy-Off) will reduce the smearable contamination to acceptable release limits without affecting the beta dose equivalent readings. The TURCO agents 4502 and 4521 were effective not only in removing the smearable contamination but also in reducing beta surface equivalent dose rate levels. Analyses of the spent TURCO agents indicated the major contaminants removed were isotopes of Cesium.

Those results were corroborated during the August 10 tests. On that date, however, it was shown that the use of a bristle brush, in lieu of a sponge or cloth wipes, when using Tide as a cleaning agent, did result in some reduction of the beta dose rate. The observations at Turkey Point also indicated that there was no significant continuing buildup of cask surface contamination with time as the fuel transfer operations proceeded. The smear counts after two weeks of operation were generally in the range of 10,000 to 60,000 dpm/100 cm^2 when no decontamination of the cask surface, other than a water rinse, had been performed. The beta surface dose rate equivalent continued in the range of 10 to 30 mR/hr. After four weeks of operation, these ranges of readings were almost identical.

Stainless steel depends on an oxide film to preserve its corrosion resistance. This thin film (several molecules thick) is readily formed in air at room temperature. Review of available literature (Ref. 1, 2 and 3) indicates several mechanisms for radioactive isotopes to become semi-fixed contaminants on stainless steel surfaces. These include adsorption, absorption, diffusion and chemical reaction. In cases where the contaminant is adsorbed or absorbed, removal can be accomplished by wetting the contaminant and mechanically removing it. In cases where the contaminant has become imbedded in the oxide film by diffusion or has reacted with the oxide, removal requires some action to reverse the process. This might require dissolution of the oxide film or reaction with another material to render the contaminant soluble.

Experience gained at LAC BWR and at Turkey Point indicate that mild decontamination agents such as window cleaners are effective for removing loose surface contamination. However, these cleaners are ineffective in removing the source of beta radiation which is the precursor to future removable surface contamination. More aggressive cleaning agents such as the potassium permanganate and ammonium citrate of the TURCO products, or more vigorous cleaning methods such as the use of stiff bristled brushes or steam, are needed to remove smearable contamination as well as imbedded contaminants.

The final decontamination at Turkey Point employed steam and a mild TURCO detergent. The average removable contamination after this treatment was 4000 dpm/100 cm^2. The cask was allowed to weather on the decontamination pad and later wrapped in plastic with fourteen access "windows" on the trailer from August 26, 1981, to September 2, 1981, when a final removable contamination survey was made. The average removable contamination was 4,900 dpm/100 cm^2 with beta surface dose equivalent rates ranging from 2.5 to 5 mR/hr.

Conclusions and Recommendations

Based on the experience during shipment of fuel from MSF to LAC BWR and the experiments and observations during the campaign at Turkey Point, it can be concluded that the precursor of excessive removable contamination after a shipment is residual imbedded contamination that was inadequately removed during pre-shipment decontamination of the cask. The mechanisms responsible for release of this imbedded contamination include thermal cycling, vibration, atmospheric changes, scrubbing action of winds and wetting and drying cycles during weathering.

Evidence of inadequate removal of imbedded contamination is a high dose rate of beta radiation at the surface of the cask. From experiments with decontaminating agents and methods, reduction of surface beta radiation fields to less than 15 mR/hr are practicable. Once the beta field has been reduced to a low level, it can be maintained by prudent use of protective devices such as strippable paint or plastic sheaths when the cask is to be immersed in pools with significant contamination levels. In lieu of preventative methods, more aggressive cleaning agents must be used.

To provide assurance that future shipments of the NAC-1D cask and other spent fuel shipping packages meet acceptable contamination level requirements it is recommended that:

1. Shippers be required to perform a beta radiation survey in addition to the removable contamination survey currently performed to assure compliance with 49 CFR 173.397.

