Appendix B

Summary of Equipment Class Descriptions and Caveats

Contents

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* GERS are included for this equipment class

Appendix B
Summary of Equipment Class Descriptions and Caveats

INTRODUCTION

The purpose of this appendix is to summarize the descriptions of the equipment classes and the inclusion and exclusion rules, also called caveats, which apply to the classes of equipment determined to be seismically rugged based on earthquake experience data and generic seismic testing data. The "equipment class descriptions" summarize the general parameters of this equipment. The "caveats" identify the important characteristics and features which an item of equipment should have in order to verify its seismic adequacy.

The procedure for using these class descriptions and caveats is covered in Section 4. Note, however, that if equipment-specific seismic qualification data is used instead of the earthquake experience data or generic seismic testing data summarized in this appendix, then the equipment should meet any specific restrictions applicable to that equipment-specific qualification data rather than the class descriptions and caveats in this appendix.

This appendix is organized by equipment class corresponding to the listing in Section 3, Table 3-1. For each equipment class, the class description and the caveats applicable to the Bounding Spectrum are given first. Next, the class description and the caveats applicable to the GERS are given, when available. (Note: Some equipment classes have more than one GERS while other classes have none.) A plot of the GERS follows the caveats for each applicable equipment class.

The class descriptions and caveats summarized in this appendix are based on the information contained in References 4, 5, and 6. More details and photographs are given in References 4 and 6. Note that in some cases, clarifying remarks have been included in this appendix which are not contained in the above reference documents. These clarifying remarks include such things as the reason for including a particular caveat, the intent of the caveat, and recommended allowables for stress analysis. These clarifying remarks are based on experience gained during the SQUG trial plant reviews and serve to help guide the Seismic Capability Engineers in making judgment.

Note: The Seismic Capability Engineers should not use the summaries contained in this appendix unless they have thoroughly reviewed and understand the above reference documents.

Certain important caveats from the above reference documents are included in this appendix even though they are also covered in other sections of the GIP, such as:

- Equipment should be adequately anchored.
- Relays for which chatter is not acceptable should be specifically evaluated.
- Possible seismic interaction concerns should not adversely affect the equipment.

Past earthquake experience has shown that these three concerns are very important to equipment seismic adequacy. The anchorage evaluation guidelines are addressed in Section 4.4 and Appendix C of the GIP. The relay evaluation guidelines are addressed in Section 6. The seismic interaction evaluation guidelines are presented in Section 4.5 and Appendix D.

Note that although the primary responsibility for conducting the relay evaluation described in Section 6 is the Lead Relay Reviewer, the Seismic Capability Engineers should be alert for any seismically induced systems effects which may lead to loss of function or malfunction of the equipment being evaluated.

B.1 MOTOR CONTROL CENTERS

B.1.1 Bounding Spectrum - Motor Control Centers

[1]The seismic capacity for the equipment class of motor control centers (MCCs) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes control and electrical fault protection systems for motors powered at 600 volts or less (typically 480 volts). Motor controllers are mounted in sheet metal cubicles with controller cubicles typically assembled into stacks which are lined up side-by-side and bolted together to form a motor control center. This equipment class includes motor controllers mounted in individual cubicles on racks or walls as well as freestanding MCCs.

Individual motor controllers are normally mounted in a sheet metal box that can be removed from its cubicle in the motor control center. Motor controllers are arranged in vertical stacks or sections attached to each other within the MCC assembly. The individual components of the motor controller are attached to the sides and rear face of the box. Motor controller cubicles typically include the following types of components: molded case circuit breaker (or disconnect switch), magnetic contactors, a control transformer, fuses, push buttons, and pilot lights.

The motor controller cubicles are typically arranged in vertical stacks within an MCC assembly. Each stack is a separate sheet metal enclosure, usually reinforced at its corners by overlapped sheet metal or steel angle framework. Stacks are bolted together through adjacent sheet metal side walls or steel framework.

Motor control centers may be either single- or double-sided. Double-sided MCCs have controller cubicles on both the front and rear face of the cabinet, with vertical bus bars routed through a center compartment between the front and rear stacks of controller cubicles. Single-sided MCCs typically route electrical connections through vertical raceways along the sides of each stack section.

