

Seismic Isolators



TECH NOTES



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SEISMIC ISOLATORS

MECHANICAL, ELECTRICAL AND PLUMBING (MEP), SEISMIC RESTRAINT SELECTION GUIDELINES:

With the continuous push to ever more stringent life safety related building codes, it has become commonplace for historically non-seismic regions of the country, to require seismic restraint of MEP equipment. VMC as being members of many of the councils and committees on the subject, and as being a founding member of VISCMA, (Vibration Isolation and Seismic Controls Manufacturers Association), has the expertise necessary to assist you in the proper selection of seismic restraints. There are many places to receive information on the application of seismic restraints. Two such references are: ASHRAE Applications, Chapter 58 and FEMA 412, 413 & 414, Seismic Installation Guides for MEP Equipment.



based upon ASCE-7, installations of non-structural components must now be viewed as part of the seismic system in a building. Examples of the new model building codes are IBC® 2000 through IBC® 2018. This condition requires the manufacturers of components within that system to be structurally and/or operationally compliant with the loads specified in the building codes. Depending on the calculated 'Seismic Design Category', nonstructural components may be required to fully function after a seismic event. The manufacturer will now be required by the local building official to have a 'Certificate of Compliance' attached to its equipment. An in-depth study of IBC® Chapter 17 is required to fully understand the scope of this requirement. You may also consult www.ibcapproval.com for further information on compliance.

In the latest version of the code, all calculations are

performed per ASCE7.

The predominant force from a seismic event is a lateral or 'shear' load which is introduced at the base of the building or structure.

This load is transmitted through the building and into the equipment to which it is attached. After this, the load is assumed to act at the center of gravity of the equipment as an inertial load measured in "g's". The initial design work will be to determine the adequacy of the supports that attach the equipment to the building structure. The attachment points where the equipment attaches to the building structure need to be designed to ensure that the equipment stays in place after an earthquake. These points are also called reaction points.

To calculate the loads at these reaction points, a free body diagram must be made of the equipment, showing the CG (center of gravity) location and the reaction locations. The direction of the applied seismic load is to be such that it creates the highest loads at the reaction points. These reactions will have horizontal and vertical components. The vertical component will be induced by the vertical cg height of the equipment. The angle of the force that creates this worst case is called the 'principal angle'.

Once the highest reaction load is determined, the support is analyzed for adequacy. Generally, this load will be applied to the top of a seismic restraint and carried into the building structure through the restraint. The calculated load shall be compared to quoted allowables for the particular isolator being used. Throughout this catalog, VMC shows curves of allowables for our seismic mounts.

After this load is carried through the isolator, it must now be carried into the building structure by means of bolting or welding. VMC provides bolt holes in all of its floor isolators for anchoring to concrete or bolting to steel. A calculation needs to be performed to calculate the induced tension on the bolts and compare these with quoted allowables for the particular bolt being used. Typically, ICC-ES publishes load ratings for most common

concrete anchors. Where the installation is into building steel, use of ASD allowables is acceptable.

What follows is a typical approach taken when determining what seismic restraint is required for a particular application.

When beginning a seismic installation analysis, there are a few important questions that must be answered.

1. What is your location in the country?

- a. This will determine the un-factored local seismic force.

2. On what type of soil is the structure standing?

- a. This will determine the soil factor to be applied to the seismic force.

3. In what type of structure is the equipment being installed?

- a. This will determine the seismic use group of the building.

4. What type of component is being installed?

- a. This will determine the amplification and importance factors to be applied to the seismic force.

5. Where within the structure is the equipment being installed?

- a. This will determine the amplification due to the installed height within the building. As the unit's installation point within the structure gets higher, the seismic load increases on the equipment due to the 'pendulum' effect.

6. How am I attaching the equipment to the structure?

- a. This will determine the attachment amplification factor.

These questions each have a specific piece of information necessary to determine:

1. Does the equipment need to have seismic restraints?
2. For what level of seismic force do I need to design?

will go through a few examples. Pages and tables are referenced to ASCE7-10.