2. Quantification of permissible levels of beta radiation be established by experience with actual shipping campaigns.

3. Initially, Beta fields for casks prepared for shipment be limited to a maximum of 15 mR/hr at contact.

Appendix A - Receiving Contamination Survey Data 1976 & 1977
GE Morris to San Onofre

Date	Cask	Highest dpm/100 cm^2
3-17-76	1C	4,700
3-19-76	1D	12,400
3-21-76	1B	8,800
3-25-76	1C	4,600
3-27-76	1D	11,900
3-28-76	1B	2,100
3-31-76	1C	4,000
4-02-76	1A	2,200
4-03-76	1D	21,400
4-05-76	1B	19,400
4-07-76	1C	4,800
4-09-76	1A	2,700
4-10-76	1D	5,900
4-12-76	1B	9,900
4-14-76	1C	7,730
4-16-76	1A	5,200
4-19-76	1D	21,200
4-22-76	1C	2,100
4-23-76	1A	12,400
4-27-76	1B	5,000
4-29-76	1C	4,500
5-03-76	1A	2,500
5-04-76	1D	17,400
5-06-76	1C	3,700
5-09-76	1B	5,300
5-11-76	1A	10,000
5-15-76	1D	94,000*
5-15-76	1B	3,870
5-17-76	1C	6,000
5-20-76	1A	2,100
5-21-76	1D	9,100
5-24-76	1C	11,400
5-26-76	1B	56,400*
5-27-76	1A	53,400*
5-28-76	1D	42,100*
6-01-76	1C	2,200
6-02-76	1B	13,600
6-03-76	1D	14,400
6-05-76	1A	8,000
6-10-76	1C	2,400
6-11-76	1B	1,600
6-12-76	1D	21,200
6-16-76	1A	3,200
6-19-76	1C	2,300
3-29-77	1C	3,300
4-13-77	1B	42,200*
4-25-77	1C	2,600
5-02-77	1B	19,200
5-03-77	1D	88,300*
5-05-77	1C	13,400
5-11-77	1B	144,000*
5-16-77	1C	2,400
5-15-77	1D	1,000

* Reported

Appendix B - Receiving Contamination Survey Data - 1980
GE Morris to San Onofre

Date	Cask	Highest dpm/100 cm^2
1-21	1D	19,000
1-22	1E	< 2,200
1-29	1D	8,000
2-16	1E	< 2,200
2-18	1D	3,400
2-27	1E	< 2,200
2-27	1D	4,200
3-6	1E	< 2,200
3-8	1D	3,100
3-15	1E	3,000
3-16	1D	< 2,200
3-22	1E	7,000
3-24	1D	5,500
8-12	1D	35,000
8-23	1D	39,000
9-7	1D	21,000

Appendix C - Receiving Contamination Survey Data - 1981
Cask NAC-1D

Date	Trip	Highest dpm/100 cm^2
2-2	B&W to Oyster Creek	80,000
2-20	Oyster Creek to BCL	1,400
4-30	BCL to Calvert Cliff	50,000
5-5	Calvert Cliff to BCL	17,500
5-15	BCL to GE MSF	9,000
5-27	MSF to LAC BWR	8,300
5-28	LAC BWR to MSF	10,600
5-30	MSF to LAC BWR	380,000
5-31	LAC BWR to MSF	283,000
6-2	MSF to LAC BWR	2,200,000
6-5	LAC BWR to MSF	2,200*
6-7	MSF to LAC BWR	2,500*
6-11	LAC BWR to BCL	1,700*
7-2	BCL to Turkey Point	100,000**

* Plastic wrapped
** Plastic wrapped - high reading unconfirmed

APPENDIX D

NAC-1 CASK CONTAMINATION SURVEY AND
DECONTAMINATION TEST PROCEDURE

1.0 PURPOSE

This procedure provides for the collection of fixed and smearable contamination data from the outside surface of the NAC-1 cask. This procedure also provides for the application and evaluation of the effectiveness of commonly used decontamination agents.