Motor control centers may be either freestanding units or form part of a more complex assembly. In many cases, MCCs are included in an assembly with switchgear, distribution panels, and/or transformers. Another alternative to the freestanding motor control center is the wall- or rack-mounted motor control cubicle. Within these cubicles, motor control components are bolted to the inner faces of the wall in the same manner as in a small control or instrument cabinet. Access to the cubicle is usually through a swinging door that forms the front face of the cubicle.

MCC cabinet dimensions are generally standardized. Most MCC sections (stacks) are typically 20 to 24 inches wide, and 90 inches tall excluding the mounting channel. The depth of each section typically varies from about 18 to 24 inches. Typical weight of each section is less than about 650 pounds.

MCC cabinets can weigh up to about 800 pounds per section for assemblies consisting of at least two adjacent cabinet sections which are bolted together. Narrower depth MCC cabinets should be top-braced or attached to the wall.

The construction of motor control centers is typically governed by industry standards such as those developed by the National Electrical Manufacturers Association (NEMA) and Underwriters' Laboratories (UL) (e.g., NEMA ICS-6, UL-508). These standards define minimum sheet metal thickness as a function of wall area between reinforcement.

Motor control center assemblies represented in the equipment class contain motor starters (contactors), disconnect switches, and, in some cases, over-current relays. They also contain distribution panels, automatic transfer switches, and relay/instrumentation compartments, and include attachments such as junction boxes, conduit and cables. Motor controllers are represented in a variety of mounting configurations ranging from individual mounted controllers to MCC assemblies in outdoor enclosures.

The Bounding Spectrum (BS) represents the seismic capacity of a Motor Control Center (MCC) if the MCC meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

MCC/BS Caveat 1 - Earthquake Experience Equipment Class. The MCC should be similar to and bounded by the MCC class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst-case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MCC/BS Caveat 2 - Rating of 600 V or Less. The MCC should have a 600 V rating or less. This is the upper limit voltage rating of MCCs in the earthquake experience equipment class.

MCC/BS Caveat 3 - Adjacent Cabinets Bolted Together. Adjacent cabinets which are close enough to impact each other and sections of a multi-bay cabinet assembly should be bolted together if any of these cabinets contains essential relays as defined in Section 6. The concern addressed in this caveat is that unbolted cabinets could respond out of phase to one another and impact each other during an earthquake. This would cause impact loadings and high frequency vibration loadings which could cause any essential, impact-sensitive relays to chatter.

MCC/BS Caveat 4 - Attached Weight of 100 Pounds or Less. Equipment and their enclosures (but not conduit) mounted externally to cabinets and supported by them should have a weight less than about 100 pounds for a cabinet assembly, [2]i.e., a combination or a lineup of a number of individual adjacent cabinets, bays, or frames. The concern is that the center of gravity of the cabinet will be raised too high, the total weight of the cabinets will be too large, or large eccentric weights will introduce excessive torsion. This additional load may also reduce the natural frequency of the cabinet below 8 Hz. This concern is directed primarily toward equipment which is attached to the cabinet but is not normally supplied with the MCC and thereby possibly not included in the earthquake experience equipment class. The load path for the attached component through the cabinet should be carefully examined. In addition, its attachment should be reviewed to ascertain whether the attached component may become a seismic interaction hazard source. Conduit was deleted from this caveat since conduit supported above an MCC is well represented by the earthquake experience data. Additional support of the cabinet and attached equipment will alleviate these concerns and satisfy the intent of this caveat.

For the purposes of anchorage checking, the effective weight of any attached conduit and equipment should be included in the cabinet weight.

MCC/BS Caveat 5 - Externally Attached Items Rigidly Anchored. Externally attached items should be rigidly attached to the cabinet. The concern addressed by this caveat is that these items could impact the cabinet and possibly lead to relay chatter, or impact other components of the MCC as a seismic interaction hazard. As an example, some electrical cabinets have small, externally attached panels mounted on hinges to the main cabinet frame. During seismic motion the externally attached panel may swing and cause significant impact loading to the electrical panel.