The basic equation to calculate seismic loads on MEP equipment is:

$$F_p = \frac{0.4 * a_p * S_{DS} * W_p}{\left(\frac{I_p}{1}\right)} * \left(1 + 2 * \left(\frac{z}{h}\right)\right)$$

Also:

$$S_{DS} = \left(\frac{2}{3}\right) * S_{MS}$$

$$S_{MS} = \frac{1}{F_a * S_s}$$

And:

$$0.3 * S_{DS} * I_p * W_p < F_p < 1.6 * S_{DS} * I_p * W_p$$

Where:

a_p = The attachment amplification factor from table 13.6-1

S_{DS} = Design Spectral Response Acc. at short period, Section 11.4.4

S_{MS} = Max Earthquake Spectral Response Acc. for Short Period

F_a = Site Coefficient (Use "D" if unknown)

S_s = Mapped Spectral Acc. for Short Period

z = Height of the equipment attachment to the structure

h = Average Roof Height

R_p = Component Response Modification factor from Table 13.6-1

I_p = Component Importance factor from Section 13.1.3

W_p = The operating weight of the system

Using the most prevalent codes currently a



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EXAMPLE #1 - Determine the seismic force for the following situation:

Location: Charleston, SC (Zip Code 29420)

Soil: Site Class 'D' (See code)

Structure Type: Three-Story School

Component Type: Rooftop Air Handler

Attachment Type: Isolated Roof Curb

From the seismic maps in IBC:

$$S_s \sim 1.56$$

$$S_1 \sim 0.44$$

$$\text{Site Class 'D': } F_a = 1.0 \text{ at } S_s = 1.56$$

From this information, calculate S_{DS} :

$$S_{DS} = \left(\frac{2}{3}\right) * F_a * S_s = 1.04$$

Determine Category, (Seismic Use Group), from Table 1.5-1.

$$\text{Risk Category} = \text{IV}$$

Find Seismic Design Category, SDC from Table 11.6-1:

$$\text{Since } S_1 < 0.75,$$

$$\text{Seismic Design Category} = \text{D}$$

From the appropriate tables:

$$a_p = 2.5 \quad R_p = 2.5 \quad I_p = 1.0$$

Check exemptions section 13.1.4. For a Category 'D', all mechanical and electrical components shall meet the seismic requirements of the code, except components that weigh less than 20 lbs. with provisions.

Calculate z/h ; since this is installed on the roof, $z/h = 1$:

$$\text{Lateral g force} = \frac{0.4 * 2.5 * 1.04 * 3}{2.5} = 1.25 \text{ g's}$$

$$0.3 * S_{DS} * I_p * W_p = 0.312 \text{ g}; 1.6 * S_{DS} * I_p * W_p = 1.66 \text{ g's}$$

Therefore the design seismic load is 1.25 g.

EXAMPLE #2 - Determine the seismic force for the following situation:

Location: Sacramento CA (Zip Code 98515)

Soil: Site Class 'C' (By Civil Survey)

Structure Type: Five-Story Office

Component Type: Mechanical Room Pumps

Attachment Type: Concrete Inertia Base

From the seismic maps in IBC:

$$S_s \sim 0.52 \quad S_1 \sim 0.21$$

$$\text{Site Class 'C': } F_a = 1.2 \text{ at } S_s = 0.52$$

From this information, calculate S_{DS} :

$$S_{DS} = \left(\frac{2}{3}\right) * F_a * S_s = 0.42$$

Determine Category, (Seismic Use Group), from Table 1.5-1.

$$\text{Risk Category} = \text{I}$$

Find Seismic Design Category, SDC from Table 11.6-1.

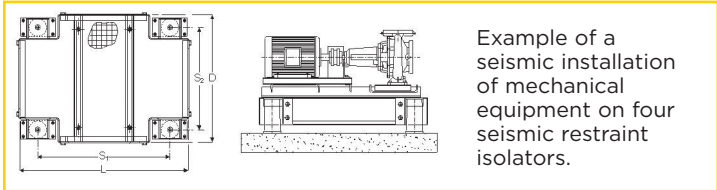
$$\text{Seismic Design Category} = \text{C}$$

From the appropriate tables:

$$a_p = 2.5 \quad R_p = 2.5 \quad I_p = 1.0$$

Check exemptions in section 13.1.4. For a Category 'C', all mechanical and electrical components with an $I_p = 1.0$ are exempt from the seismic requirements of the code.