2.0 EQUIPMENT

The equipment required for this procedure is:

2.1 A radiation survey instrument capable of measuring contact beta-gamma and gamma radiation.

2.2 A box of pre-cut smears.

2.3 A smear counting instrument (in dpm).

2.4 Various decontamination agents.

3.0 PROCEDURE

3.1 A contact radiation survey is made over the length of the cask. The survey is made in two passes at one-foot intervals on the centerline of each of the four quadrants of the cask. During the first pass in each quadrant, the contact gamma radiation is measured (beta shield closed). During the second pass, the contact beta-gamma radiation is measured. These data are recorded on the attached forms.

3.2 A smear (dpm/100 cm^2) is taken at each point that a radiation field is measured. The results of the smear are recorded opposite the radiation readings on the reporting form.

3.3 Following the completion of the radiation and smear surveys, two one-foot square test areas on each face (at about the four-foot and six-foot elevation levels) will be decontaminated using the available decontamination agents.

3.4 After decontamination, a new smear of the test area(s) will be made and the results will be recorded. The contact beta-gamma and gamma will be measured to assess the effectiveness of each agent in removing fixed surface contamination.

3.5 The results of all radiation surveys will be documented and independently verified. The record of results will be dated and signed by the individuals performing and verifying the measurements.

APPENDIX E

MEMO

TO: C. C. Hoffman RCB FLD/81/56/ETS

FROM: F. L. Danese, R. C. Bonnett

SUBJECT: D Cask Contamination Survey at Florida Power & Light, Turkey Point

DATE: July 30, 1981

We arrived at Turkey Point Nuclear Station, Homestead, Florida approximately 9:00 a.m. July 26, 1981. Entry for Danese was delayed due to lost badge, so the process for obtaining a picture badge had to be gone through again. At about 10:30 a.m., Danese received his badge and joined Bonnett and Mr. Bill Wymer in his office. We discussed our plan with Mr. Wymer to perform a beta-gamma and smearable survey on each quadrant of the NAC-1D cask. Mr. Wymer informed us that the cask was in the pool and it was very near crew change so we would have to wait until the next crew was at work. At approximately 12:30 p.m., the cask arrived at the cask wash-down area and was turned over to us and a Health Physics Technician from FP&L (Chris Caldwell).

Using a tape, we marked lines off at 12" intervals, beginning at the base of the cask on each of the four faces. We then did a beta-gamma and smearable survey at each line and Chris Caldwell (FP&L) recorded the results. Following his complete survey, eight areas (about 3" X 8"), were marked on the cask and each of these areas was decontaminated with a different agent. A smear survey was made to verify that the surface was below DOT limits (2,200 dpm). When the smear results were below DOT limits, a beta-gamma radiation was again measured and recorded. All of the data collected is shown on the attached survey sheets.