MCC/BS Caveat 6 - General Configuration Similar to NEMA Standards. The general configuration of the cabinets should be similar to those constructed to NEMA Standards. The MCC does not have to conform exactly to the NEMA standards but should be similar with regard to the gage of the steel, internal structure and support. This caveat is intended to preclude unusual designs not covered by the equipment class (thin gage material, flimsy internal structure, etc.). In general, cabinets manufactured by the major manufacturers of MCCs conform to this caveat if they have not been modified.

MCC/BS Caveat 7 - Cutouts Not Large. Cutouts in the lower half of the cabinet sheathing should be less than 6 inches wide and 12 inches high. One concern of this caveat is that these cutouts will reduce the natural frequency. A second concern is that the shear load from the earthquake will not be able to be transferred through the shear walls to the anchorage. There are many standard MCCs that exceed this caveat; however, in many cases, the area around the cutout is reinforced with additional plate or steel members alleviating the concern of shear transfer. This caveat is of more concern for cutouts modifying the standard design that are not reinforced.

MCC/BS Caveat 8 - Doors/Buckets Secured. All doors and drawout buckets should be secured by a latch or fastener. The concern addressed by this caveat is that the doors and drawout buckets could open during an earthquake and repeatedly impact the housing, causing internal components such as relays and contactors to malfunction or chatter.

MCC/BS Caveat 9 - Natural Frequency Relative to 8 Hz Limit Considered. When using Method A from Table 4-l for comparing seismic capacity to seismic demand, the lowest natural frequency of the cabinet should be estimated in accordance with the guidelines of Section 4.2 (i.e., relative to the 8 Hz limit).

MCC/BS Caveat 10 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

MCC/BS Caveat 11 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

MCC/BS Caveat 12 - Any Other Concerns? The Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the MCC as described in Section 4.3.

B.1.2 GERS - Motor Control Centers

[1]The seismic capacity for the equipment class of MCCs may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes control and electrical fault protection systems for motors powered at 600 VAC (480 VAC nominal), 250 VDC, or less. MCCs in the testing equipment class typically include several enclosure sections which are normally about 20 inches wide, about 20 inches deep, and about 90 inches high. These sections are fabricated of 14 gage (0.0747 inches thick) or

heavier steel sheets and are supported at the floor on base channels which are either integral with the MCC frame or are external members connected by internal bolts to the MCC frame. Multiple MCC sections may be grouped together to make widths to 120 inches or greater. The weight per section of these MCCs ranges from 200 to 800 pounds.

The types of components typically housed within MCCs in the equipment class include contactors, overload relays, various types of other relays, circuit breakers, disconnect switches, control or distribution transformers, and panelboards. MCCs may also have indicator lamps and meters mounted on them.

The GERS represent the seismic capacity of a Motor Control Center (MCC) if the MCC meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

MCC/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The MCC should be similar to and bounded by the MCC class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MCC/GERS Caveat 2 - Bounding Spectrum Caveats. The MCC should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

MCC/GERS Caveat 3 - Floor-Mounted Cabinet. The MCC should be floor-mounted. This is the mounting configuration for all MCCs in the generic seismic testing equipment class.

MCC/GERS Caveat 4 - Weight Less Than 800 Pounds. The maximum weight per vertical section should be less than about 800 pounds. This is the upper bound weight of MCCs in the generic seismic testing equipment class.

MCC/GERS Caveat 5 - Anchored Through Base Channel. The MCC should be anchored through a base channel integral to the MCC frame or an external base channel which is connected to the MCC frame by internal bolts. The intent of this caveat is to avoid anchoring

MCCs through flimsy or flexible sections in which significant bending of sheet metal could occur during an earthquake.