TAG GENERIC PUMP:



Example of a seismic installation of mechanical equipment on four seismic restraint isolators.

This pump is mounted on a VMC Modular Pouring Form with 4 VMC supplied, ASCM Seismic Restraints. The mounts are to be anchored to a housekeeping pad.

W max = 200 lbs g's = 0.40 F_p = 800 lbs

Overall unit dimensions:

L = 72" D = 48" H_{max} = 18"

X_{cg} ~ 34" Y_{cg} ~ 22" H_{cg} ~ 6"

Isolator Depth, S₂ = 39"

Total Isolator Spacing, S₁ = 60"

Calculate principal angle of applied load:

$$\text{prin} \sim \arctan (S_2/S_1) = 33.0 \text{ deg}$$

$$F_{px} = 436 \text{ lbs} \quad F_{py} = 671 \text{ lbs}$$

$$M_x = F_{py} * H_{cg} + W * (D/2 - Y_{cg}) = 8025 \text{ in-lbs}$$

$$M_y = F_{px} * H_{cg} + W * (L/2 - X_{cg}) = 6616 \text{ in-lbs}$$

Maximum tension load per isolator = 158 lbs

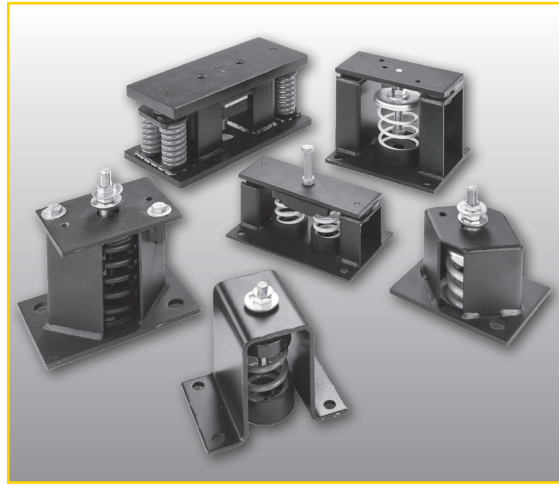
Maximum shear load per isolator = 200 lbs

The simultaneously applied allowables for an

ASCM-100 are:

