August 2, 1983

STATE OF MICHIGAN)
) SS.
COUNTY OF WASHTENAW)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330-OL
	)	

Affidavit of Dr. Palanichamy Shunmugavel

My name is Dr. Palanichamy Shunmugavel. I have previously been a witness in this proceeding and my professional qualifications are in the record. I swear that the statements made in the attached Affidavit are true and correct.

Palanichamy Shunmugavel

Signed and sworn to
before me this 2nd
day of August, 1983

Linda Louise Cole
Notary Public

LINDA LOUISE COLE
Notary Public, Washtenaw County, Michigan
My Commission Expires August 16, 1985

AFFIDAVIT OF
DR. PALANICHAMY SHUNMUGAVEL
ON ETHAFOAM

I. INTRODUCTION

My name is Palanichamy Shunmugavel. I am an Engineering Specialist in the civil/structural department of Bechtel Power Corporation in Ann Arbor, Michigan. My resumé has been introduced earlier in these proceedings.

In connection with my role as an Engineering Specialist, on February 17, 1983, I appeared before the Licensing Board to sponsor testimony on behalf of the Applicant regarding Seismic Category I duct banks at the Midland site. During the course of oral examination on this testimony, the Licensing Board inquired about the use of Ethafoam[1] brand polyethylene foam to isolate the duct banks. Specifically, the Board asked (1) the purpose of the use of Ethafoam; (2) whether there is any assurance that Ethafoam will retain its physical or structural integrity while buried in the soil over the 40-year life of the plant; and (3) whether there are any standards, tests or qualifications that document the ability of Ethafoam to withstand the conditions that it will encounter while buried in the soil.[2] This affidavit is provided in response to these inquiries.

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1 Ethafoam is a trademark of the Dow Chemical Company.

2 Tr. 12025-12027

II. GENERAL DESCRIPTION OF ETHAFOAM[3]

Ethafoam is a flexible, closed-cell expanded polyethylene (plastic) foam produced by the Dow Chemical Company. It is a physically stable material that resists shattering, breakage or crumbling when flexed, cut or struck. Ethafoam also displays excellent chemical stability, and it is exceptionally resistant to most solvents and other chemicals at room temperatures.

Stability of the material is dependent upon the load imposed on the foam, exposure time and the temperature involved; therefore, no specific maximum use temperature is given by Dow for Ethafoam products. In applications where Ethafoam is not subjected to load stress, such as the uses described below in Section III, Ethafoam products can be used successfully while exposed to intermittent temperatures of up to 165°F. Over an extended period of exposure, ultraviolet rays in sunlight can cause some degradation of Ethafoam.

Dow Chemical Company has evaluated typical properties of Ethafoam under the methods adopted by the American Society

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3 Source: "Designing Packages to Survive Shipping and Handling with Ethafoam Brand Polyethylene Foam," Form No. 172-221-80, Dow Chemical U.S.A. This document is a 29 page promotional brochure which principally describes shipping and packaging uses for Ethafoam. Therefore, the brochure has not been attached as an exhibit. Unless otherwise indicated, all discussions herein refer to the product known as Ethafoam 220.

for Testing Materials (ASTM). As can be seen from Exhibit 1 attached hereto, Dow has analyzed Ethafoam using ASTM Test Method D-790, D-3575 and D-3576[4]. Dow has also analyzed Ethafoam using ASTM Test Method D-1596.[5]

III. APPROPRIATENESS OF ETHAFOAM FOR MIDLAND SITE APPLICATIONS

As a result of the Licensing Board's inquiries about Ethafoam, on March 3, 1983, N.W. Swanberg of Bechtel prepared and mailed a letter to Dow asking for specific information regarding this product. I reviewed the letter before it was mailed, and verified that items 1, 2 and 3 of the letter accurately characterize the conditions of Ethafoam use with respect to duct banks and piping at the Midland site. A copy of this letter is attached hereto as Exhibit 2. On June 9, 1983, Dow Chemical responded to Mr. Swanberg's letter. This

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4 Exhibit 1 cautions that the typical properties listed are not to be considered specification values. As described below, with respect to Ethafoam 220, Applicant does not rely on the properties listed in Exhibit 1, and therefore does not require verification of these properties in its procurement documents. However, pursuant to Applicant's agreement with the NRC Staff relating to remedial soils work, all Ethafoam is purchased as "Q", which provides proper documentation establishing that the material being supplied is in fact Ethafoam. Additional quality assurance requirements with respect to material testing and specifications apply to the purchase of Ethafoam 120 for the use described in Section III(H), below.

5 Source: "Designing Packages to Survive Shipping and Handling with Ethafoam Brand Polyethylene Foams," Form No. 172-221-80, Dow Chemical U.S.A.

response is attached hereto as Exhibit 3. Dow's response highlights some Ethafoam characteristics which are important to its use at the Midland site:

-- Dow has no performance history covering Ethafoam use for 40 years.[6]

-- While Dow has no specific performance history covering Ethafoam buried in the ground, Dow notes that the product has good resistance to acids, bases and salts. Long term contact with hydrocarbons, however, is not advisable.

-- Oxidation of Ethafoam can occur at elevated temperatures over long periods of time. Thus, while no oxidation would be anticipated in Ethafoam maintained at soil temperature of about 60°F for 40 years, the onset of oxidation might occur as early as one to three years in Ethafoam maintained continuously at 165°F. Fully oxidized Ethafoam disintegrates into a powdery form.

-- Ultraviolet rays from the sun will gradually deteriorate the surface of Ethafoam. However, no such deterioration would occur in buried Ethafoam.

