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SUBJECT: Forwards complete response to SA Varga 800421 request for info on Category 1 masonry walls employed by plants under CP & OL review.

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Licensing Branch No. 1
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
NRC INFORMATION REQUEST:
CATEGORY I MASONRY WALLS
ER 100450 FILE 841-2
PLA-523

Dear Mr. Youngblood:

This is a complete reply to Mr. S. A. Varga's letter dated April 21, 1980 requesting information on Category I Masonry Walls employed by plants under construction permit and operating license review.

Enclosed are the responses to your questions. This information is presently being incorporated into the FSAR and will be submitted in a future amendment.

We trust these responses satisfactorily answer any concerns you may have pertaining to the design adequacy of the Category I Masonry Walls employed at the Susquehanna Steam Electric Station. However, should any questions arise, please do not hesitate to inform us.

Very truly yours,

NW Curtis

Norman W. Curtis

WEB/mks

Enclosure

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RESPONSE TO

"INFORMATION REQUEST ON CATEGORY I MASONRY WALLS

EMPLOYED BY PLANTS UNDER CP AND OL REVIEW"

by the

Nuclear Regulatory Commission

QUESTION 1:

Are there any concrete masonry walls being used in any of the Category I Structures of your plant? If the answer is "no" to this question, there is no need to answer the following questions.

RESPONSE:

Yes.

QUESTION 2:

Indicate the loads and load combinations to which the walls were designed to resist. If load factors other than one (1) have been employed, please indicate their magnitudes.

RESPONSE:

All concrete masonry blockwalls in the reactor building are designed for the following loads and load combinations (to be indicated in Table 3.8-8 of the FSAR). These load combinations apply to out-of-plane loading as well as in-plane loading.

Condition	Load Combination	Allowable Stress*
Normal	$D+L+T_o+H_o$	f_s, S_m
Normal/Severe	$D+L+T_o+H_o+E+D_s$	$1.33f_s, 1.33S_m$
Normal/Extreme	$D+L+T_o+H_o+W'$	$0.9f_y, 1.67S_m$
Abnormal	$D+L+(T_o+T_a)+R+1.25P+H_a$	$0.9f_y, 1.67S_m$
Abnormal/Severe	$D+L+(T_o+T_a)+R+1.25P+H_a+1.25E+D_s$	$0.9f_y, 1.67S_m$
Abnormal/Extreme	$D+L+(T_o+T_a)+R+P+H_a+E'+D'_s$	$0.9f_y, 1.67S_m$

NOTE: For double wythe walls designed as composite sections, the allowable shear or tension between masonry block and concrete or grout infill is considered to be equal to three percent of the compressive strength of the block.

WHERE:

D	=	Dead load.
L	=	Live Load.
T_o	=	Thermal effects during normal operating conditions including temperature gradients and equipment and pipe reactions.
T_a	=	Added thermal effects (over and above operating thermal effects) which occur during a design accident.
P	=	Design basis accident pressure load.
R	=	Local force or pressure on structure due to postulated pipe rupture including the effects of steam/water jet impingement, pipe whip, and pipe reaction.
E	=	Load due to Operating Basis Earthquake.
E'	=	Load due to Safe Shutdown Earthquake.
W'	=	Tornado Wind Load.
H_o	=	Force on structure due to thermal expansion of pipes under operating conditions.
H_a	=	Force on structure due to thermal expansion of pipes under accident conditions.
O_s	=	Force on blockwall due to story drift under Operating Basis Earthquake Loading.
O'_s	=	Force on blockwall due to story drift under Safe Shutdown Earthquake Loading.
S_m	=	Allowable stress for reinforced concrete masonry per UBC, Table 24-H (special inspection) for global wall analysis; or allowable stress for unreinforced concrete masonry per UBC Table 24-B (special inspection) for local wall analysis as a result of attachments.
f'_s	=	Allowable working stress in tension for reinforcing bars (as specified in ACI 318-71).
f_y	=	Yield strength of reinforcing steel.