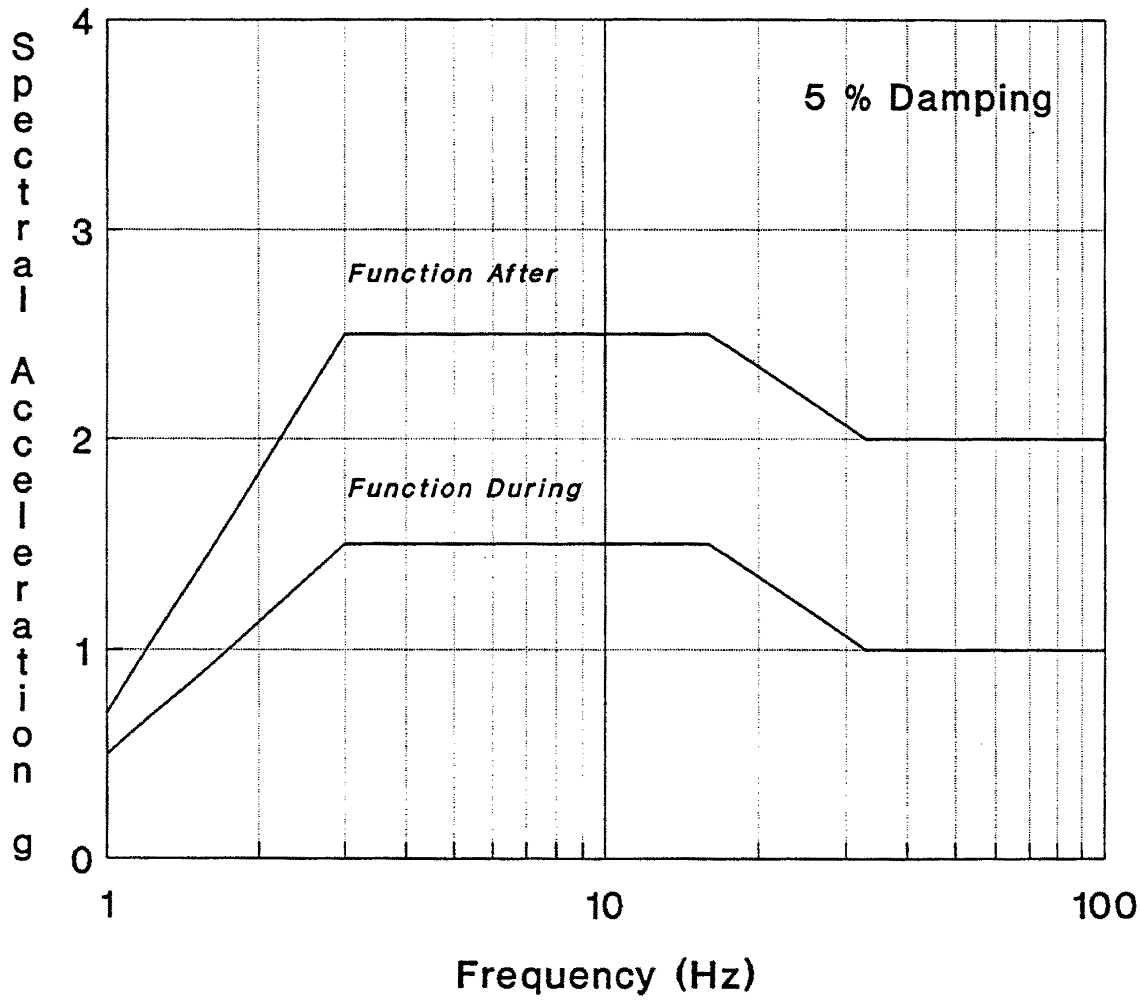
MCC/GERS Caveat 6 - Load Path Check. To use the “Function After” GERS, the load transfer path from the anchorage to base frame of the MCC should be checked for strength and stiffness. In particular, the following load path elements should be checked for adequacy. There should be stiff anchorage connections for each section to secure the unit to the floor, e.g., 4 anchors for a single MCC cabinet or 2 anchors for interior cabinets in a multi-cabinet assembly if these anchors are located near the shear wall of the cabinet and adjacent cabinets are bolted together. If the MCC frame is connected to external base structural members provided by the manufacturer with internal mounting bolts, then there should be at least four of these internal mounting bolts per section, and these bolts should be at least 3/8 inches in diameter. Any sheet metal cabinet components used for anchorage should have reinforcement. Excessive eccentricities in the internal load path which allow significant bending of sheet metal should be evaluated separately for strength and stiffness.