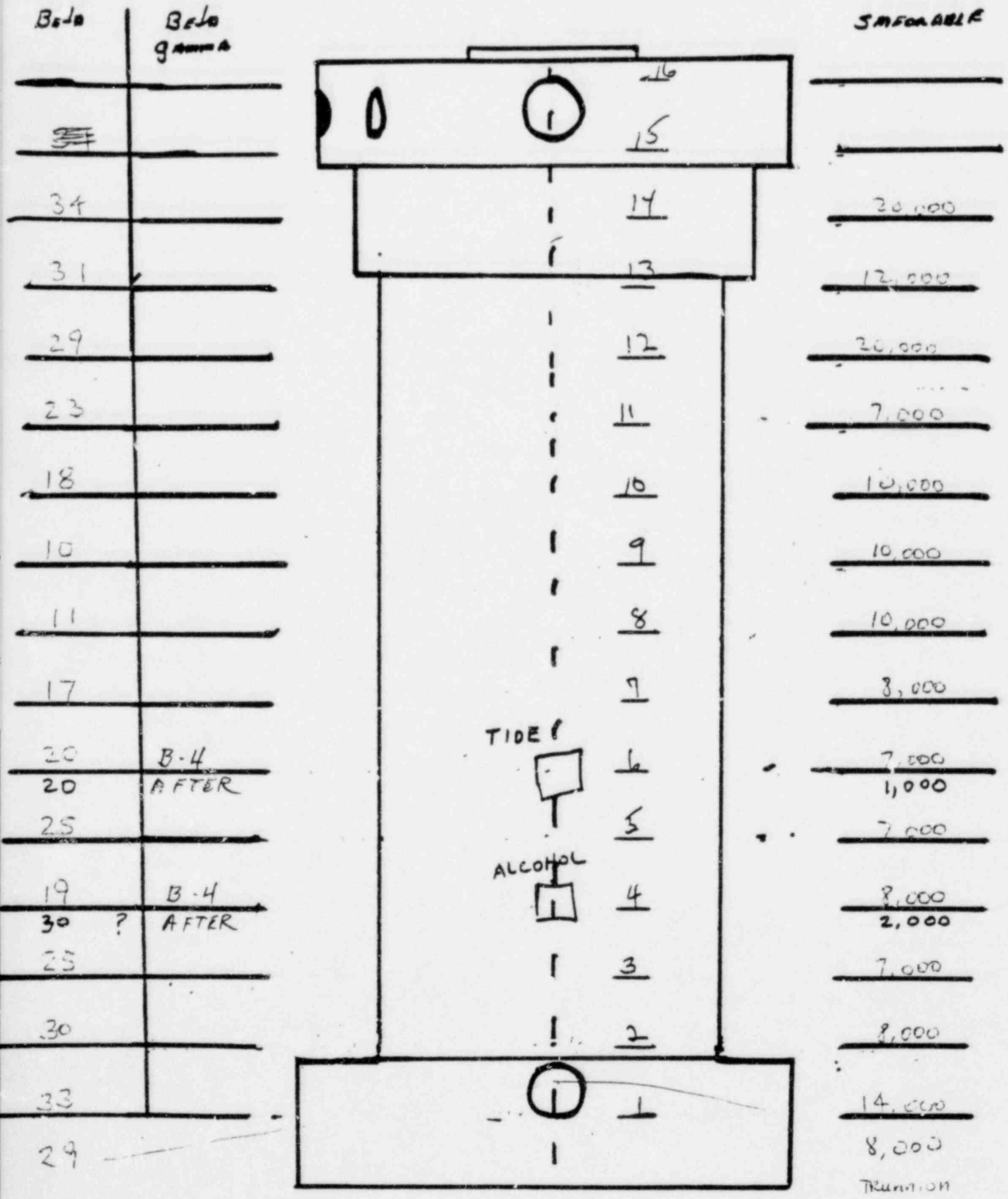
All tests were concluded at about 4:30 p.m.