The following sections outline the specific soils-related uses to which Ethafoam has been or will be applied. As will be seen, in most applications, the Ethafoam will not be exposed to elevated temperatures and will therefore not be subject to temperature-related oxidation. Moreover, in all soils-related applications, the Ethafoam will be buried and therefore free from ultraviolet light degradation. Further,

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6 Polyethylene plastic did not exist 40 years ago; this plastic has only been in wide-spread use for approximately 20 years or less.

the Ethafoam is not expected to be exposed to hydrocarbons.[7] In the soils-related uses described below (except for the use described in Section III(H), below), Ethafoam is used merely as a forming piece to create the equivalent of an air gap; the resiliency and cushioning properties of the Ethafoam are not relied upon.[8] Thus, potential temperature-related oxidation is of no consequence.[9]

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7 There are several locations at the Midland site where large quantities of hydrocarbons can be found. However, in all except one of these locations, no Ethafoam is involved in a soils-related use. In the one instance, Ethafoam was used to wrap a diesel fuel line penetrating concrete. As is described in Section III(E), below, the Ethafoam was used to create a gap around the line during the placing of the concrete, not for any structural purpose. The gap would still remain if the Ethafoam were to degrade; thus, contact of this Ethafoam with hydrocarbons is of no concern.

8 During the course of oral examination on my testimony regarding Seismic Category I duct banks, I agreed with Judge Harbour that the purpose of Ethafoam was to "provide a crushable material so that the duct banks would not be subjected to shear." Tr. 12025. This statement may be misleading without explanation. While I was being questioned, I was aware that Ethafoam is not relied upon in soils-related applications to provide support. In my answer, I intended to convey that the purpose of the Ethafoam is to provide a zone of low resistance through which the duct bank could move before contacting an object in a manner that might create strain. I did not intend to suggest that the Ethafoam is used as a cushion.

9 Applicant's investigation of these Licensing Board questions has uncovered an Ethafoam application unrelated to soils matters, where the plastic may have been relied upon to provide support in an elevated temperature environment. Specifically, two "Q" spent fuel pool pipelines which may operate at above ambient temperatures have been found to be wrapped in Ethafoam and encased in thick concrete shielding. These lines are currently being evaluated to determine the effect -- if any -- of oxidation of the Ethafoam. The situation will be reported under 10 CFR §50.55(e) if appropriate.

A. Application: Between Building Foundation Wall and Fly Ash Concrete Backfill

A 2-inch thick layer of Ethafoam has been or will be placed between the foundation of the service water pump structure and circulating water intake structure and the low strength fly ash concrete backfill that is being placed in the excavation area to the north of these two structures.[10] The purpose of this application is to provide both a pouring mold ("formwork") for the liquid concrete and a space between the structure foundations and the concrete so as to allow for seismic movement. For this use, an air gap could serve the same purpose, so long as the gap were sealed to prevent the accumulation of foreign materials in the gap. The Ethafoam will be completely buried, and will be exposed only to normal soil temperatures (about 60°F); thus, no ultraviolet or temperature-related oxidation will occur.

B. Application: Surrounding Duct Banks Encased in Fly Ash Concrete Backfill

A 6-inch thick layer of Ethafoam has been or will be used to surround portions of duct banks around which the fly ash concrete backfill is placed. This Ethafoam blanket stops where the duct bank enters compacted soil backfill.[11] The

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10 See figure attached hereto as Exhibit 4.

11 See figure attached hereto as Exhibit 5.

purpose of this application is to provide a space between the duct bank and the concrete backfill at the point where the duct bank enters compacted soil backfill, thus creating a transition that will eliminate concentrated shear strain to the duct bank caused by differential settlement. The Ethafoam is not used to support the duct bank; a 6-inch air gap between the duct bank and the concrete backfill would serve the same purpose. Calculations have established that, in almost every instance, these duct banks can span the Ethafoam created gap without undue deflection or unacceptable strain; the concrete backfill supports the duct banks at one end while compacted soil backfill supports the duct banks at the other end. In the few instances where additional support was deemed necessary, supports were added at the interface between the duct banks and the structures which the duct banks penetrated.

The maximum anticipated soil settlement at the Midland site is 3 inches. Thus, the 6-inch Ethafoam gap will provide sufficient space to allow for the maximum predicted settlement at interfaces. In addition, the Midland site settlement monitoring stations will keep site personnel informed as to any settlement at these duct bank transition locations. See, e.g., SSER #2, §2.5.4.4.5, Figure 2.11.

The Ethafoam will be buried and exposed only to normal soil temperatures. Thus, no ultraviolet or temperature-related oxidation will occur.

C. Application: Surrounding Duct Banks Encased in Concrete Backfill at Building Penetrations

This application is a combination of the previous two. Here, the Ethafoam is used both to prevent contact between the duct bank and the concrete backfill, and to provide a space between the building foundation and the concrete backfill[12] The discussions presented with respect to the previous two applications are equally applicable here.

D. Application: Surrounding 26-Inch Service Water Piping Encased in Concrete Backfill

A 6-inch thick layer of Ethafoam has been or will be used to surround portions of 26-inch service water system lines around which the concrete backfill is placed. This Ethafoam blanket stops where the piping enters compacted soil backfill.[13] As with the duct banks, the purpose of the Ethafoam is to provide a space between the piping and the concrete backfill at the point where the piping enters compacted soil backfill, thus creating a transition that will eliminate concentrated shear strain to the piping caused by differential settlement.

This Ethafoam application is fully underground, so ultraviolet oxidation will not occur. However, the pipelines

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12 See figure attached hereto as Exhibit 6.