All concrete masonry blockwalls in Category I Structures other than the reactor building are designed for the following loads and load combinations (to be indicated in Table 3.8-9 of the FSAR). These load combinations apply to out-of-plane loading as well as in-plane loading.

Condition	Load Combination	Allowable Stress *
Normal	$D+L+T_o+H_o$	f_s, S_m
Normal/Severe	$D+L+T_o+H_o+E+D_s$	$1.33f_y, 1.33\ S_m$
Normal/Extreme	$D+L+T_o+H_o+W'$	$0.9f_y, 1.67\ S_m$
Abnormal	$D+L+(T_o+T_a)+R+H_a$	$0.9f_y, 1.67\ S_m$
Abnormal/Severe	$D+L+(T_o+T_a)+R+H_a+1.25E+D_s$	$0.9f_y, 1.67\ S_m$
Abnormal/Extreme	$D+L+(T_o+T_a)+R+H_a+E'+D'_s$	$0.9f_y, 1.67\ S_m$

*NOTE: For double wythe walls designed as composite sections, the allowable shear or tension between masonry block and concrete or grout infill is considered to be equal to three percent of the compressive strength of the block. The variables are the same as previously defined.

QUESTION 3:

In addition to complying with the applicable requirements of the SRP Sections 3.5, 3.7, and 3.8, is there any code, such as the "Uniform Building Code" or the Building Code Requirements for Concrete Masonry Structures" (proposed by the American Concrete Institute) which was or is being used to guide the design of these walls? Please identify and discuss any exceptions or deviations from the SRP requirements or the aforementioned codes.

RESPONSE:

The "Uniform Building Code" and the "Building Code Requirements for Concrete Masonry Structures" (ACI 531 - to be referenced as Item #14A of Table 3.8-1 in the FSAR) are used to guide the design of the blockwalls. Load combinations and allowable stresses not covered by the above codes are described in response #2.

QUESTION 4:

Indicate the method that you used to calculate the dynamic forces in masonry walls due to earthquake (i.e., where it is a code's method such as Uniform Building Code, or a dynamic analysis. Identify the code and its effective date if the code's method has been used. Indicate the input motion if a dynamic analysis has been performed.

RESPONSE:

Concrete masonry blockwalls in all Seismic Category I structures have been analyzed dynamically as described below (to be indicated in Section 3.7b.3.1.5 of the FSAR). They are designed for out-of-plane and in-plane inertia forces generated by the mass of the blockwall and attachment loads, combined with other loads as described in Response #2.

The dynamic analysis of concrete masonry blockwalls in Class I structures is performed by the response spectrum method. Frequency calculations for blockwalls supporting Class I attachments or located in areas of Class I equipment are based on either cracked section, partially cracked section, or uncracked section properties; whichever represents the condition based upon the calculated loads. The cracked and uncracked section analysis are described within the codes referred to in Response #3.

The partially cracked section analysis is based on the following ACI 318 formula:

$$I_e = (M_{cr}/M_a)^3 I_g + (1-(M_{cr}/M_a)^3) I_{cr}$$

where,

I_e = effective moment of inertia.

I_{cr} = moment of inertia of cracked section.

M_a = bending moment applied to the blockwall.

I_g = Cross section moment of inertia (uncracked)

M_{cr} = cracking bending moment = $\frac{fr\ I_g}{yt}$

fr = modulus of rupture for masonry = 50 psi
modulus of rupture for concrete = $6\ f'_c$ psi

Y_t = distance from centroid axis of gross section to the extreme fiber in tension.

For assembling the effects of frequency variations on the responses, the variable items such as boundary conditions, mass, modulus of elasticity, and cracking moment are considered. The damping values used are listed below (to be indicated in Table 4.7b-2 of the FSAR).

Concrete masonry structures	OBE	SSE
Uncracked	2	5
Cracked	4	7

The response of attachments to blockwalls is determined as described in Section 3.7b.3.1.1.1 of the FSAR.