FLD/RCB:bam

Attachments

cc: Danese
Johnson
Danese file
Corporate

SOUTH FACE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Beta gamma
SAMPLABLE
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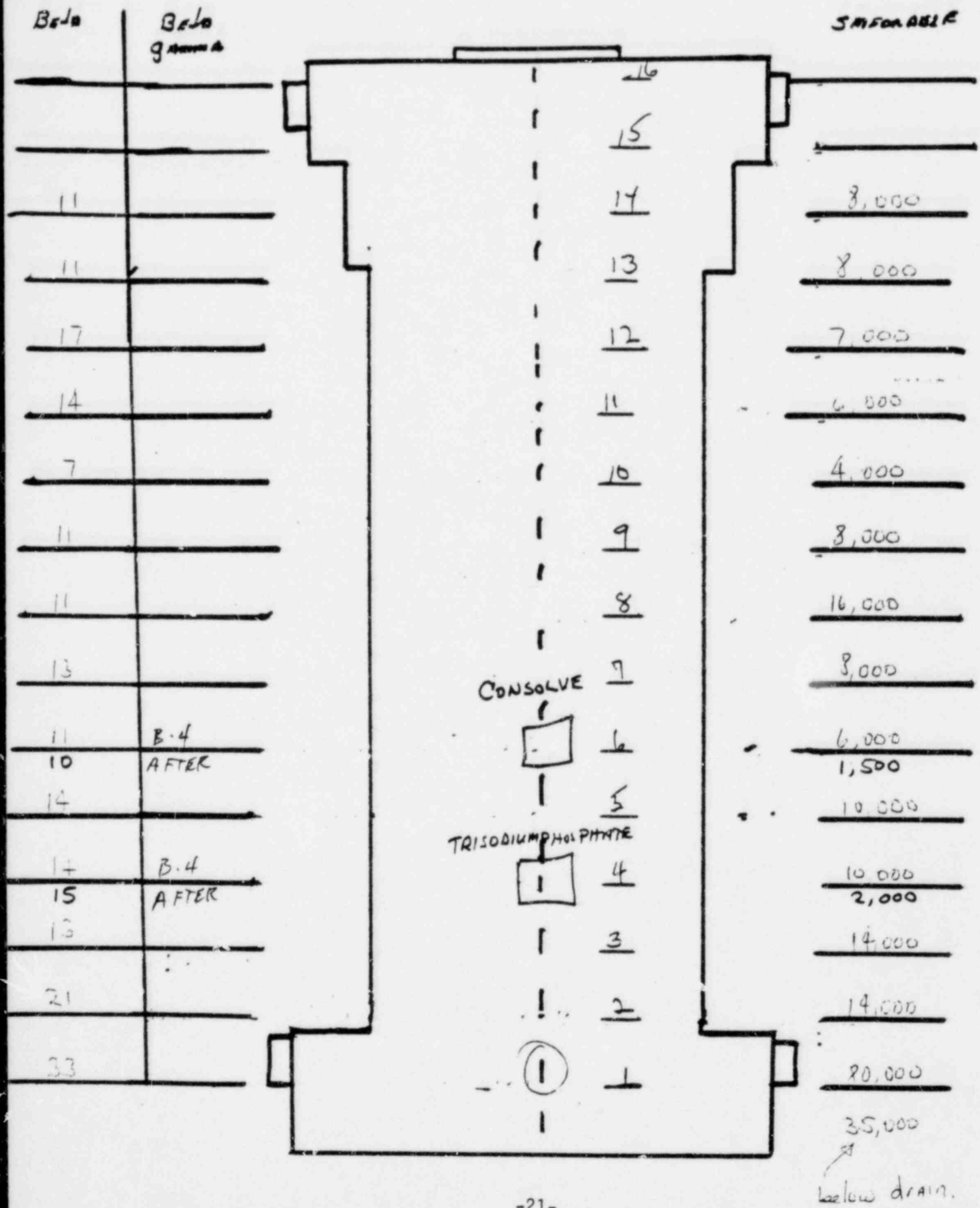
Trunnion

