RETURN TO 396-SS PDR M-39

nutech ENGINEERS

145 MARTINVALE LANE • SAN JOSE, CALIFORNIA 95119 • PHONE (408) 629-9800 • TELEX 352060

January 17, 1986
JVM-86-010

Mr. John Roberts
Project Manager
Advanced Fuel and Spent Fuel
Licensing Branch
Division of Fuel Cycle and Material Safety
United Sates Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Transmittal of Information in Support of Topical Report NUH-001

Dear John,

During our recent meeting on January 8, NUTECH committed to provide some additional information to clarify our Topical Report and response to the reviewers' questions. Most of the information is provided in this letter. The remainder will be sent by a separate letter and will contain:

- An analysis of the thermally induced bending stresses in the DSC cover plates
- Neutron dose at the HSM air vents
- Reference for dose conversion factor used in canister leakage analysis
- A check and/or re-evaluation of HSM skyshine calculations

A draft copy of proposed revisions to Chapter 11 of the Topical Report was sent by Wayne Booth of NUTECH to John Spraul on January 14th.

The cladding and HSM concrete temperature decay curves are being transmitted here as Attachment 1. The ACI 349 committee member contacted by Mohammad Shamszad in reference to allowable concrete temperatures is Thomas J. Duffy of Sargent & Lundy, 55 East Monroe St., Chicago.

add'l info
26318

The shielding information requested by the reviewers is being sent as Attachment 2. The attachment contains an ANS paper comparing the results of DOT, ANISN and QADMOD in the HSM analysis, the DOT-IV input and output for the HSM analysis, number densities in the DSC fuel region, and dose estimates for the HSM in-service inspection.

Please note that the DOT-IV I/O being submitted is for the H. B. Robinson ISFSI. It is included so that the reviewers may evaluate the HSM model used in the shielding analysis of the Topical Report.

The remaining item being submitted as Attachment 3 is a list of g loadings used in prior topical report submittals for dry storage casks. It is our intent to demonstrate that the g loads assumed in NUH-001 are reasonable and practical with existing cask impact limiter technology. In addition to the list, may I refer you to the following individuals at Sandia National Laboratory who are involved in cask and impact limiter design and evaluation:

George Allen	(505) 844-5678
Bill Uncapher	(505) 844-5678
Bob Glass	(505) 844-5678
Dick Eakes	(505) 844-5678

Should you have any questions regarding this information, please feel free to call me at (408) 281-6379.

Very truly yours,

John V Massey

John V. Massey, Ph.D.
NUHOMS Program Manager
NUTECH, Inc.

/mr

Attachments

cc: D. M. Koss (CP&L)
J. M. Rosa (NUTECH)

nutech
ENGINEERS

ATTACHMENT 1

Temperatures Versus Time

The following graphs and tables show the heat and resulting temperature decay of various components in the NUHOMS system. The calculations were done using the HEATING6 program and the same methodology as described in section 8.1.3 of the NUHOMS topical.

The maximum fuel rod cladding temperature versus time is shown in Figure 4.3 of this attachment.

The 15 months, until code temperatures are met for 100°F ambient conditions, referred to on page 8.1-48 comes from a concrete temperature decay of approximately 5.5°F/year and assuming the maximum temperature to be 207°F (this is the expected maximum temperature if the air is always 100°F and the module outer surface is cycled through 12 hours of solar heat flux and 12 hours of no solar heat flux). If the most conservative maximum temperature, 214°F (100°F ambient temperature with infinitly long solar heat flux), were used, it would take slightly over 30 months before the maximum concrete temperature would be below 200°F.

APPENDIX 1

Decay Heat

Table 1 presents the decay heat for a 15 x 15 Westinghouse Fuel Assembly with a burnup 35000 MWD/MTU. for various times after discharge (ref. 1).

Table 1
Decay Heat for a Westinghouse 15 x 15 Fuel Assembly
with a Burnup of 35000 MWD/MTU

Time After Discharge	Decay Heat (KW)
150 days	10.0
1 year	5.31
2 year	2.88
3 year	1.86
4 year	1.34
5 year	1.07
6 year	0.904
7 year	0.804
8 year	0.738
9 year	0.689
10 year	0.651

nutech
San Jose, California

PROJECT NUHOMS GENERIC DESIGN FILE NO. ADV001.0409

OWNER NUTECH INC.

CLIENT NUTECH INC.

In order to predict the decay heat at 15 years after discharge a curve taking the following form

$$P = a t^{b} \qquad \text{(Eq 1)}$$

was developed based on the data in table 1. Using a curve fitting routine on an HP-11C Owner's Handbook (Ref 10) were determined

$a = 4.866$

$b = -0.902$

$r^2 = 0.995$

$$P = (4.866)\, t^{-0.902} \qquad \text{(Eq 2)}$$

Table 2 presents the actual and calculated decay heat rates using Eq 1

Table 2

Time After Discharge	Calculated Decay Heat (kw)	Actual Decay Heat (Kw)	% Error
150 days	10.85	10.0	8.5
1	4.87	5.31	8.4
2	2.60	2.88	9.6
3	1.81	1.86	2.9
4	1.39	1.34	5.4
5	0.94	1.07	12.1
6	0.97	0.904	6.9
7	0.84	0.804	4.6
8	0.746	0.738	1.1
9	0.670	0.689	2.7
10	0.610	0.651	6.3
15	0.423	—	—

REVISION	0					PAGE 34
PREPARED BY/ DATE	BWF/10-21-85					OF 34
CHECKED BY/ DATE	JRB/10-23-85					

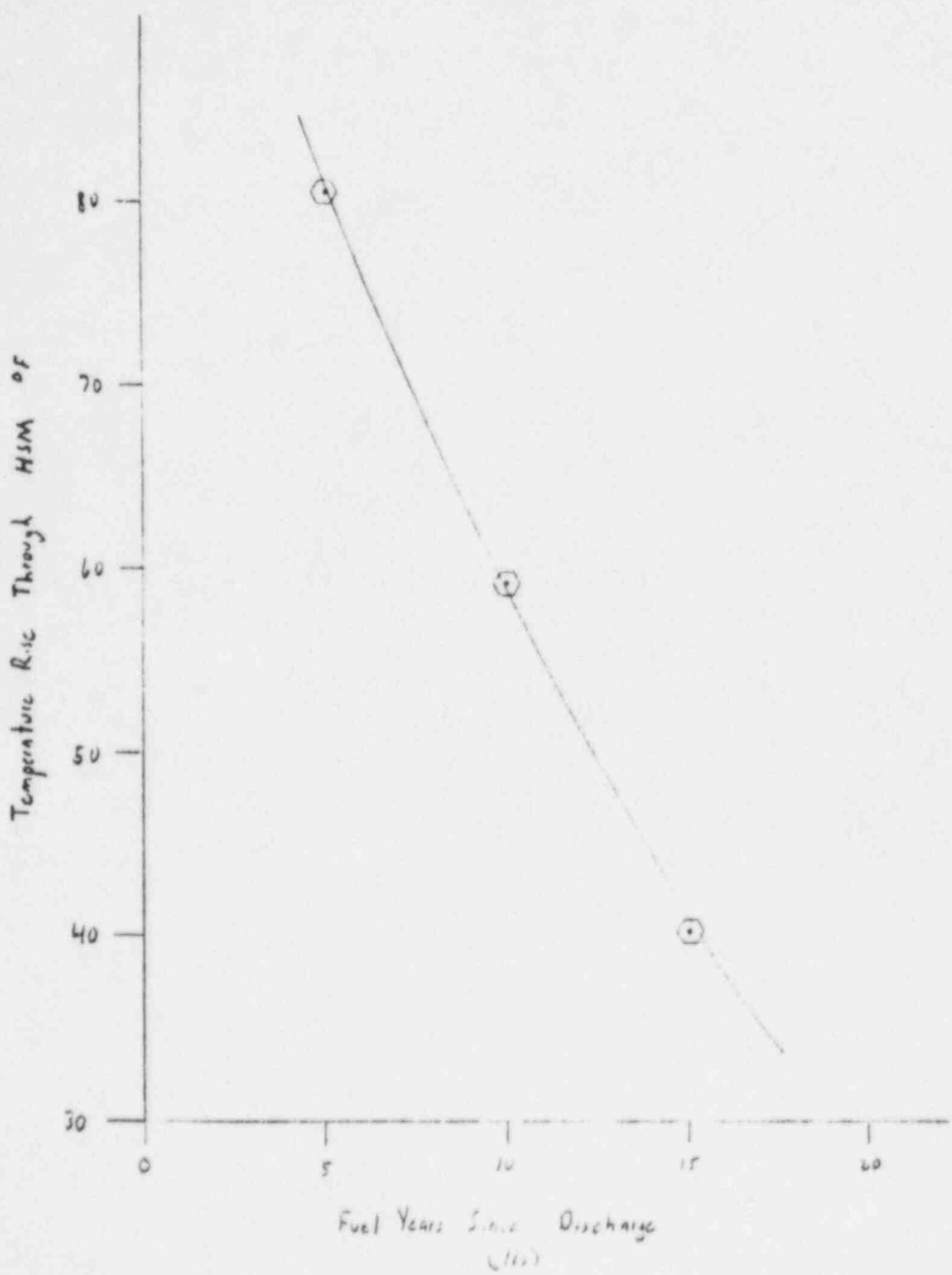
nutech
San Jose, California

PROJECT NUHOMS GENERIC DESIGN FILE NO. ADV001.0409

OWNER NUTECH INC.

CLIENT NUTECH INC.