13 See figure attached hereto as Exhibit 7.

are expected to reach temperatures of up to 109°F during normal system operation, with temporary excursions to much higher temperatures in emergency conditions. It is anticipated that normal operating temperatures could lead to gradual oxidation of the Ethafoam within the 40-year life of the plant. However, such oxidation is of no consequence, because the Ethafoam is not relied upon for support. Calculations have established that this piping is capable of spanning the longest Ethafoam-created gap without undue deflection or unacceptable strain; the concrete backfill supports the pipe at one end while compacted soil backfill supports the pipe at the other end. Pipe deflection is not expected under any postulated circumstance (including soil settlement and earthquakes) to exceed that available within the 6-inch gap between the pipe and the concrete backfill. Disintegration of the Ethafoam would leave a void between the piping and the concrete backfill, and this void would serve the same spacing purpose as the Ethafoam. Moreover, the Midland site monitoring stations will keep site personnel informed as to any settlement at these service water piping transition locations. See, e.g., SSER2, §2.5.4.4.5, Figure 2.11.

E. Application: As a Form for Penetrations Through Concrete Block or Poured Concrete Walls

A layer of Ethafoam is placed around various Category I and non-Category I items that penetrate Category I and non-

Category I interior walls, foundations or footings.[14] The purpose of the Ethafoam is to provide a form around which concrete can be placed or concrete blocks can be cemented in place. When the concrete dries or the concrete block installation is complete, a gap is formed around the penetrating object, thus preventing structural interactions betweens the penetrating object and the wall, footing or foundation. The Ethafoam is not used for support.

Some of the penetrating objects (pipelines, for example) are expected to reach elevated temperatures during normal system operation. It is anticipated that these temperatures could lead to oxidation of the Ethafoam within the 40-year life of the plant. Such oxidation, however, would be of no consequence. Disintegration of the Ethafoam would leave a void around the penetrating object, and the creation of this void is the very reason Ethafoam is used.

F. Application: Between Two Structures

A 2-inch thick layer of Ethafoam is often placed below final grade between two adjacent structures.[15] The pur-

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14 See figure attached hereto as Exhibit 8. This exhibit shows a concrete block wall, but this type of penetration is also made through placed concrete walls.

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15 See figure attached hereto as Exhibit 9.

pose of this application is to provide a space below final grade between the structures so as to allow for seismic movement. (Above final grade level, Ethafoam is not used, and the space between the structures is usually greater than two inches.) For this use, an air gap could serve the same purpose, so long as the gap were sealed to prevent the accumulation of foreign materials in the gap. Because the Ethafoam is completely buried and exposed only to normal soil temperatures, no ultraviolet or temperature-related oxidation will occur.

G. Application: Between Soil and Lagging during Excavation

Excavation work is currently taking place at the Midland site. As soil is removed during excavation, wooden planks, stamped steel sheets or steel tubing, commonly referred to as "lagging," are placed against the unexcavated soil to prevent soil collapse into the pit. For the auxiliary building underpinning, Ethafoam 120 is placed between the corrugations of the stamped steel lagging and the soil so as to prevent soil movement after the lagging is installed.[16] Thus, this is the one soils-related use for which Ethafoam is relied upon to provide support in any way. This is a tem-

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16 See figure attached herto as Exhibit 10.

porary use, during which oxidation of the Ethafoam will not occur. After the work requiring the excavation is completed, the excavation will be filled with concrete or backfill with the lagging and Ethafoam still in place, thus preventing surrounding soil from collapsing into the pit. The buried Ethafoam will not degrade during the 40-year life of the plant, and would cause no undesirable effects even if it were to degrade.

H. Application: Spacing Between Certain Buried Non-"Q" Utilities

There are several locations at the Midland site where buried non-"Q" utilities cross each other closely enough to make it difficult to properly compact backfill between the utilities. One such location is to the north of the circulating water pump structure and the service water pump structure. At this location, the buried piping and utilities are being encased in the concrete backfill, which will prevent contact between the utilities. Ethafoam is not used to prevent contact between buries utilities at this location.

At other locations at the site, non-"Q" utilities such as sewer pipes and pipes carrying water for fire protection purposes are in close proximity where they intersect. Here, blocks of Ethafoam are placed between the utilities to allow for proper soil compaction around the intersection.

(Ethafoam is not used in this manner for spacing between two "Q" utilities or a "Q" and a non-"Q" utility.) In each instance, the utilities in question are buried and operate at near normal soil temperature, so no ultrviolet or temperature-related oxidation of the Ethaform is expected over the lift of the plant.

IV. CONCLUSION

The above discussion has described the soils-related puposes for which Ethafoam has been used, and has demonstrated that Ethafoam is appropriate for these uses. No adverse effects are anticipated during the 40-year life of the plant from the uses that have been described herein.