SECTION 3.7b.3.1.1.1

Seismic qualification of equipment is performed by analysis when the equipment can be adequately represented by a model and the analysis can either be an equivalent static analysis or a dynamic analysis.

Equivalent static analysis is described in Subsection 3.7b.3.5.

The dynamic analysis is performed by the response spectrum method. In case of single degree of freedom systems, the response acceleration is selected from the appropriate response spectrum curve at the natural frequency of the equipment. For rigid equipment (i.e., frequency greater than 33 cps), this acceleration corresponds to the maximum floor acceleration. In case of multi-degree of freedom systems, the largest value of acceleration is chosen assuming the frequency of the equipment varies by $\pm$ 10%. Where the fundamental frequency is greater than 33 cps, the inertia loads are calculated by using an acceleration value equal to 1.5 times the floor acceleration value.

The three components of earthquake motion are combined in accordance with Section 3.7b.2.6 of the FSAR.

SECTION 3.7b.2.6

The response spectrum method is used in seismic analysis of structures. Independent analyses are done for the vertical and two horizontal (east-west and north-south) directions. For design purposes, the response value used is the maximum value obtained by adding the response due to vertical earthquake with the larger value of the response to one of the horizontal earthquakes by the absolute sum method.

QUESTION 5:

How were the masonry walls and the piping/equipment supports attached to them designed? Provide enough numerical examples including details of reinforcement and attachments to illustrate the methods and procedures used to analyze and design the walls and the anchors needed for supporting poping/equipment (as applicable).

RESPONSE:

The blockwalls in all Category I structures are analyzed by the response spectrum method and designed using the working stress method. In the original blockwall design, the response was computed based upon the gross section properties (i.e., un-cracked section). Currently, this original analysis/design is being evaluated for the cracked section criteria as described in Response #4.

After the dynamic response is determined, the design forces are computed and the resulting stresses are checked as noted below:

1. Local Analysis:

The blockwall is analyzed for any attachment loads. The resulting stresses are checked so as not to exceed the allowable stresses for unreinforced grouted masonry per UBC Table 24-B (Special Inspection).

2. Global Analysis:

a. Out-of-plane loads:

Wall inertia forces, attachment loads, story drift and other applicable loads perpendicular to the plane of the wall are combined in accordance with Response #2. The resulting stresses are checked so as not to exceed allowable stresses for reinforced, grouted masonry per UBC Table 24-H (special inspection) as modified in Response #2. Where the evaluation indicates that the design stresses exceed the allowable stresses, fixes are designed such that the criteria is satisfied.

b. In-plane loads:

Same as bove in part "a", except that the inertia loads and section properties considered are in the in-plane direction (i.e., parallel to the wall).

Generally, blockwall attachments are light items such as junction boxes. And electrical conduits; as such, no special reinforcement details for the localized areas are required. As a result, details for the localized areas are required. As a result, details shown on project drawing C-805 (Sheets 1 through 3 enclosed) are used as standards. For isolated cases where additional reinforcement and/or special details are required, these are shown on the block wall elevation drawings. For example, enclosed see Drawing C-1254, Section A.

Project blockwalls generally do not support Category I equipment except for light items such as fuse boxes. This is also true for Category I large piping supports.

When Category I items are attached to blockwalls, the connection is provided by means of through bolts. Structural Steel components of the attachments for other than pipe supports are designed in accordance with the AISC specification. The transfer of load from the attachment in the blockwall is by shear. The methodology for designing the blockwalls is as discussed above.

The design method employed for the pipe supports/hangers and numerical examples will be submitted later.

QUESTION 6:

Provide plant and elevation views of the plant structures showing the location of all masonry walls for your facility.

RESPONSE:

Refer to the following Susquehanna Steam Electric Station Project Drawings (codes enclosed) which provide plant and elevation views of all blockwalls in Category I Structures.

Reactor Building - Drawings C-1201 through C-1208

Drawings C-1302 through C-1309

Diesel Generator Building - Drawing C-1248.

RWM-BJH/kes