Fig 4.2
Air Temperature rise through HSM Vs Years Since Discharge
(70°F Ambient Temperature)



REVISION	0					PAGE 28
PREPARED BY/ DATE	[illegible]/10-23-85					OF 34
CHECKED BY/ DATE	JKB/10-23-85					

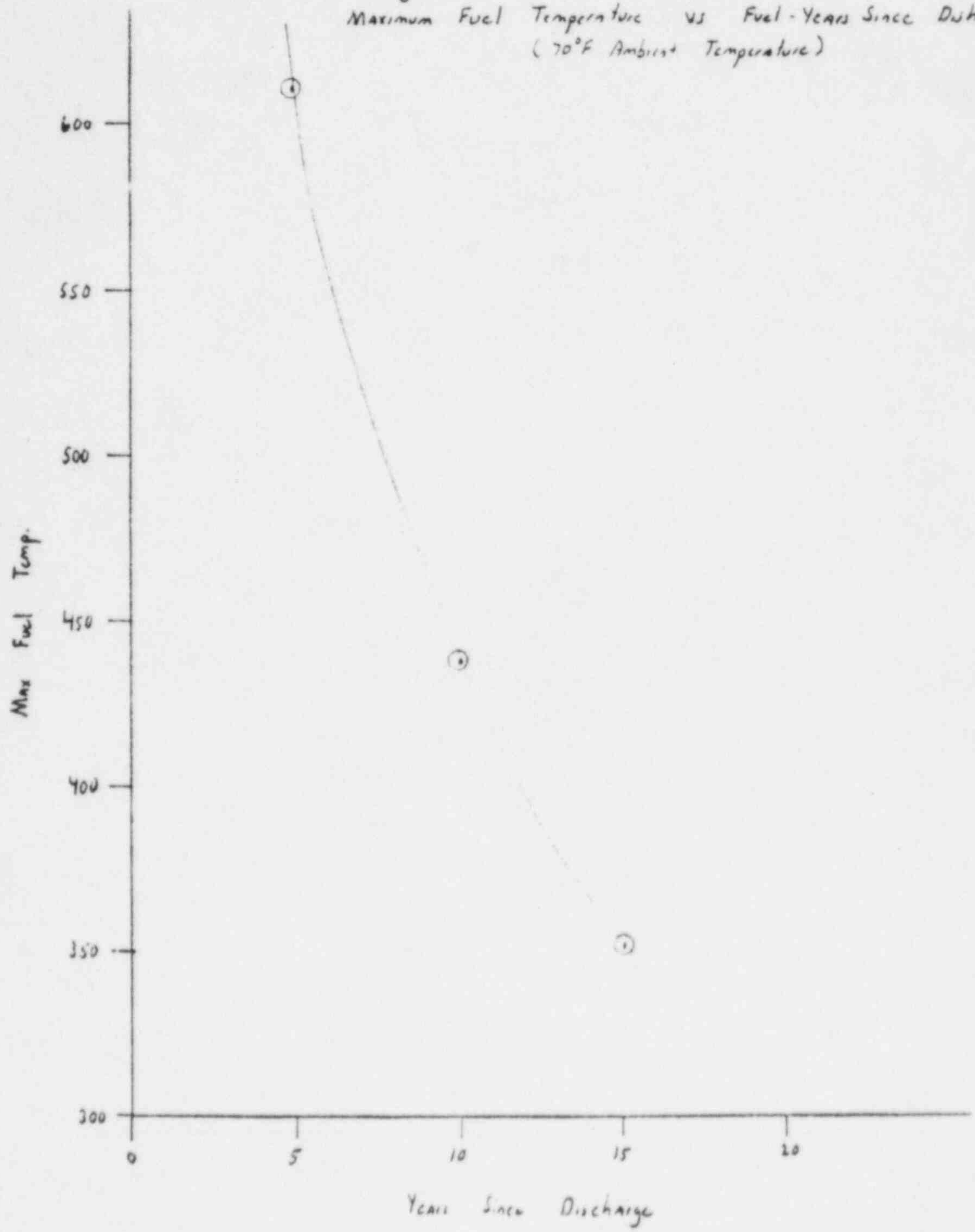
nutech
San Jose, California

PROJECT NUHOMS GENERIC DESIGN FILE NO. ADV001-0409

OWNER NUTECH INC.

CLIENT NUTECH INC.

Fig 4.3
Maximum Fuel Temperature vs Fuel-Years Since Discharge
(70°F Ambient Temperature)



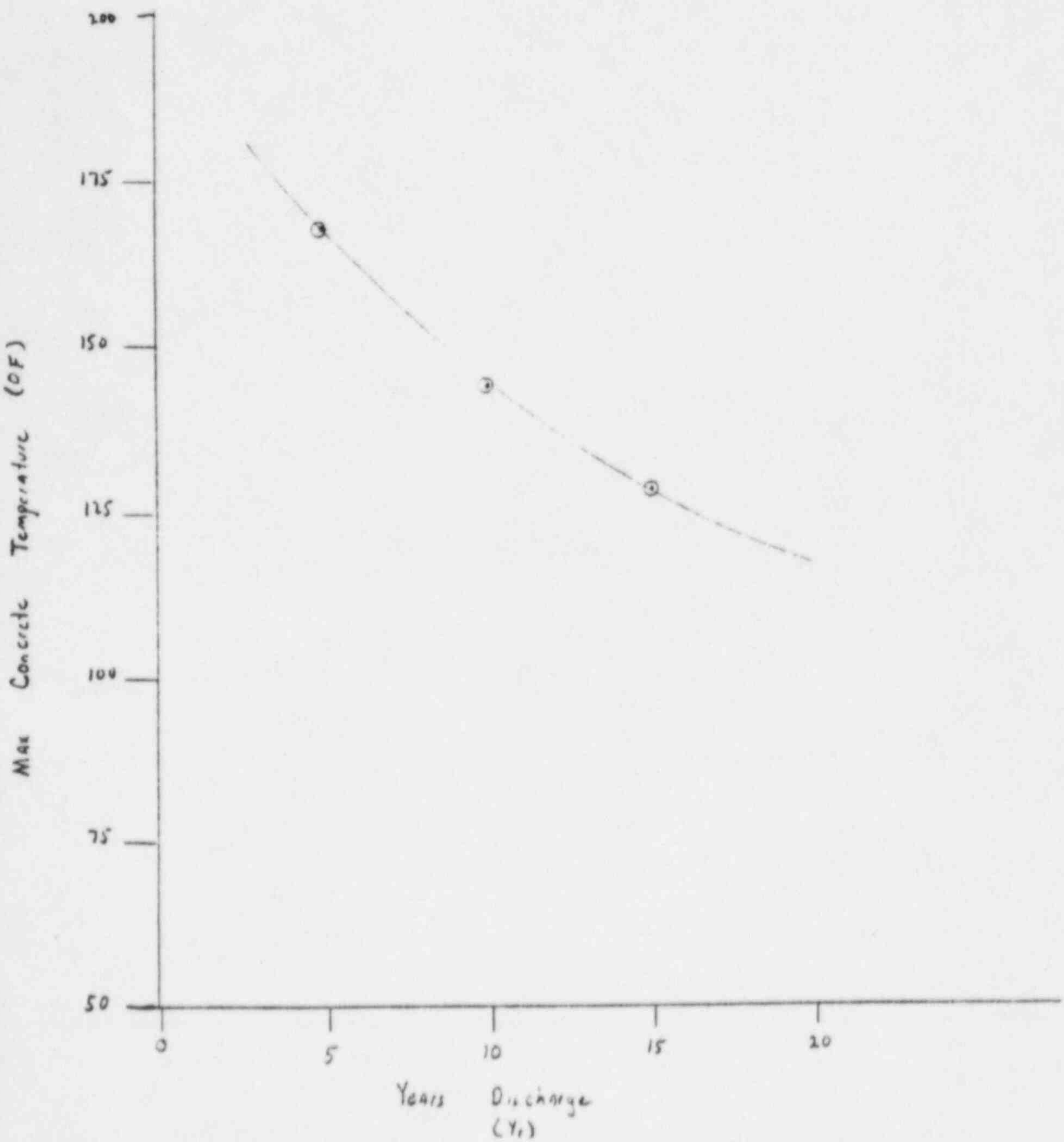
REVISION	0					PAGE 25
PREPARED BY/ DATE	[illegible]					OF 34
CHECKED BY/ DATE	JRB 10-23-85					

PROJECT NUHOMS GENERIC DESIGN FILE NO. ADV001 .040

OWNER NUTECH INC.

CLIENT NUTECH INC.

Fig 4.4
Max Concrete Temp vs Year Discharge
(70° Ambient)



REVISION	0					PAGE 30
PREPARED BY/ DATE	DWE/10-21-85					OF 34
CHECKED BY/ DATE	JKB/ 10-23-85					

nutech
San Jose, California

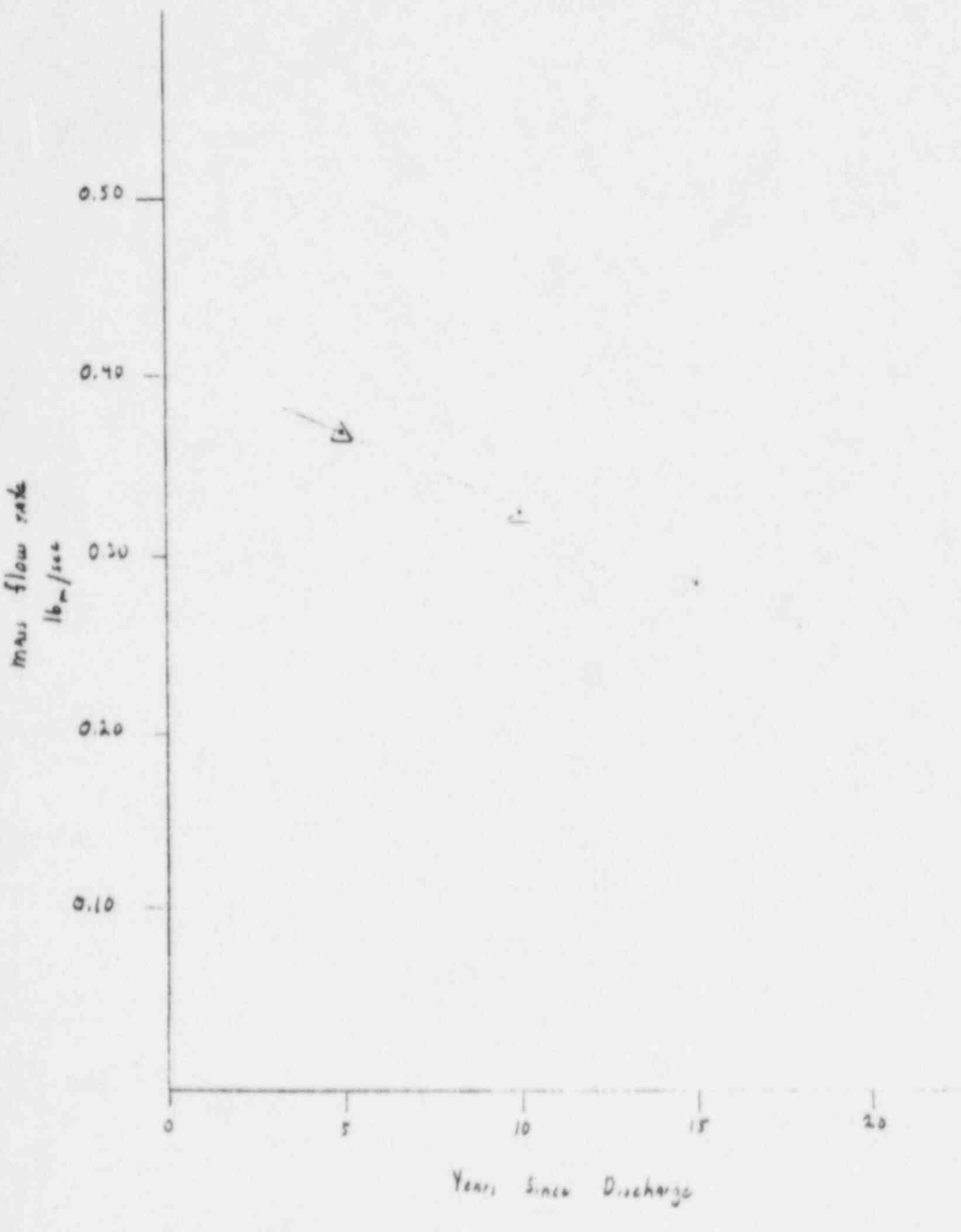
PROJECT NUHOMS GENERIC DESIGN FILE NO. ADV001-409