TABLE 1—Typical Properties* of ETHAFOAM Products

TYPICAL PROPERTIES	TEST PROCEDURE	ETHAFOAM 221 SHEET	ETHAFOAM 222 SHEET	ETHAFOAM 220 PLANK	ETHAFOAM 400 PLANK	ETHAFOAM 600 PLANK	ETHAFOAM 900 PLANK
Density (PCF)	ASTM D 3575 Test C	1.8	2.7	2.2	4	6	9
Cell Size (MM)	ASTM D 3576 Dow Modified	⅛"=2.0 ¼"=2.2 ½"=2.4	⅛"=1.0 ¼"=1.2 ½"=1.4	1.3	1.2	1.1	1.0
Compressive Strength (PSI)	ASTM D 3575 Test B						
	at 5%	—	2.5	3.5	6.5	15	44
	at 10%	—	3	5	8.5	17	48
	at 25%	3	6	8	12	20	54
	at 50%	—	15	15	21	33	75
Compressive Creep (% Deflection)	ASTM D 3575 Test BB Loaded @ specified PSI static load for 1000 hrs.						
	75°F	—	—	<5 @ 1.5 PSI	<5 @ 3 PSI	<5 @ 4 PSI	<4 @ 20 PSI
	160°F	—	—	<5 @ .25 PSI	<6 @ 1 PSI	<5 @ 2 PSI	<7 @ 7 PSI
Tensile Strength (PSI)	ASTM D 3575 Test E	60	100	50	65	80	130
Tensile Elongation (%)	ASTM D 3575 Test E	60	80	60	70	70	100
Tear Strength (lb./in.)	ASTM D 3575 Test D	—	30	15	25	30	50
Flexural Modulus (PSI)	ASTM D-790	—	—	300	500	700	1100
Buoyancy (PCF)	ASTM D 3575 Test AA	55-60	55-60	55-60	55-60	53-58	50-55
Thermal Conductivity (BTU—in./hr. ft.² °F) at 75°F mean temperature	ASTM D 3575 Test EE Method B	⅛"=0.3 ¼"=0.4 ½"=0.4	⅛"=0.3 ½"=0.4	0.4	0.4	0.4	0.4
Thermal Stability (% Shrinkage)	ASTM D 3575 Test F Conditioned @ specified temp. with no load:						
	24 hrs	—	−1.0 @ 165°F	−10 @ 165°F	−1.0 @ 165°F	−1.0 @ 165°F	−1.0 @ 165°F
	48 hrs	—	−1.5 @ 165°F	−2.4 @ 165°F	−1.5 @ 165°F	−1.0 @ 165°F	−1.0 @ 165°F

*Not to be considered specification values.

Source: "Ethafoam Brand Polyethylene Foam," Form No. 172-125-80, p. 7, Dow Chemical U.S.A.

Bechtel Associates Professional Corporation

777 East Eisenhower Parkway
Ann Arbor, Michigan

Mail Address P.O. Box 1000, Ann Arbor, Michigan 48106

107019

March 3,1983

Dow Chemical
Technical Service and Development
Research Center
P.O. Box 515
Granville, Ohio 43020

Attention: Mr. Gary Miller

Subject: Midland Plant Units 1 and 2
Consumers Power Company
Bechtel Job 7220-101
ETHAFOAM DATA

In reference to our telephone conversation on February 17, 1983, our client, Consumers Power Company, requires additional information regarding the behavior of your products Ethafoam #220 and #120 as follows:

1. All information shall be related to the plant life of 40 years.

2. The ethaform will be buried 6 feet deep at all times. Is there any chemical reaction during the period of the time encasing 30"Ø, 26"Ø pipe and electrical duct bank?

3. Temperature difference between 165F and 45F for pipe only. Temperature around duct bank would be normal ground temperature (60F $\pm$ 5F).

4. Hardening and disintegrating possibility of ethafoam during 40 year duration (underground).

5. Elasticity behavior (40 year duration)

   a) compressibility
   b) resiliency
   c) rigidity
   d) cushioning
   e) flexibility

6. Light stability (40 years duration).

7. Related test procedures, if any.

We will appreciate your cooperation in answering the above items to our client's satisfaction. We would like to have, if possible, the answers in 3 weeks.

Exhibit 2

i070i9

If you have any related questions, please call Steve Hartstern at 813-994-7802 or Julian Berezanski at 813-996-3466.

Very truly yours,

151

N.W. Swanberg
Project Engineer - Soils

NWS/JB/cs(SD)
03010402

cc: R.C. Bauman

bcc: L.A. Boomer
J. Berezanski
B. Dhar
S.C. Hartstern
D. Lewis
P. Shunmugavel
N.W. Swanberg

Written Response Requested: Yes

Com Use: NA

Exhibit 2
(cont'd.)

DOW CHEMICAL U.S.A.

June 9, 1983

GRANVILLE RESEARCH CENTER
P.O. BOX 515
GRANVILLE, OHIO 43023

Mr. N.W. Swanberg
Bechtel Associates Professional Corp.
777 East Eisenhower Parkway
P.O. Box 1000
Ann Arbor, MI 48106

RE: MIDLAND PLANT
CONSUMERS POWER COMPANY

You have inquired about the performance of our polyethylene foam products, ETHAFOAM* 220 and ETHAFOAM HS 120 over a 40 year period while incasing pipes buried six feet in the earth. You indicate a pipe temperature ranging from 165°F to 45°F and ground temperature of 60°F (+ 5°F). Specifically, you are interested in chemical reaction from the earth and physical property change. We do not have performance history under your conditions or for that length of time and cannot determine appropriateness of ETHAFOAM for your end-use. However, to help you make that determination, we will comment on several points you have raised.

1) Chemical Reaction - The base plastic in ETHAFOAM is polyethylene which has good resistance to most chemicals such as acids, bases, and salts. However, long term contact with hydrocarbons is not advisable as property deterioration would result.

2) Oxidation - Oxidation of ETHAFOAM can occur at elevated temperatures for long periods of time. Onset of oxidation of ETHAFOAM adjacent to a pipe at 165°F continuously might occur as early as one to three years. No oxidation of ETHAFOAM adjacent to the earth at 60°F would be anticipated in 40 years. If significant oxidation of foam does occur, the material will gradually lose strength such as compression and tensile. Also, its resiliency will fall off - that is its ability to recover from compression or flexing. Eventually, the foam at 165°F will disintegrate to a powdery form.