EAST FACE


Beta
Beta gamma
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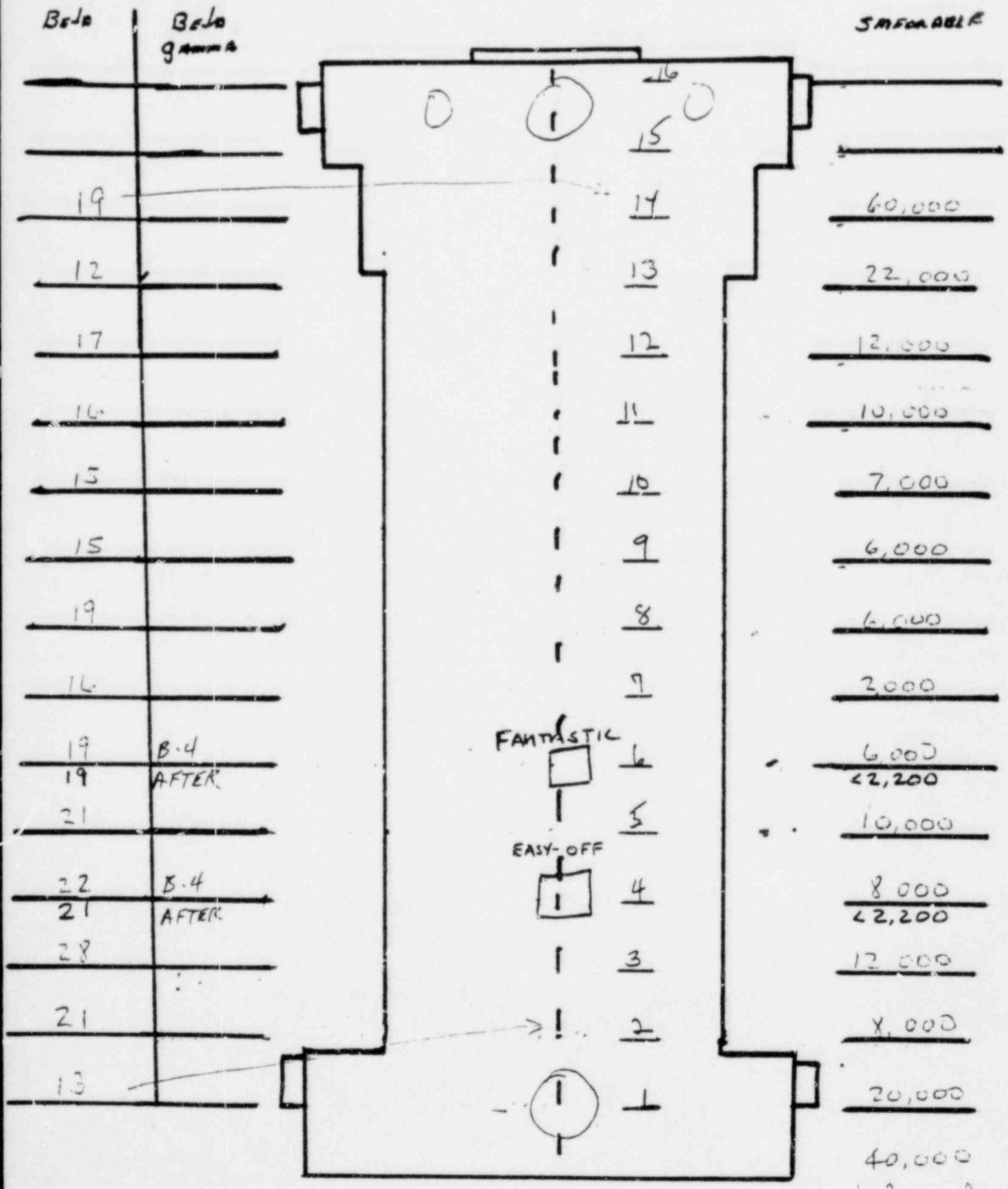
20,000
35,000
below drain.