OWNER NUTECH INC.

CLIENT NUTECH INC.

Fig 4.5

Mass Flow Rate Through HSM Vs Years Since Discharge
(70°F Ambient Temperature)



REVISION	0				
PREPARED BY/ DATE	[illegible]/10-21-85				
CHECKED BY/ DATE	JKB/10-23-85				

Attachment 2

- ANS Paper "Shielding Calculation Techniques Used in the Design of Fuel Storage Systems"

- GIP/DOT Input

- Fuel Region Number Densities

- HSM In-Service Inspection Dose Estimates

SHIELDING CALCULATION TECHNIQUES USED IN THE DESIGN OF FUEL STORAGE SYSTEMS

Sylvia S. Wang and John V. Massey

INTRODUCTION

The NUTECH Horizontal Modular Storage (NUHOMS[1]) System is an independent irradiated fuel storage installation designed to store irradiated fuel in a safe dry environment. It is a modular dry storage facility consisting of a dry shielded canister (DSC), a concrete horizontal storage module (HSM), an on-site transfer cask, a cask skid and trailer, and a hydraulic ram. Figure 1 shows a typical system. All the components in the storage system have a design life of 50 years or more. The canister shown in Figure 2 is approximately 3 feet in diameter. It is a half-inch thick steel shell with an internal basket designed to hold 7 PWR spent fuel assemblies. Both ends of the canister are shielded by a 2-inch thick steel closure plate and a 5-inch thick lead shield plug. The HSM are built in units. A typical eight-module unit (four by two back-to-back unit) would hold a year's fuel discharge from a typical reactor. The shield walls (at the front, sides and roof of the unit) are 3.5 feet thick, reinforced concrete.

This paper describes the shielding calculations used in the design of the NUHOMS system. The radiation source strength and the various geometries analyzed are discussed. A comparison of the major analyses methods (i.e. hand calculations, point kernal with buildup, one-dimensional transport and two-dimensional transport) is also provided.

Radiation Source

The neutron and gamma radiation sources include the design basis pressurized water reactor (PWR) irradiated fuel, activated

portions of the fuel assembly, and secondary gammas produced by neutrons passing through the shielding materials. All sources, except secondary gammas, are considered physically bound in the source region.

The design basis PWR irradiated fuel has been subjected to 880 full power days at an average specific power of 37.5 MW(t)/MTHM resulting in an average fuel burnup of 33,000 MWd/MTHM. The initial enrichment is 3.2 weight percent (w/o) ^{235}U, and a post irradiation time of five years is assumed. Fuel which meets these criteria are bounded by the sources used in this analysis. Any other combination of irradiation time, burnup, specific power, enrichment, and post-irradiation time is acceptable, provided the gamma and neutron radiation source criteria are satisfied.

Neutron sources are based on spontaneous fission contributions from ^{244}Cm and ^{242}Cm isotopes, and (α, n) reactions with the oxygen in the irradiated fuel. The fission spectrum used in shielding calculations is that of ^{235}U. The total neutron source strength for the seven fuel assemblies contained in the DSC is 9.98×10^8 neutrons per second (obtained from ORIGEN2[2] calculations).

Gamma radiation sources include 70 principal fission product nuclides within the irradiated fuel, and several activation products and actinide elements present in the irradiated fuel and fuel assemblies. The gamma energy spectrum includes contributions from each source isotope as determined by the ORIGEN2 computer code for the design basis irradiated fuel. The total gamma source strength for the seven fuel assemblies in each DSC is 1.67×10^{16} MeV per second. The 8-group gamma energy spectrum is presented in Table 1.

Shielding Analysis

Radiation shielding analysis were performed on the system to provide adequate protection and keep the radiation dose rates as low as reasonably achievable. Various computational techniques were applied in the analysis and the results are compared in order to verify the radiation safety of the system.

Three particular computer codes were used extensively in the shielding design. The one-dimensional discrete ordinates code ANISN[3], is used for scoping study. The point-kernal gamma shielding code QADMOD[4] is also used for scoping study, especially at locations where appropriate 3-dimensional geometric approximation is required. The 2-dimensional transport code DOT[5] is applied for final verification.

The areas which were analyzed are shown in Figure 3. Centerline dose rates through the concrete walls (location 1), the HSM door (location 4) and along the DSC centerline (location 5 and 2.1) were used to asses the overall effectiveness of the bulk shielding. Calculation of the dose rates at points 3, 6, and 2.2 was done in order to assess the radiation reflections and streaming through the various gaps and penetrations in the shielding.

Design Calculations In the preliminary, conceptual design of the NUHOMS system, hand calculations using point and slab source geometries were performed to define the material thicknesses required to reduce dose rates to an acceptable level. Table 2 shows the locations, dose rate criteria and the material thickness which resulted from the preliminary hand calculations.

This preliminary design underwent simultaneous mechanical, structural and nuclear analyses and was modified to meet the sometimes conflicting design criteria of the three disciplines. Inexpensive (compared to multidimensional transport and Monte

Carlo techniques) calculations using the QADMOD and ANISN shielding codes was performed to finalize the materials, thickness and the penetration designs (see Table 3 results). These analyses provided the acceptability (from a shielding and radiation protection point of view) of the mechanical-structural design of the DSC and HSM.

In addition to the direct, bulk shielding calculations the ANISN and QADMOD results were used in conjunction with hand albedo calculations to conservatively estimate the doses at the HSM air inlet and exit penetrations and the top surface of the DSC inside the cask at the DSC-cask gap.

Comparison of DOT, ANISN and QADMOD Calculations for A NUHOMS Test Unit

Of particular interest are the shielding calculations performed on the DSC-HSM model (Figure 4) which represents a NUHOMS test and demonstration unit. The shield plug at the end of the canister has two cut-off edges to accommodate a site specific cask. This problem was modeled with QADMOD, ANISN, and DOT-IV to examining the radiation dose at the surfaces of the module and the canister.

In the DOT model, cylindrical coordinates were used with reflected boundary conditions assumed at the midplane of the module and at the centerline of the canister (to simulate the symmetric system (Figure 5)). Macroscopic cross-section data were prepared by the Group-Organized Cross Section Input Program[4] using the Bugle-80 library[6] data. The seven irradiated fuel assemblies inside the canister were modeled as a homogenized cylindrical source region with the diameter approximating the outside surface of the fuel assemblies. A $S_{10}P_3$ approximation with unbiased angular quadrature set was used to obtain the neutron and gamma fluxes at the HSM roof and the DSC end shield.

Fifty-six fine mesh points were assigned axially with mesh spacing no more than 1.14 cm near the vicinity of the duct opening in order to scrutinize localized streaming effect.

The ANISN code was used at the S_8P_3 level in conjunction with the flux-and-dose-rate calculation module XSDOSE[7] to estimate the radiation doses at detectors A, B, E, F and G. For detectors A and B, a cylindrical source is assumed in ANISN to calculate the angular flux emanating from the concrete surface, then XSDOSE performs a numerical integration over the finite cylindrical surface to obtain scalar fluxes and dose rates at the points of interest. For detectors E and F, an ANISN calculation using slab geometry along the axis of the canister was done first, then the angular flux distribution on the top boundary of the shield plug was used in the XSDOSE integration over the circular disc as seen on the top view of the DSC. Figure 6 illustrated these two models.

In the QADMOD approach, the DSC-HSM system was modeled with Cartesian coordinates. The geometric interpretation of this model is the most realistic compared with the other two approaches.

Results of the shielding calculations using these three computer programs are given in Table 4. The gamma and neutron dose rates along the centerline of the module roof are plotted in Figures 7 and 8 respectively.

As expected, at points away from the air exhaust duct, the radiation dose on the roof surface was treated satisfactorily by all methods. The lower concrete density applied in the QADMOD (2.3 g/cc vs. 2.46 g/cc in DOT) could be part of the reason that the QADMOD result is higher at detector A.

The neutron dose outside the canister surface at detector G shows satisfactory agreement between the DOT and ANISN calculations.

The QADMOD result of gamma dose rate at the air exhaust slot opening (detector C) includes both a direct attenuation component (200 mrem/hr) and a first-order reflected component calculated by the albedo method (1400 mrem/hr). It is lower than the DOT result for two reasons: 1) multiple surface reflection was not included in the QADMOD calculation, 2) the DOT model treats the slot penetration as circumferential whereas QADMOD model illustrates the real slot size as 4" x 36".

Near the module front opening and at the canister end shield, scattering from the module interior concrete wall contributes significantly to the dose level at the shield plug surfaces (detectors E and F), underestimations of both QADMOD and ANISN are evident.

Summary

In summary, hand calculation estimations provide conservative preliminary shielding design for the NUHOMS system. Final analyses by various computer programs verify that the radiation level at any surface of the system is within 10 CFR72 limits. Agreement of data by different computational techniques further justify the validity of calculation results in the NUHOMS shielding analysis.