*Trademark of The Dow Chemical Company.

Exhibit 3

3) Light Stability - Ultraviolet rays from the sun will gradually deteriorate the surface of ETHAFOAM* in much the same way oxidation affects it. However, no effect would be anticipated in the buried condition.

We trust this helps in your consideration of our ETHAFOAM products.

Very truly yours,

Gary Miller

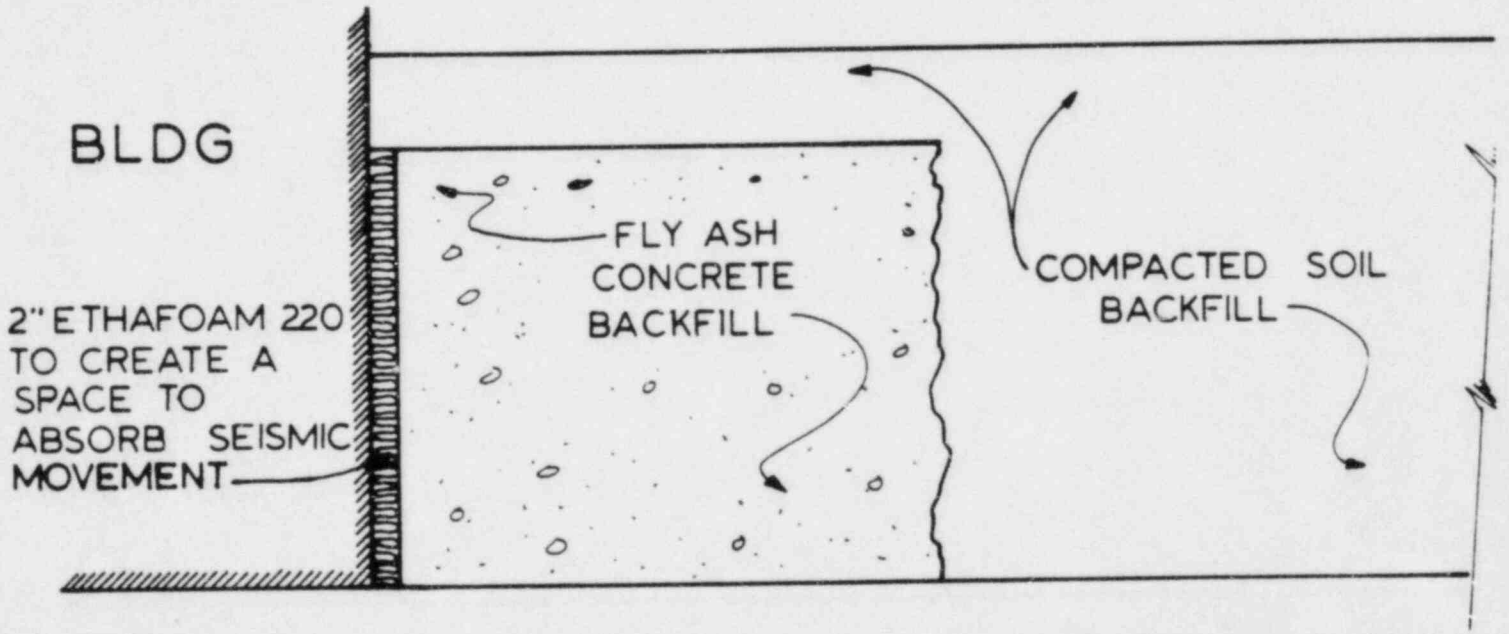
Gary Miller
Industrial Foams TS&D

jm

cc: Julian Berezanski, Bechtel
Steve Harlstern, Bechtel
Jeff Lee, Dow, Detroit Sales

Exhibit 3
(cont'd.)