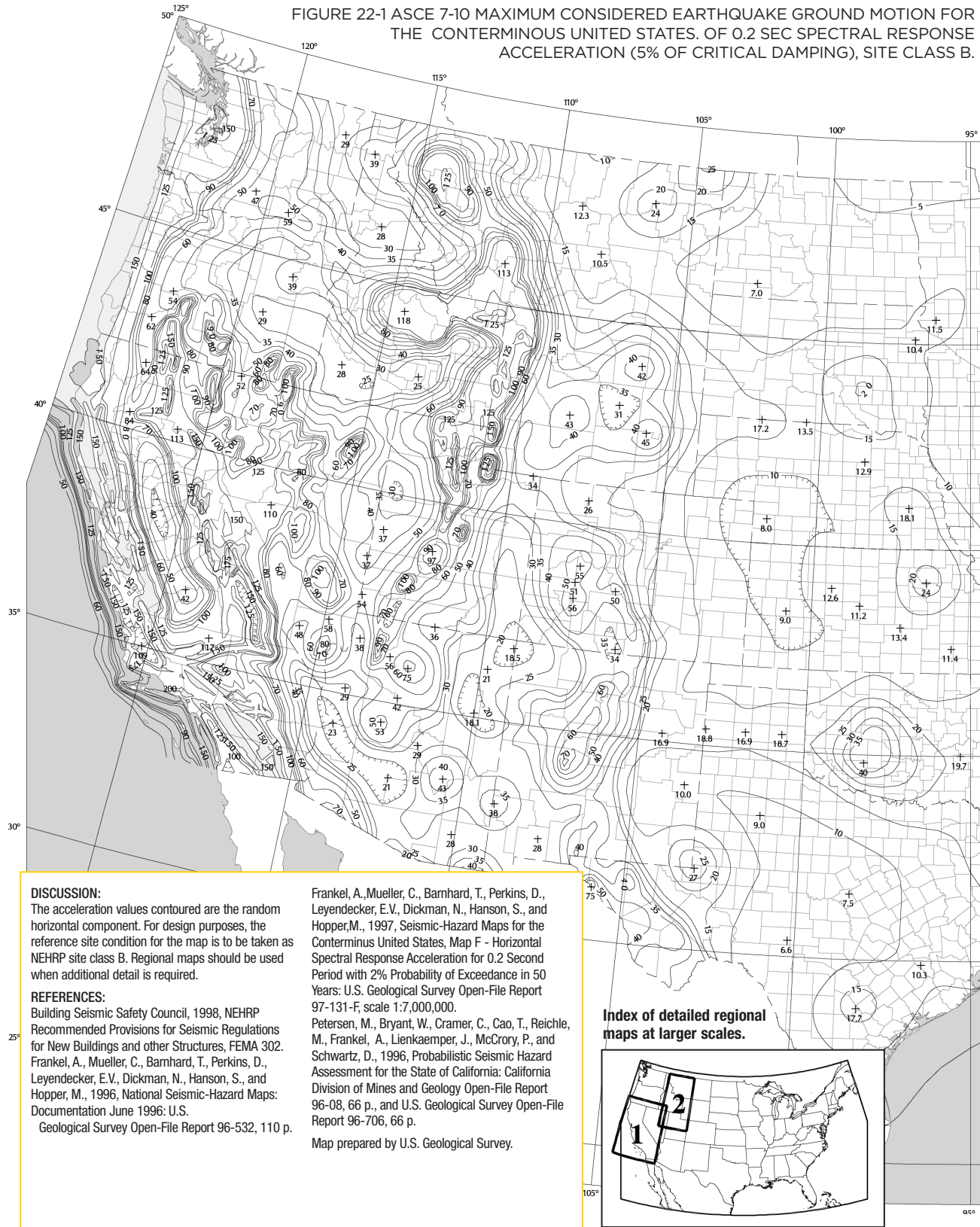
At P_t max = 158 lbs P_s all = 653 lbs

Therefore, use of this pump with 4 ASCM's is acceptable.



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FIGURE 22-1 ASCE 7-10 MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION FOR THE CONTERMINOUS UNITED STATES. OF 0.2 SEC SPECTRAL RESPONSE ACCELERATION (5% OF CRITICAL DAMPING), SITE CLASS B.



DISCUSSION:
The acceleration values contoured are the random horizontal component. For design purposes, the reference site condition for the map is to be taken as NEHRP site class B. Regional maps should be used when additional detail is required.

REFERENCES:
Building Seismic Safety Council, 1998, NEHRP Recommended Provisions for Seismic Regulations for New Buildings and other Structures, FEMA 302.
Frankel, A., Mueller, C., Barnhard, T., Perkins, D., Leyendecker, E.V., Dickman, N., Hanson, S., and Hopper, M., 1996, National Seismic-Hazard Maps: Documentation June 1996: U.S. Geological Survey Open-File Report 96-532, 110 p.

Frankel, A., Mueller, C., Barnhard, T., Perkins, D., Leyendecker, E.V., Dickman, N., Hanson, S., and Hopper, M., 1997, Seismic-Hazard Maps for the Conterminous United States, Map F - Horizontal Spectral Response Acceleration for 0.2 Second Period with 2% Probability of Exceedance in 50 Years: U.S. Geological Survey Open-File Report 97-131-F, scale 1:7,000,000.
Petersen, M., Bryant, W., Cramer, C., Cao, T., Reichle, M., Frankel, A., Lienkaemper, J., McCrory, P., and Schwartz, D., 1996, Probabilistic Seismic Hazard Assessment for the State of California: California Division of Mines and Geology Open-File Report 96-08, 66 p., and U.S. Geological Survey Open-File Report 96-706, 66 p.
Map prepared by U.S. Geological Survey.

Index of detailed regional maps at larger scales.