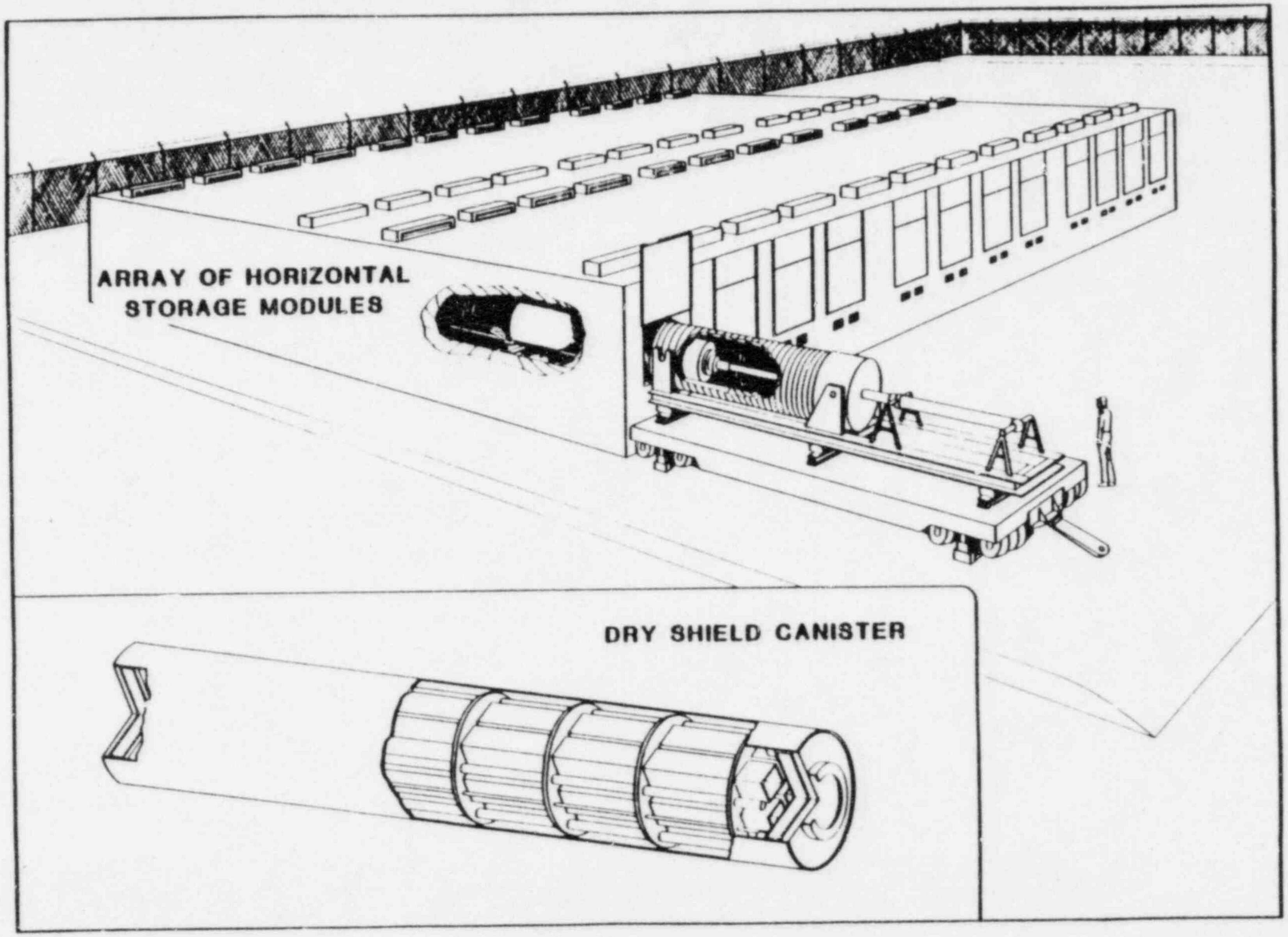


FIGURE 1
NUTECH HORIZONTAL MODULAR STORAGE
SYSTEM FOR IRRADIATED FUEL

NUHOMS

nutech

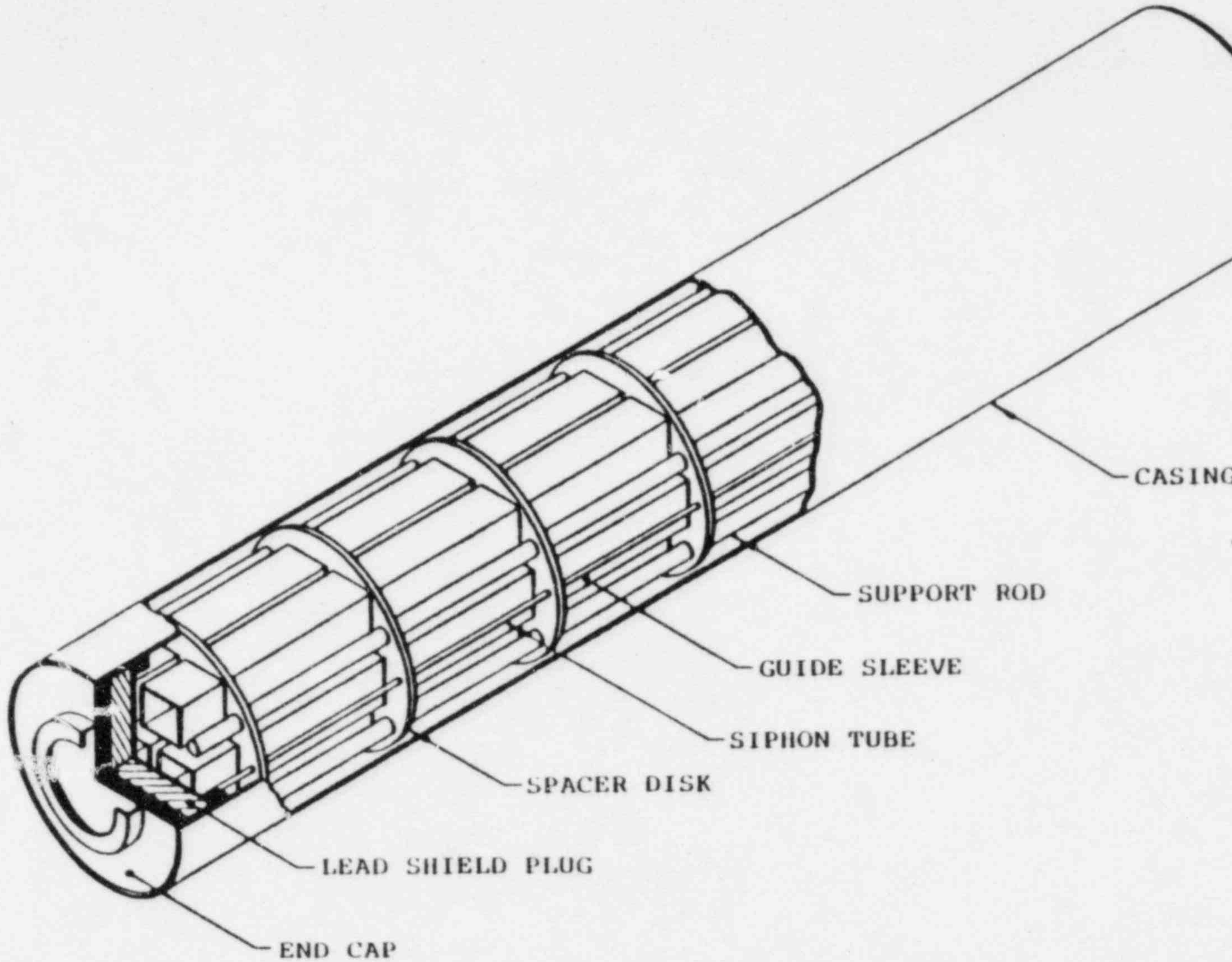


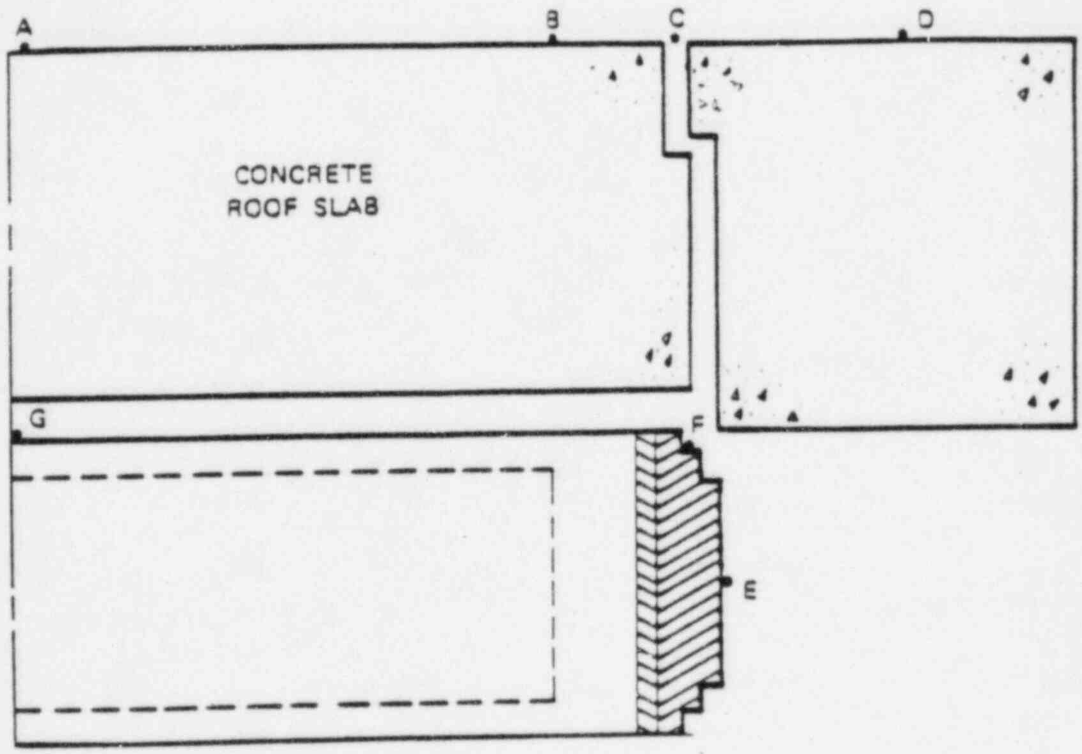
Figure 2

<u>DRY SHIELDED CANISTER</u>
<u>AND INTERNAL BASKET</u>
<u>OF THE NUHOMS SYSTEM</u>

Table 4

SHIELDING ANALYSIS RESULTS

DETECTOR	GAMMA DOSE RATE (mrem/hr)			NEUTRON DOSE RATE (mrem/hr)	
	DOT – IV	QADMOD	ANISN	DOT – IV	ANISN
A	4.7 + 0	8.0 + 0	3.3 + 0	3.9 - 2	2.3 - 2
B	3.7 + 0	3.3 + 0	1.6 + 0	3.4 - 2	1.2 - 2
C	4.5 + 3	1.6 + 3	–	2.9 + 0	–
D	3.2 + 0	2.0 + 0	–	2.0 - 2	–
E	8.5 + 2	3.5 + 1	8.0 + 0	4.1 + 2	2.3 + 1
F	4.8 + 4	3.1 + 4	5.9 + 3	5.7 + 2	4.0 + 1
G	3.2 + 7	2.2 + 7	1.9 + 7	3.1 + 3	3.0 + 3