CASE 1 - GENERAL CONDITION



CASE 2 - ELECTRICAL DUCT BANK

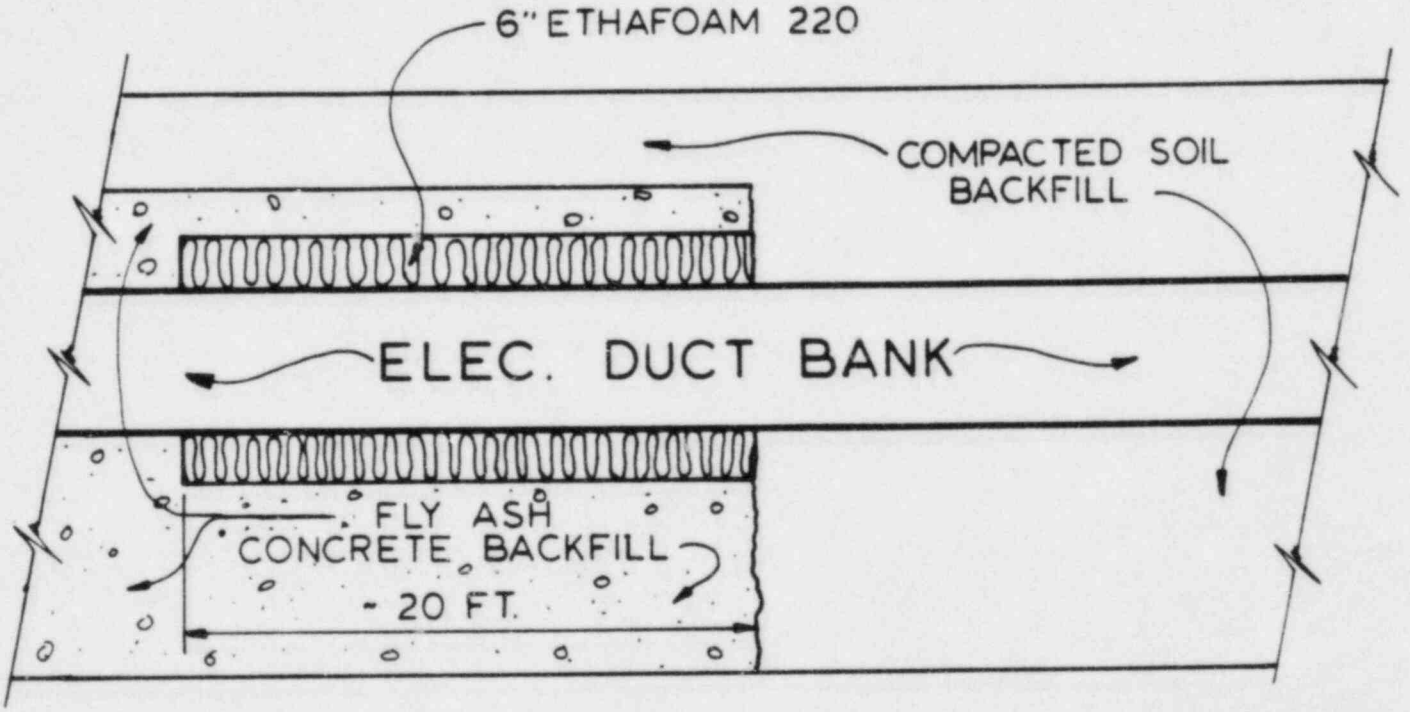


Exhibit 5

CASE 3 - ELECTRICAL DUCT BANK

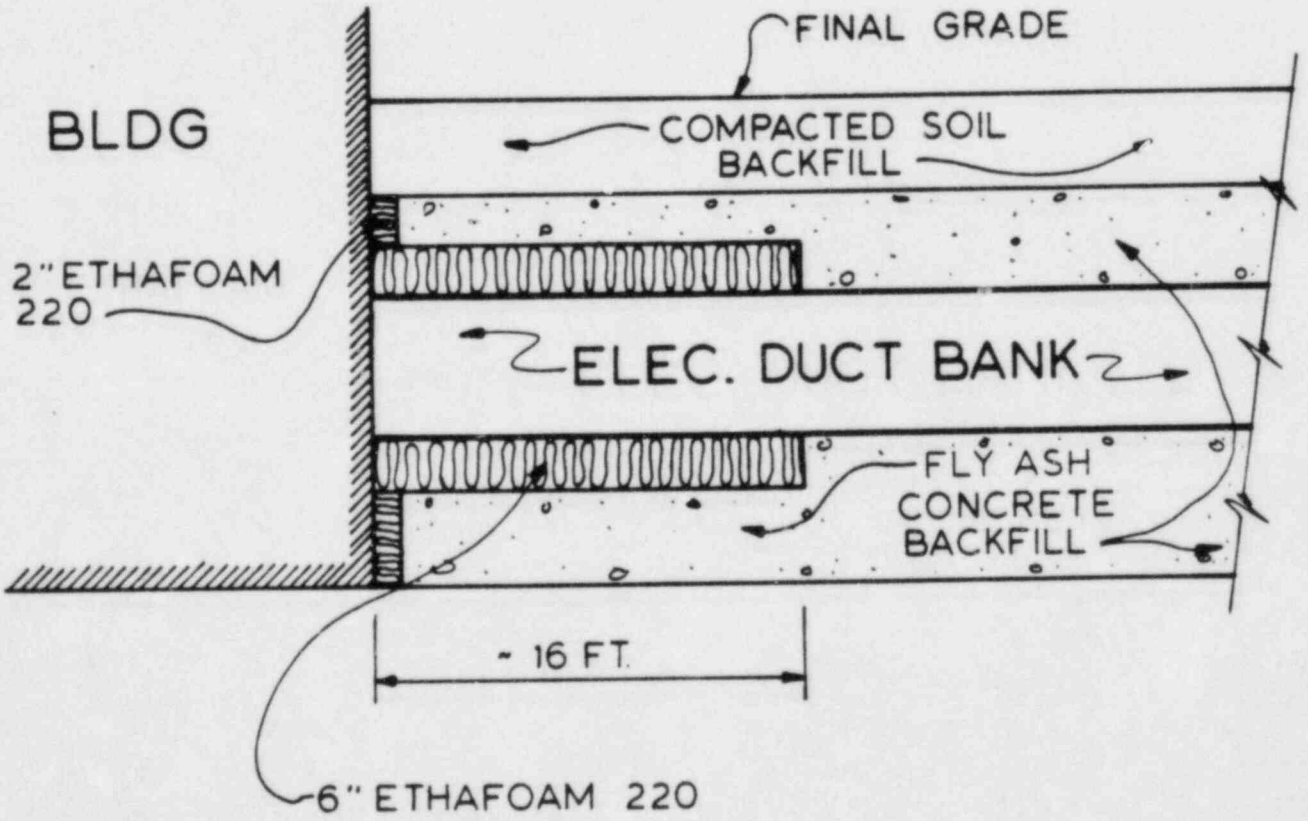