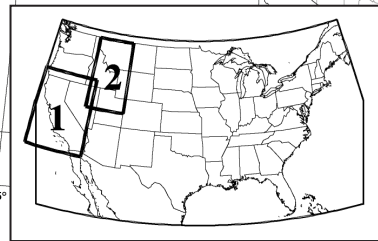
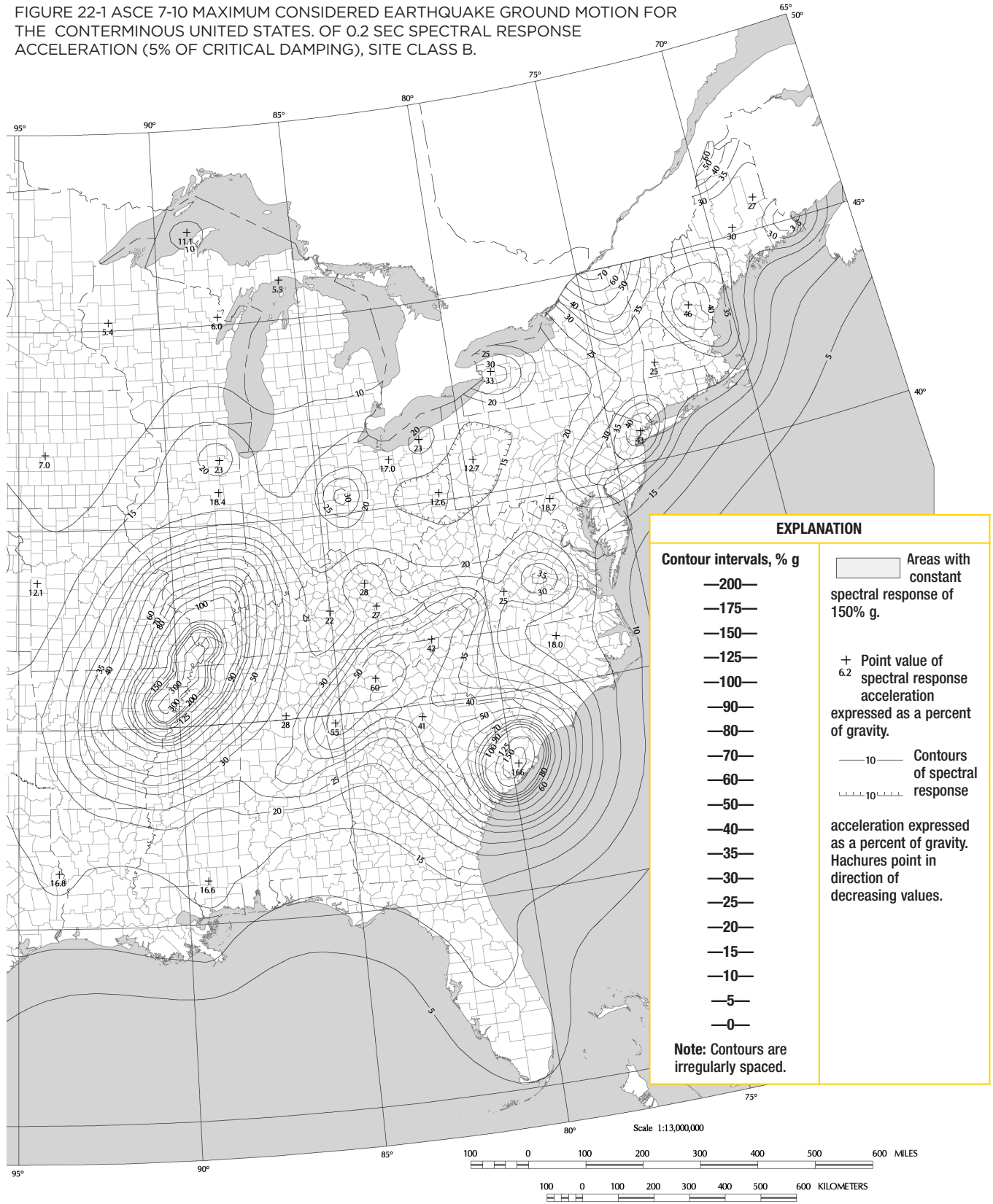


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