REFERENCES

1. NUTECH Inc., "The Topical Report for the NUTECH Horizontal Modular Storage System for Irradiated Fuel," NUH-001 (DocketM-39) NUTECH Inc., San Jose, Ca (1984)

2. ORNL, "ORIGEN2-Isotope Generation and Depletion Code - Matrix Exponential Method" CCC-371, ORNL (1982)

3. ORNL, "ANISN-ORNL: A One-Dimensional Discrete Ordinates Transport Code with Anisotropic Scattering," CCC-254, ORNL (1977)

4. J. H. Price and W.G.M. Blattner, "Utilization Instructions for QADMOD-G" RRA-N7914, Radiation Research Associates (1979)

5. W. A. Rhoades and R. L. Childs, "An Updated Version of the DOT 4 One-and-Two Dimensional Neutron/Photon Transport Code" ORNL-5851, Oak Ridge National Laboratory (1982)

6. ORNL, "RSIC Data Library Collection-Bugle-80 Cross Section" DLC-75, ORNL (1980)

7. J. A. Bucholz, "XSDOSE: A Module for Calculating Fluxes and Dose Rates at Points Outside a Shield" NUREG-CR-0200, DOE (1983)

```
     CPL HSM CROSS SECTION (GAMMA + NEUTRON)
     1$$    67     3     4    70    80     0    44    68     0     3
             2     2     2    60 E T
     10$$   45    46    47    48    45    46    47    48    45    46
        47    48    45    46    47    48    45    46    47    48
        45    46    47    48    45    46    47    48    45    46
        47    48    45    46    47    48    49    50    51    52
        49    50    51    52    49    50    51    52    53    54
        55    56    53    54    55    56    57    58    59    60
        57    58    59    60    61    62    63    64    61    62
        63    64    65    66    67    68    65    66    67    68
     11$$    0     0     0     0     1     2     3     4     5     6
         7     8     9    10    11    12    13    14    15    16
        17    18    19    20    21    22    23    24    25    26
        27    28    29    30    31    32     0     0     0     0
         5     6     7     8    37    38    39    40     0     0
         0     0    29    30    31    32     0     0     0     0
        29    30    31     32    0     0     0     0    41    42
        43    44     0     0     0     0    33    34    35    36
     12** 0.           0.           0.           0.           1.2483E-04
       1.2483E-04  1.2483E-04  1.2483E-04  6.7807E-03  6.7807E-03
       6.7807E-03  6.7807E-03  3.9871E-04  3.9871E-04  3.9871E-04
       3.9871E-04  1.3561E-03  1.3561E-03  1.3561E-03  1.3561E-03
       2.0438E-05  2.0438E-05  2.0438E-05  2.0438E-05  3.2011E-03
       3.2011E-03  3.2011E-03  3.2011E-03  1.6046E-04  1.6046E-04
       1.6046E-04  1.6046E-04  4.6444E-02  4.6444E-02  4.6444E-02
       4.6444E-02  0.          0.          0.          0.
       1.0617E-05  1.0617E-05  1.0617E-05  1.0617E-05  3.9573E-05
       3.9573E-05  3.9573E-05  3.9573E-05  0.0000E+00  0.0000E+00
       0.0000E+00  0.0000E+00  1.4648E-01  1.4648E-01  1.4648E-01
       1.4648E-01  0.0         0.0         0.0         0.0
       1.0         1.0         1.0         1.0         0.0
       0.0         0.0         0.0         3.3515E-02  3.3515E-02
       3.3515E-02  3.3515E-02  0.0         0.0         0.0000E+00
       0.0000E+00  1.0000E+00  1.0000E+00  1.0          1.0
     13$$    5     6     7     8     9    10    11    12    21    22
        23    24    29    30    31    32    33    34    35    35
        37    38    39    40    41    42    43    44    89    90
        91    92    93    94    95    96   113   114   115   116
       185   186   187   188
       T

GIP    CRAY VERSION
```

```
GIP    CRAY VERSION
```


GIP Input

```
        BOEING COMPUTER SERVICES / NUCLIB        D O T 4 . 3      O R N L                EL2.22   B2J9
11/04/85  09:39:18 PAGE      1
                                         BCS CERTIFIED VERSION   1.01     CRAY     12/17/84
                                                      LISTING OF INPUT DATA

                  1111111111222222222233333333334444444444555555555566666666667777777778
         1234567890123456789012345678901234567890123456789012345678901234567890123456789 0

         HSM FRONT & ROOF DOSE(GAMMA + NEUTRON)
         61$$      0    0    8    0    2    0    0    0    0    0    0  E
         62$$      0    3  108   42   56   67    3    4   70    0
            0   24   24    0   70    1    1    0    1    0
           20   20    0    4    0    2    0    0    0    3
            0    0    0    0    0    0    0    0    1    0
            0    0   90    0    0    8    1    1    1    1
            4   50    2    0    0    0    0    0    0    0
            0   -1
         F0  E
         63**  1.0000E+10  0.            1.0000E-03  1.0000E-02  1.0000E-02
           1.0000E-02  1.0000E+00  0.           0.           0.
           0.          0.          0.           0.           0.
           1.0000E-01  1.0000E-04  0.           0.           0.
           1.0000E+00  6.0000E-01  0.           0.3            -1.5
           0.000         0.2         0.9
         F0  E
          T
           T
         81**
          0.000000000  .023001178  .023001178 0.000000000  .017467664  .017467664
           .017467664  .017467664 0.000000000  .012345683  .013051145  .012345683
           .012345683  .013051145  .012345683 0.000000000  .017467664  .013051145
           .013051145  .017467664  .017467664  .013051145  .013051145  .017467664
          0.000000000  .023001178  .017467664  .012345683  .017467664  .023001178
           .023001178  .017467664  .012345683  .017467664  .023001178 0.000000000
           .023001178  .023001178 0.000000000  .017467664  .017467664  .017467664
           .017467664 0.000000000  .012345683  .013051145  .012345683  .012345683
           .013051145  .012345683 0.000000000  .017467664  .013051145  .013051145
           .017467664  .017467664  .013051145  .013051145  .017467664 0.000000000
           .023001178  .017467664  .012345683  .017467664  .023001178  .023001178
           .017467664  .012345683  .017467664  .023001178
         82**
          -.272165542 -.192450100  .192450100 -.544331058 -.509175078 -.192450100
           .192450100  .509175078 -.720082301 -.693888665 -.509175078 -.192450100
           .192450100  .509175078  .693888665 -.860662965 -.838870490 -.693888665
          -.509175078 -.192450100  .192450100  .509175078  .693888665  .838870490
          -.981306761 -.962250445 -.838870490 -.693888665 -.509175078 -.192450100
           .192450100  .509175078  .693888665  .838870490  .962250445 -.272165542
          -.192450100  .192450100 -.544331058 -.509175078 -.192450100  .192450100
           .509175078 -.720082301 -.693888665 -.509175078 -.192450100  .192450100
           .509175078  .693888665 -.860662965 -.838870490 -.693888665 -.509175078
          -.192450100  .192450100  .509175078  .693888665  .838870490 -.981306761
          -.962250445 -.838870490 -.693888665 -.509175078 -.192450100  .192450100
           .509175078  .693888665  .838870490  .962250445
         83**
          -.962250445 -.962250445 -.962250445 -.838870490 -.838870490 -.838870490
          -.838870490 -.838870490 -.693888665 -.693888665 -.693888665 -.693888665
          -.693888665 -.693888665 -.693888665 -.509175078 -.509175078 -.509175078
          -.509175078 -.509175078 -.509175078 -.509175078 -.509175078 -.509175078
```