Exhibit 6

CASE 4 - 26"ϕ OHBC-15,-16,-19,-20,-53,-54, -55 & -56

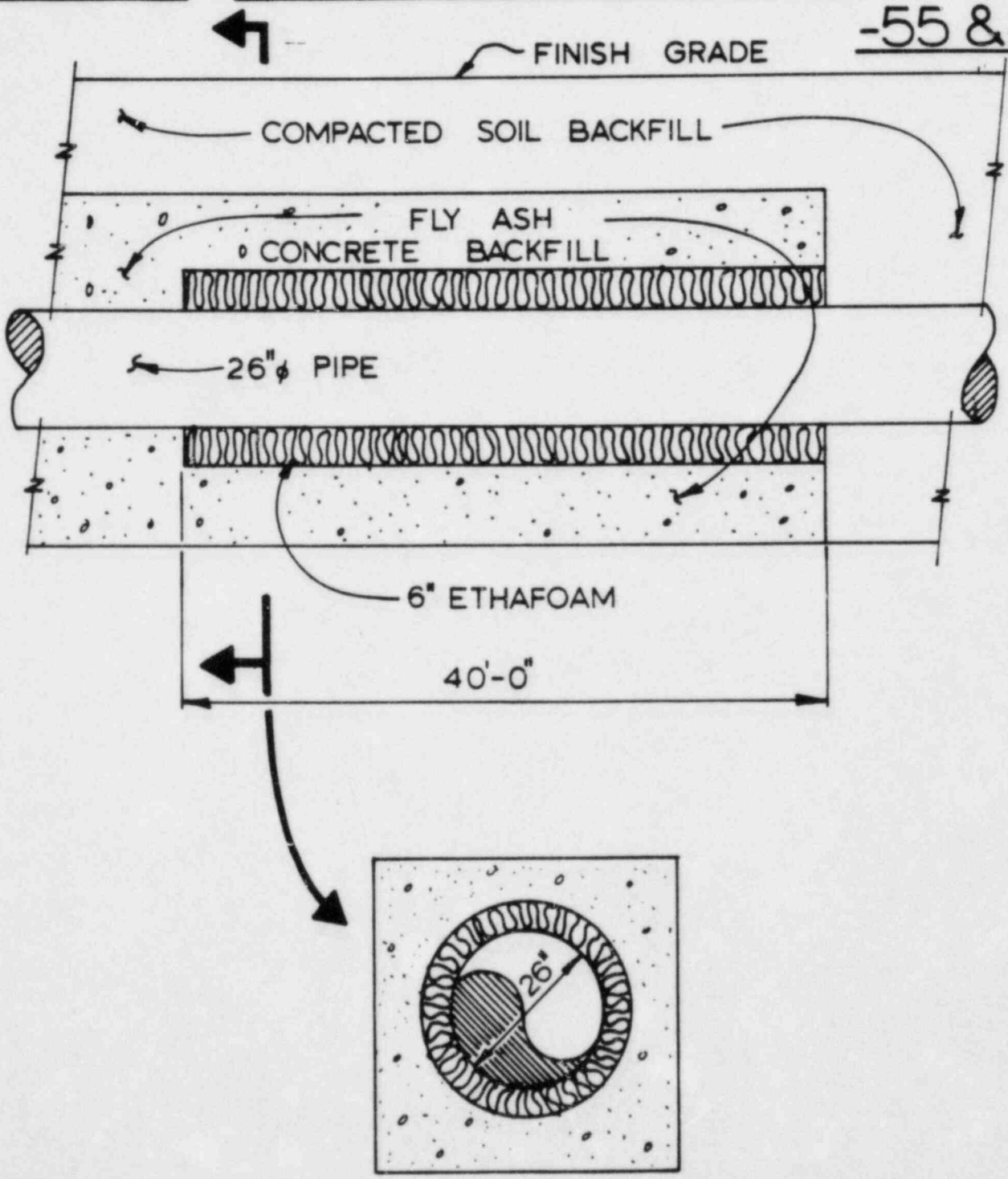


Exhibit 7

CASE 5 - WALL PENETRATION
(BLOCK OR CONC. WALL)