WEST FACE


Beta
Beta gamma
SMEARABLE
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FANTASTIC
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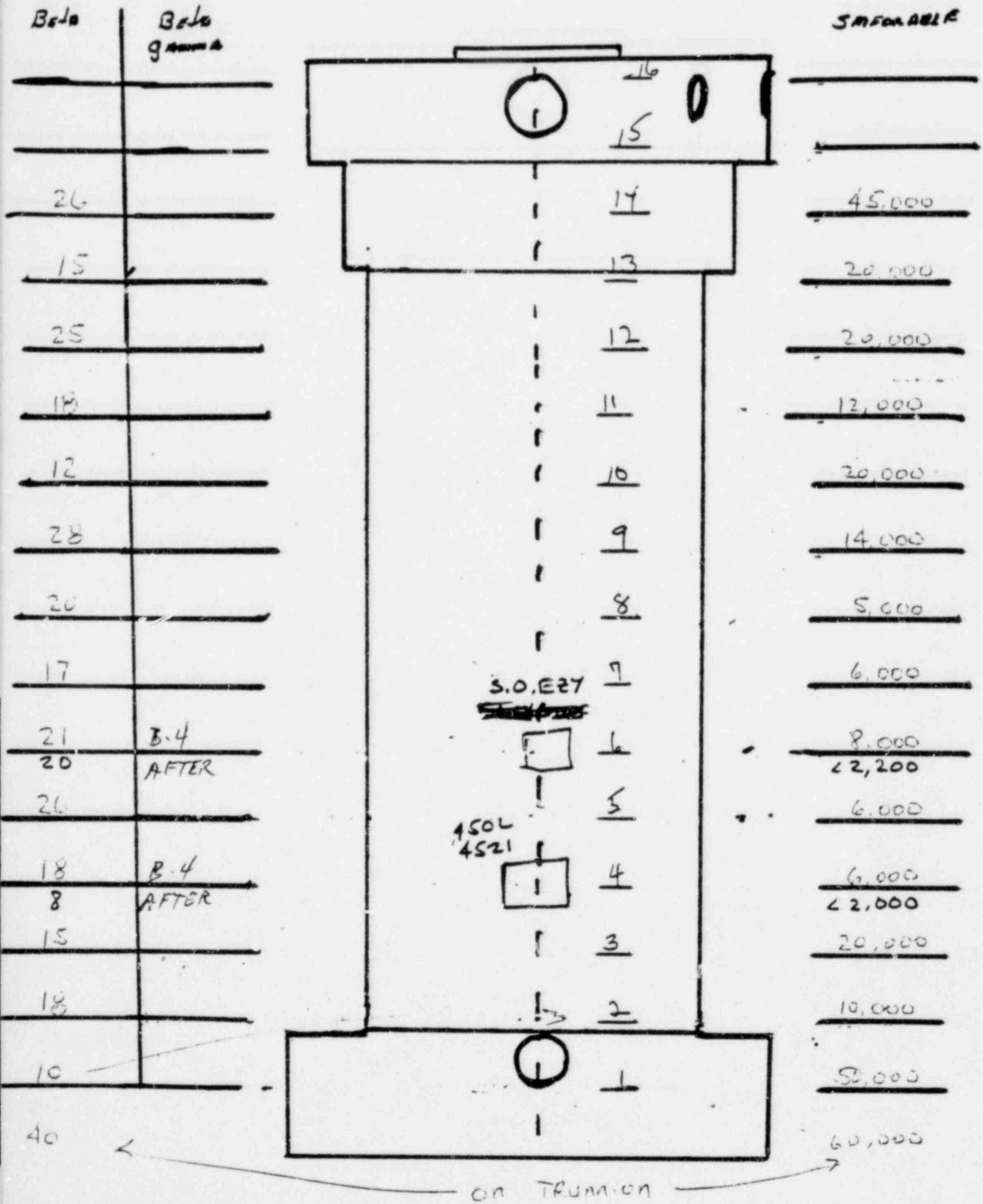
below drain

NORTH FACE


Beta
Beta gamma
SMEARABLE
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10,000
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S.O.E27
1502
4521
on TRUNNION

References

(1) Decontamination of Surfaces Contaminated with Radioisotopes: Decontamination agents, cleanability of surfaces of different kinds with the contamination with Strontium-90, Cobalt-60, Cesium-137, Iridium-192, and Thallium-204. F. Golder, T. Predmersky and O. Roka. Isotope Institute, Budapest. 1976.

(2) The Radioactive Contamination of Metal Surfaces. Graham Oldham. Nuclear Science Laboratories, University of Technology, Loughborough. 1979.

(3) On the Interaction of Cesium with Oxides of Stainless Steel. Anthony G. Warner and Robert L. Woolley, Berkeley Nuclear Laboratories, England. 1978.