DOT Input

```
  -.192450100 -.192450100 -.192450100 -.192450100 -.192450100 -.192450100
  -.192450100 -.192450100 -.192450100 -.192450100 -.192450100  .962250445
   .962250445  .962250445  .838870490  .838870490  .838870490  .838870490
   .838870490  .693888665  .693888665  .693888665  .693888665  .693888665
   .693888665  .693888665  .509175078  .509175078  .509175078  .509175078
   .509175078  .509175078  .509175078  .509175078  .509175078  .192450100
   .192450100  .192450100  .192450100  .192450100  .192450100  .192450100
   .192450100  .192450100  .192450100  .192450100
   T
2**  0.     13.998   27.996    41.994    55.992    69.99
       83.988      97.986     111.984      125.982      139.98
       147.13     154.280     161.430     168.580     175.730
       182.88    186.69      190.50       193.04     194.183
       195.326       196.469      197.612      198.755  199.23125
     199.7075    200.18375     200.66    201.13625     201.6125
     202.08875   202.565   203.04125   203.5175    203.99375
     204.47      205.105    205.74    206.375     207.01
     207.645   208.28     208.915   209.55    210.185
     210.82    221.488    232.156   242.824   253.492
     264.16    274.828    285.496  296.164   306.832  317.50
4**  0.          3.80         7.60          11.40          15.20          19.0
      22.80          26.60          26.773         30.946       33.119
       35.292      37.465          38.735      39.667         40.599
        41.531       42.463         43.395       44.03          44.8115
          45.593         46.863         48.26       54.61      60.96
        67.0983      73.2367      79.375      85.5133      91.6517
        97.79       103.9283    110.0667    116.205      122.3433
        128.4817      134.62       139.70      144.78       152.40
        160.02       167.64
8$$
     7R     1     5R     2     1R     3     5R     4     1R     5
     2R     6     1R     7     1R     8     2R     9    12R    10
     2R    11     3R    12
     9Q    42
     7R    13     5R    14     1R    15     5R    16     1R    17
     2R    18     1R    19     1R    20     2R    21    12R    22
     2R    23     3R    24
     5Q    42
     7R    25     5R    26     1R    27     5R    28     1R    29
     2R    30     1R    31     1R    32     2R    33    12R    34
     2R    35     3R    36
     1Q    42
     7R    37     5R    38     1R    39     5R    40     1R    41
     2R    42     1R    43     1R    44     2R    45    12R    46
     2R    47     3R    48
     7R    49     5R    50     1R    51     5R    52     1R    53
     2R    54     1R    55     1R    56     2R    57    12R    58
     2R    59     3R    60
     4Q    42
     7R    61     5R    62     1R    63     5R    64     1R    65
```

```
        2R   66    1R   67    1R   68    2R   69   12R   70
        2R   71    3R   72
        3Q   42
        7R   73    5R   74    1R   75    5R   76    1R   77
        2R   78    1R   79    1R   80    2R   81   12R   82
        2R   83    3R   84
        7Q   42
        7R   85    5R   86    1R   87    5R   88    1R   89
        2R   90    1R   91    1R   92    2R   93   12R   94
        2R   95    3R   96
        9Q   42
        7R   97    5R   98    1R   99    5R  100    1R  101
        2R  102    1R  103    1R  104    2R  105   12R  106
        2R  107    3R  108
        9Q   42
  9$$    1   1   1   1   1   5  13   5   5  21  21  21
       1   1   1   1   1   5  13   5   5  21  21  21
     9   9   9   9   9   5  13   5   5  21  21  21
       9   9   9   9   9   5  13   5   5  21   5   5
      13  13  13  13  13  13  13   5   5  21   5   5
      17  17  13  17  17  17  13   5   5  21   5   5
     17  17  13  17  13   5   5   5   5   5   5  21
      17  17  13   5   5   5   5   5   5   5   5  21
       5   5   5   5   5   5   5   5  21  21  21  21
    T
  96**
     19R  1.0000E+00  F0.0 T
  97**
     16R  1.0000E+00  F0.0 T
  98**
    2.0323E-02  8.8971E-02  5.3095E-01  1.2596E-00  2.8683E+00
    7.9472E+00  1.6127E+01  4.2169E+01  3.9963E+01  2.2026E+01
    2.3613E+01  1.0095E+01  2.0941E-00  1.2973E+01  3.7378E+01
    3.7297E+01  4.6654E+01  6.0684E+01  3.2949E+01  1.4566E+01
    2.5214E+01  2.0232E+01  2.2783E+01  1.1947E+01  1.7057E+01
    8.9793E-00  4.4049E+00  4.0899E-00  0.          0.
    0.          0.          0.          0.          0.
    0.          0.          0.          0.          0.
    0.          0.          0.          0.          0.
    0.          0.          2.9192E-01  0.          0.
    2.5412E-00  0.          2.2047E+01  2.2803E+04  5.1472E+06
    1.1191E+07  6.0255E+08  1.5258E+09  0.          0.
    7.0406E+09  7.2169E+08  5.4910E+08  5.3236E+08  1.8915E+09
    9.9201E+08  4.1250E+09
   F0.0 T
        END
```

DOT Input, cont.

FUEL REGION NUMBER DENSITIES

	Atom Density (atoms/b-cm)	
Material	Generic Design	Site Specific Design
U-235	1.1748-4*	2.0438-5
U-238	3.5089-3	3.2011-3
O-16	7.2528-3	6.7807-3
Fe-56	-	3.9871-4
Zr-90	1.9495-3	1.3561-3
B-10	-	1.2483-4
C12	-	1.6046-4
Steel 304	0.05369**	0.04644**

* 1.1748×10^4

** Density Factor (unitless)

Estimated Yearly On-Site Doses for
HSM In-Service-Inspection Program
(Addition to Table 7.4-1):

Daily Inspection*:	No. of Personnel	1
	Time (hrs)	60
	Ave. Dist. (ft)	4
	Dose Rate (mrem/hr)	2
	Dose/Person (mrem)	120
	Total Dose (mrem)	120
Annual Inspection:	No. of Personnel	1
	Time (hrs)	0.5
	Ave. Dist. (ft)	1.5
	Dose Rate (mrem/hr)	3.7
	Dose/Person (mrem)	5.6
	Total Dose (mrem)	5.6

* 365 days/year at 10 min./day

Attachment 3

G-Loads in Postulated Drop Accidents
Submitted in Dry Storage Cask Topical Reports

Nuclear Assurance Corporation
NAC S/T Cask defines 55 g as drop impact.

Westinghouse MC-1J cask has several different drop configurations. Maximum acceleration of cask is 104 g in a horizontal drop without impact limiters. In this drop, basket acceleration is 55 g.

REA 2023 cask uses a redwood mat for impact limitation. Acceleration is 16.3 g vertical and 26 g in the horizontal drop.

Table 1

SOURCE TERM FOR SHIELDING ANALYSIS

GAMMA SOURCE:

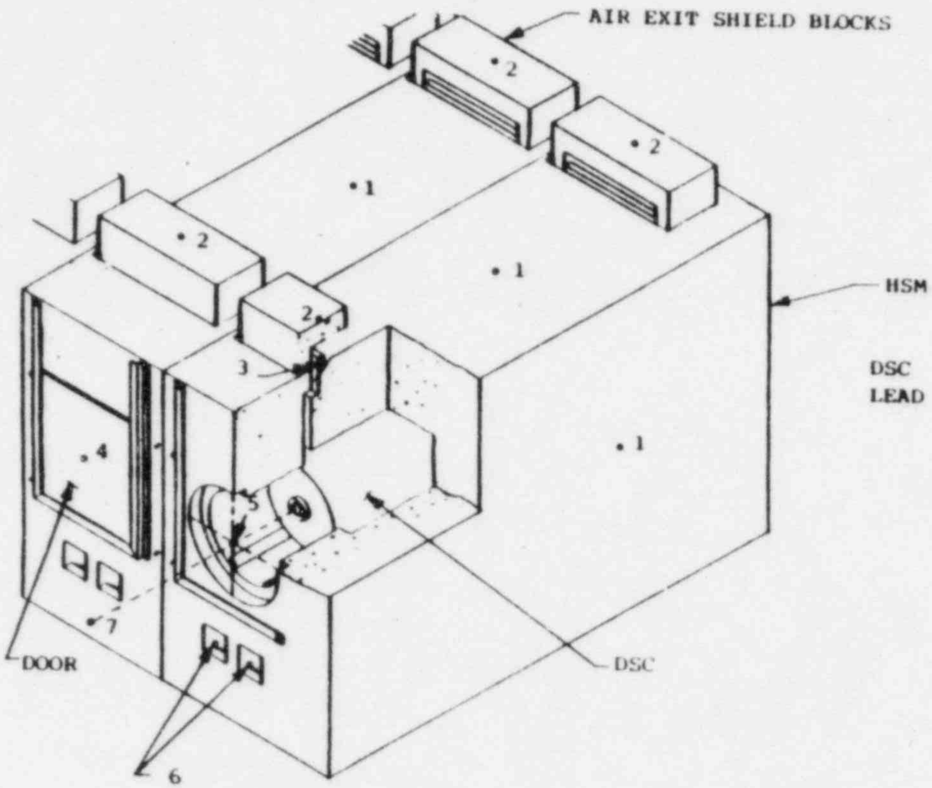
5.43 + 16 photon/sec (1.67 + 16 MeV/sec)

MEAN ENERGY (MEV)	GROUP FRACTION
0.4	1.07-1
0.8	7.59-1
1.3	1.29-1
1.7	2.94-3
2.2	2.24-3
2.5	8.12-5
3.5	1.32-6
6.15	9.02-9

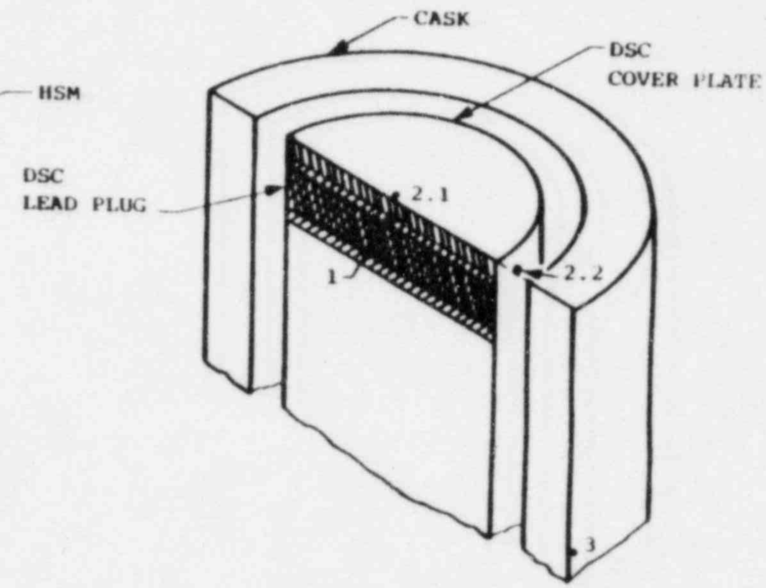
NEUTRON SOURCE:

9.98 + 8 neutron/sec

$N(E) = 0.484e^{-E} \sin h \sqrt{2\ E}$



HSM DOSE RATE LOCATIONS



DSC-CASK DOSE RATE LOCATIONS

Figure 3

Table 2

PRELIMINARY HAND CALCULATION RESULTS

Location	Material/Thickness	Dose Rates
DSC End Shields		
Lead Plug Assembly	Lead/ 5 in. and Steel/ 1 in.	<200 mrem/hr
Cover Plate	Steel/ 0.5 in.	< 50 mrem/hr
HSM		
Walls and Roof	Concrete/ 3.5 ft	< 20 mrem/hr

Table 3

COMPARISON OF QADMOD AND ANISN

SCOPING EVALUATION RESULTS

Location	Material/Thickness	Dose Rates (mrem/hr) QADMOD Gamma	ANISN Gamma	ANISN Neutron
DSC End Shields				
Lead Plug Assembly	Lead/ 5 in. and	43	12	13
	Steel/ 1 in.	12	3.5	7.8
HSM				
Walls or Roof	Concrete/ 3.5 ft	8.2	2.8	0.024
Door	Steel/ 2 in.	9.29	0.19	2.0

---

* increase from 0.5 in. in preliminary design for structural purposes.