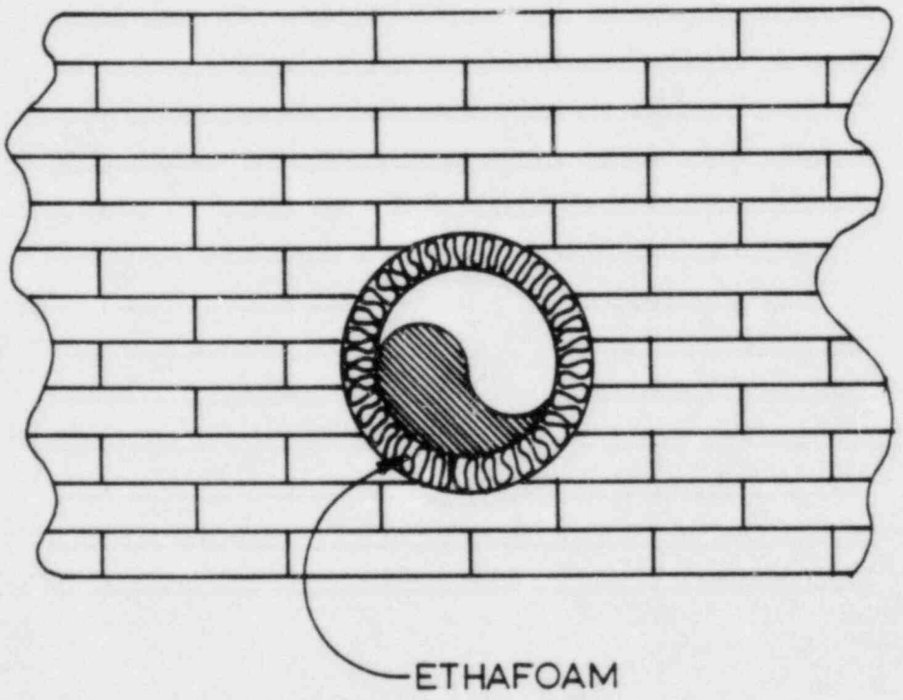
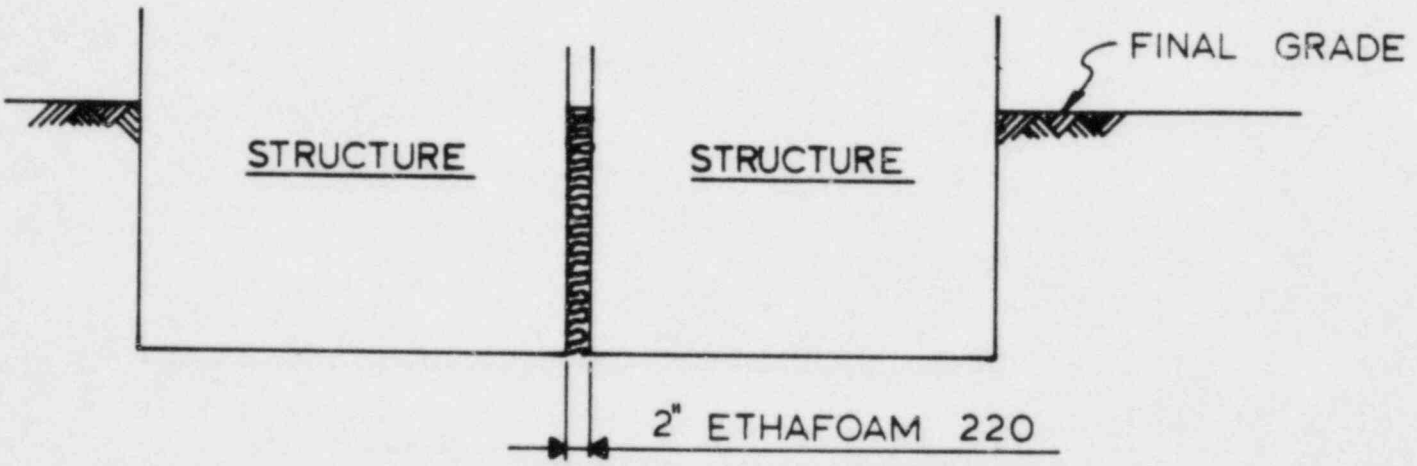
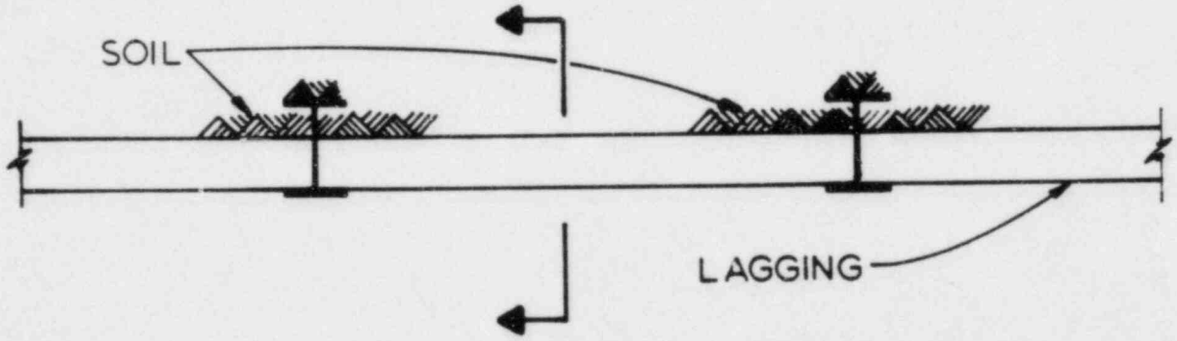


Exhibit 8

CASE 6 - BETWEEN TWO STRUCTURES



CASE 7 - BEHIND LAGGING



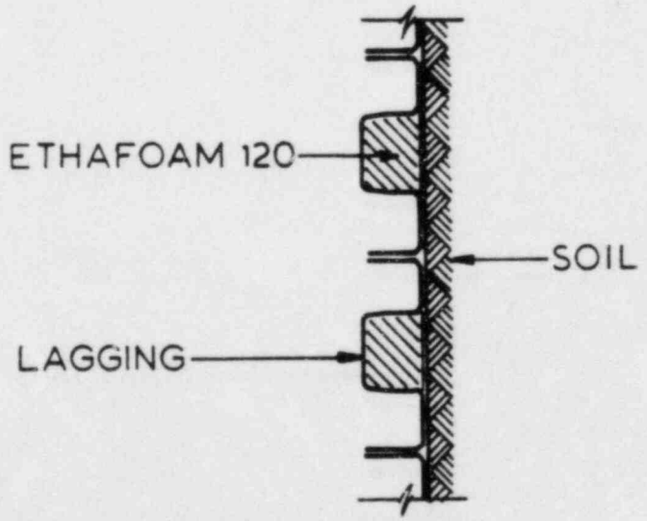


Exhibit 10

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330-OL
	)	

CERTIFICATE OF SERVICE

I, Brian R. Gilomen, one of the attorneys for Consumers Power Company, hereby certify that a copy of the Affidavit of Dr. Palanichamy Shunmugavel on Ethafoam was served upon all persons shown on the attached service list by deposit in the United States mail, first class, this 8th day of August, 1983.

Brian R. Gilomen

Brian R. Gilomen

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Carole Steinberg, Esq.
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Atomic Safety & Licensing
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