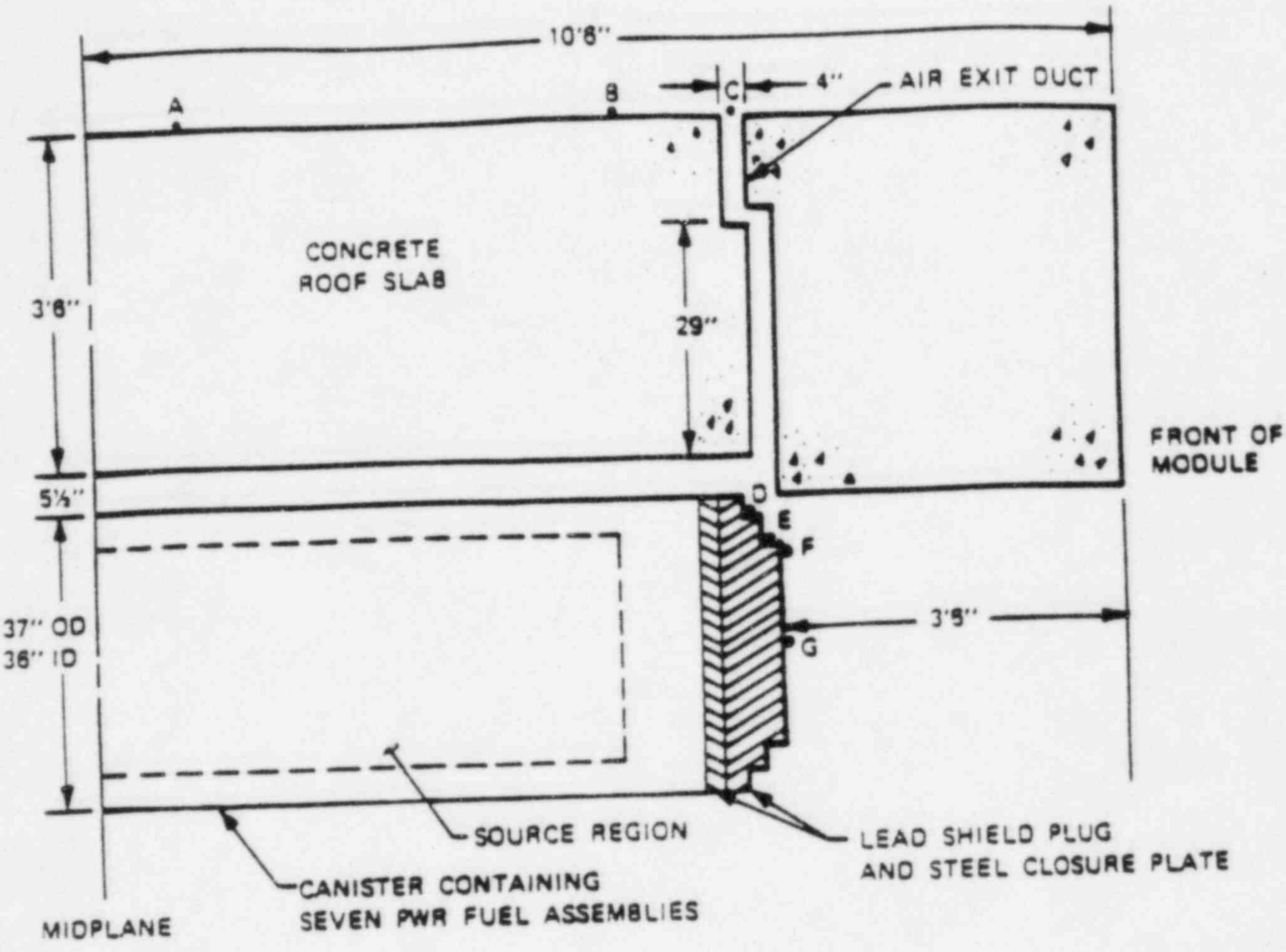
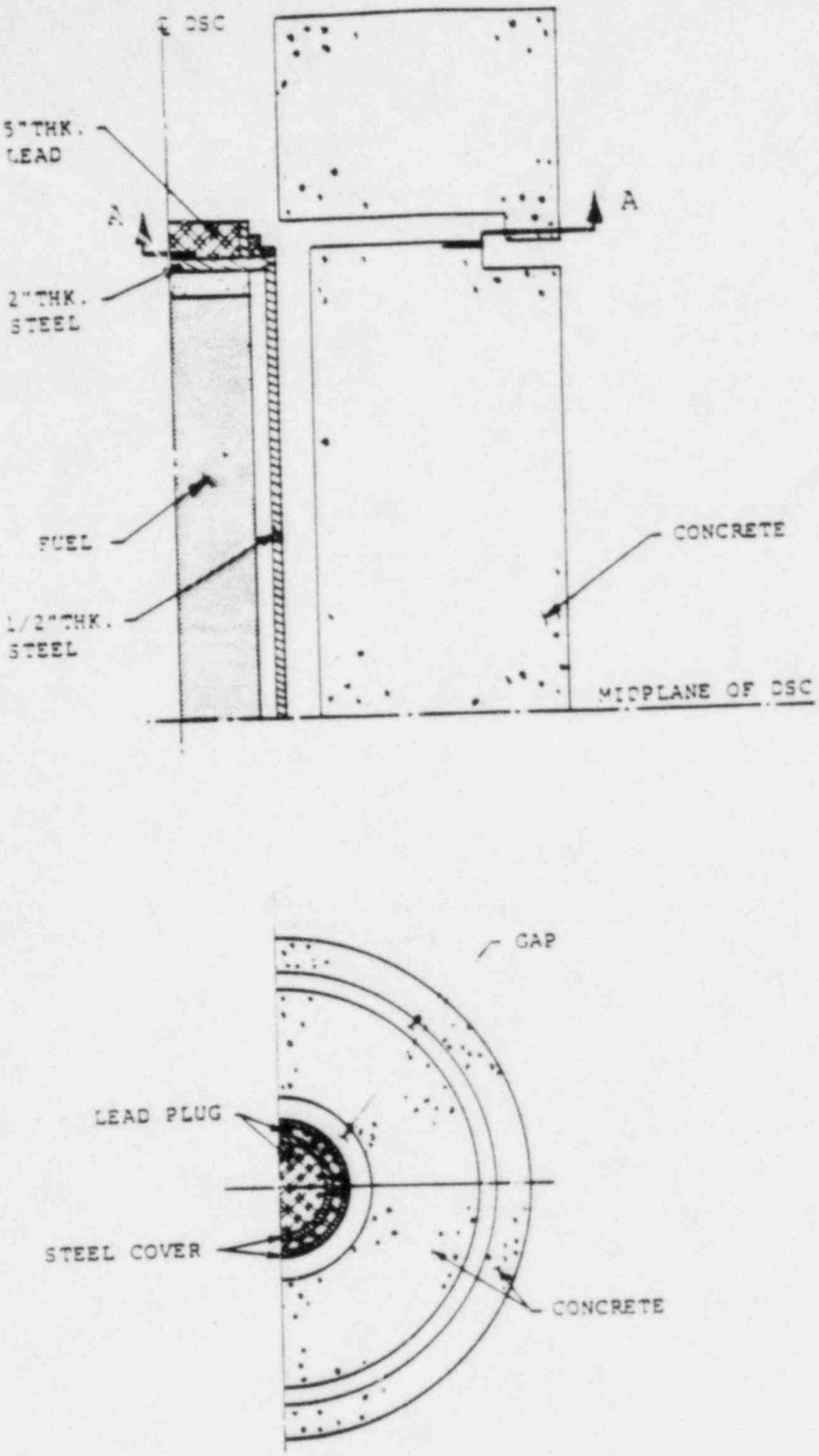


Figure 4

LOCATIONS OF INTEREST
FOR SHIELDING CALCULATIONS



SECTION A-A

Figure 5

DOT - IV MODEL OF HSM

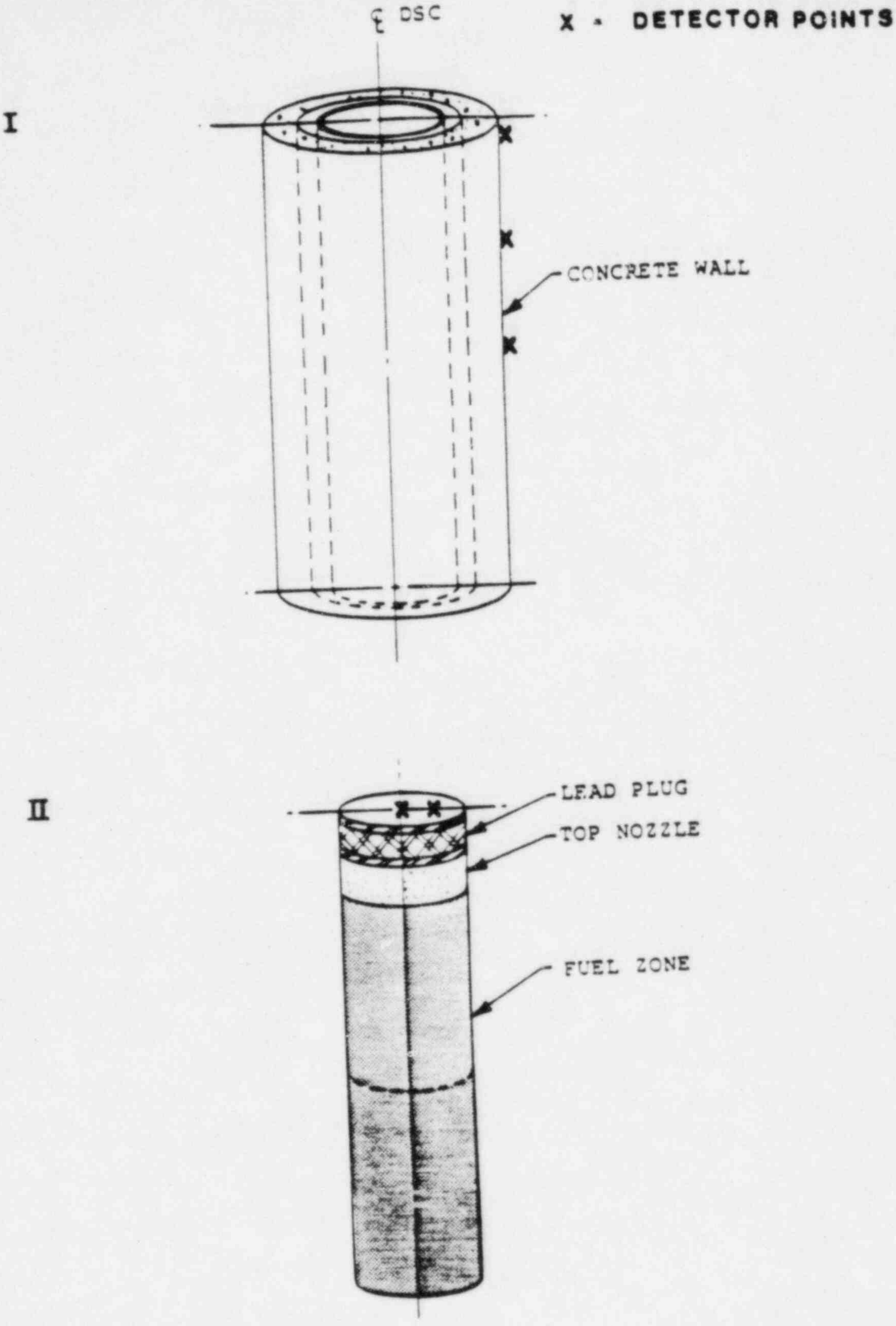


Figure 6

ANISN-XSDØSE MODEL FOR I(HSM) & II(DSC) END

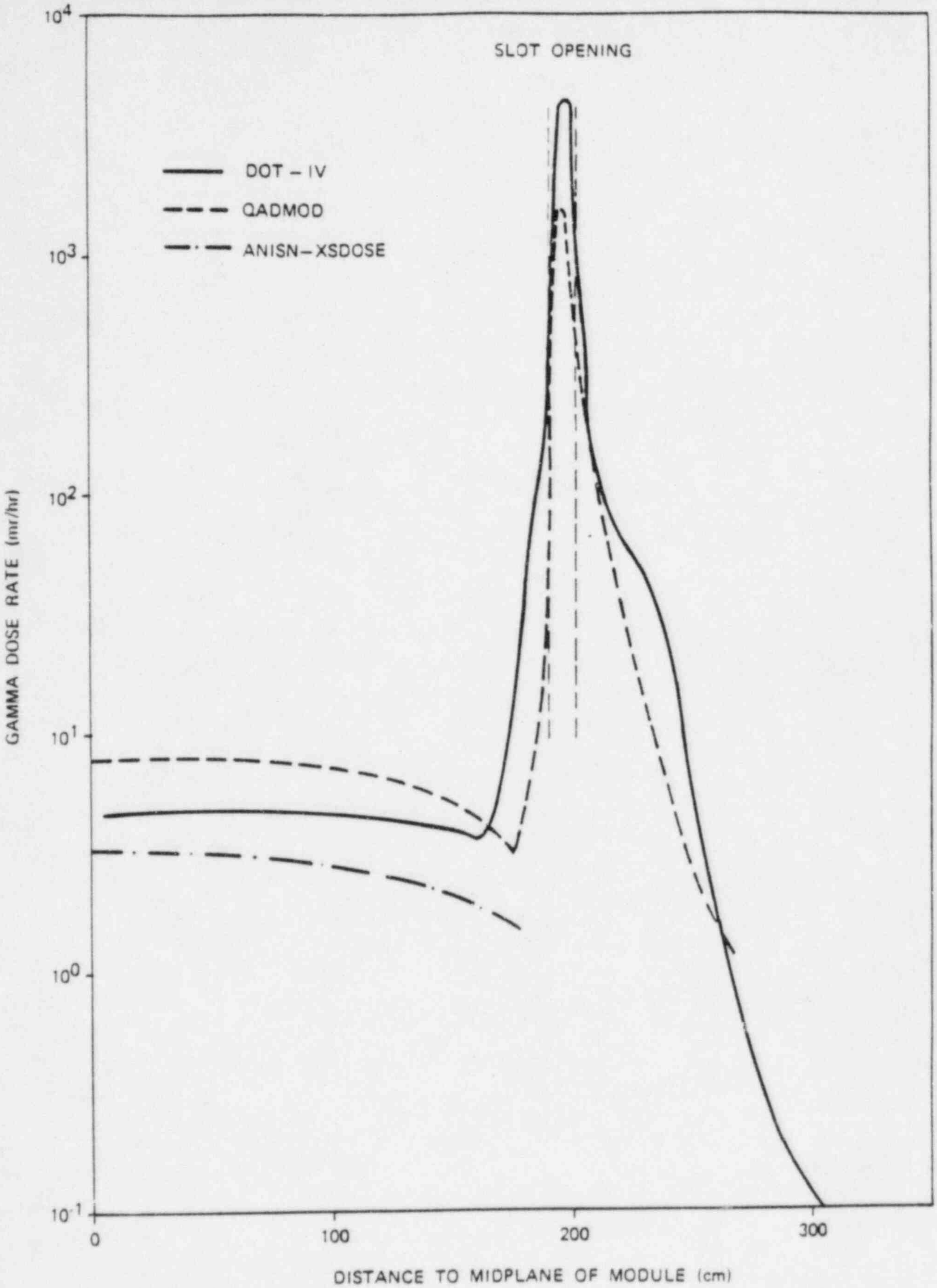


Figure 7 Gamma Dose Rate at Roof of HSM

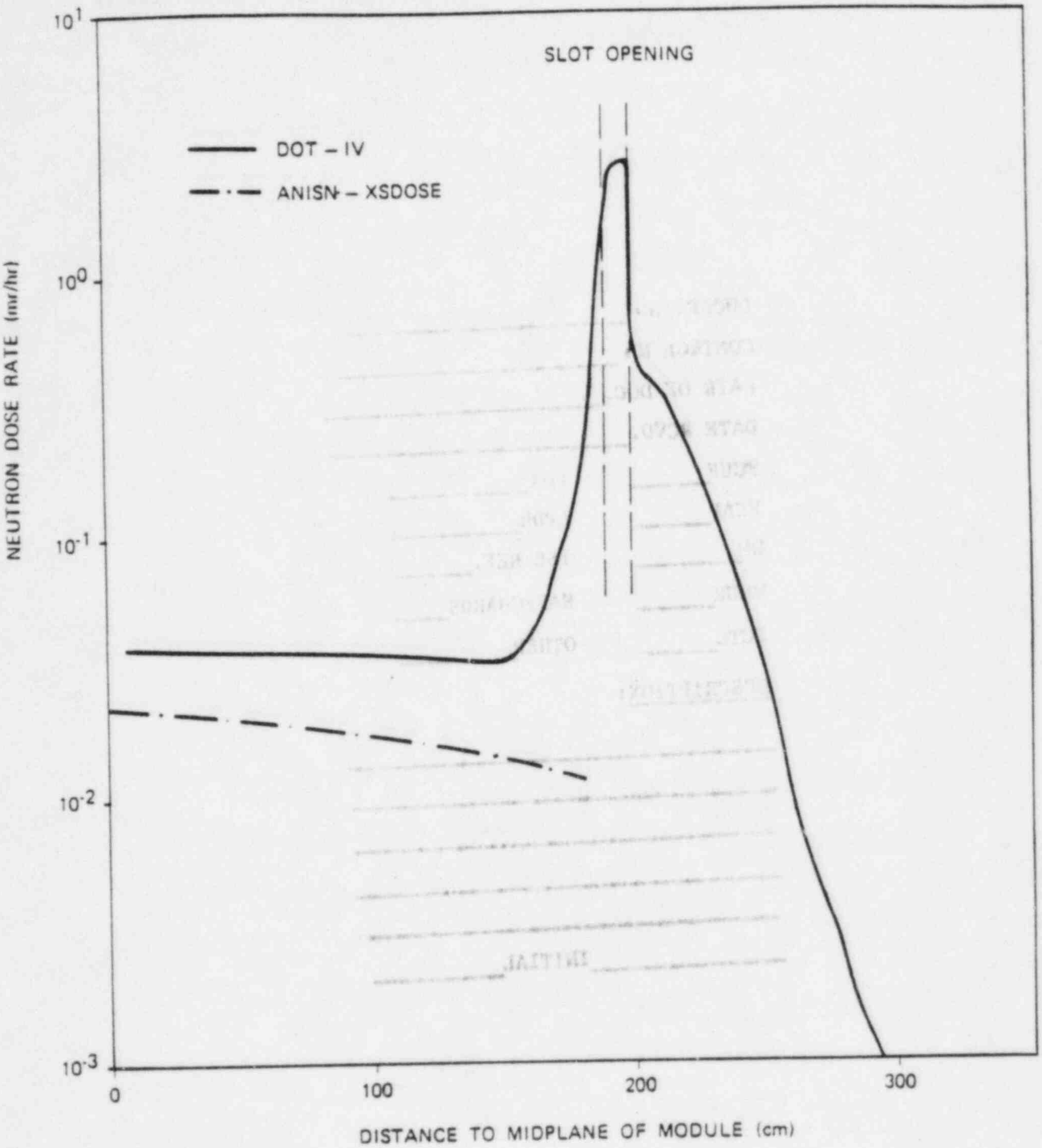


Figure 8 Neutron Dose Rate at Roof of HSM

DOCKET NO. M-39

CONTROL NO. 26318

DATE OF DOC. 01/17/86

DATE RCVD. 01/21/86

FCUF ____ PDR ✓

FCAF ✓ LPDR ____

WM ____ I&E REF. ____

WMUR ____ SAFEGUARDS ✓

FCTC ____ OTHER ____

DESCRIPTION:

transmittal of information in support of Topical Report NUH-001

01/23/86 INITIAL CEC