MCC/GERS Caveat 7 - “Function During” GERS. The “Function During” GERS can be used only if all the relays within the MCC have GERS greater than 4.5g within the amplified spectral region. For this caveat, the term “relays” does not include contactors and other starter components. Auxiliary contacts of contactors require a separate relay evaluation as described in Section 6 if they are used for external control or lockout signals.

MCC/GERS Caveat 8 - “Function After” GERS. The “Function After” GERS can be used if it can be demonstrated that the starters can be reset. The Relay Functionality Review in Section 6 describes the guidelines for evaluating the acceptability of resetting relays and starters. Note that, in general, both system tolerance of the changed state and operator availability for manual reset should be shown.

[3]MCC/GERS Caveat 9 – Adjacent Cabinets Bolted Together. Adjacent cabinets and sections of a multi-bay cabinet assembly should be bolted together, including those that do not contain essential relays. Adjacent cabinets and sections of multi-bay cabinet assemblies were bolted together when tested for this generic seismic testing equipment class.

GERS-MCC.9
2/1/91



Frequency (Hz)	1	3	16	33
Function After (g)	0.7	2.5	2.5	2.0
Function During (g)	0.5	1.5	1.5	1.0

Figure B.1-1. Generic Equipment Ruggedness Spectra (GERS) for Motor Control Centers (Source: Reference 6)

B.2 LOW VOLTAGE SWITCHGEAR

B.2.1 Bounding Spectrum - Low Voltage Switchgear (LVS)

[1]The seismic capacity for the equipment class of low voltage switchgear (LVS) assemblies may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of one or more circuit breakers and associated control relays, instrumentation, disconnect switches, and distribution buses mounted in a sheet metal enclosure. The term "low voltage switchgear" is associated with circuits of 600 volts or less, typically 440 to 480 volts in modern power plants and industrial facilities.

Switchgear assemblies are composed of vertical sections which normally contain stacks of two to four circuit breaker cubicles. The vertical section is a sheet metal enclosure welded to a framework of steel angles or channels. Each section includes a circuit breaker or other control devices in a forward compartment and bus connections for the primary circuits in the rear compartment.

A section of a switchgear assembly is typically 90 inches in height and 60 inches in depth. The width of each section ranges from 20 to 36 inches, depending on the size of the circuit breaker it contains. A typical section weighs about 2000 pounds. Individual sections are bolted together through adjoining walls to form an assembly. LVS assemblies normally include at least one cubicle that serves as a metering compartment. The compartment typically contains ammeters, voltmeters, relays, and transformers.

Most low voltage circuit breakers are the drawout type. They are mounted on a roller/rail support system that allows them to be disconnected from their primary contacts at the rear, and drawn forward out of their sheet metal enclosure for maintenance. While in operation, the circuit breaker clamps to bus bars in the rear of the switchgear assembly. Additional positive attachment of the breaker to its enclosure is made by a mechanical jack or racking mechanism which slides the breaker in or out of its operating position.

The circuit breaker can include the following types of components: spring-actuated electric contacts, a closing solenoid, various types of tripping devices (overcurrent, shunt, under voltage), fuses, and auxiliary switches.

Low voltage breakers may be combined in assemblies with transformers, distribution panels, medium voltage breakers, and motor controllers. Circuit breakers, relays, instrumentation, the switchgear assembly enclosure, internal transformers, attachments such as junction boxes, and attached conduit and cables are included in the Low Voltage Switchgear equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Low Voltage Switchgear (LVS) if the switchgear meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>LVS/BS Caveat 1 - Earthquake Experience Equipment Class</u>. The low voltage switchgear should be similar to and bounded by the LVS class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

<u>LVS/BS Caveat 2 - Rating of 600 V or Less</u>. The low voltage switchgear should have a 600 V rating or less. This is the upper bound voltage rating of LVS in the earthquake experience equipment class.

<u>LVS/BS Caveat 3 - Side-to-Side Restraint of Breaker</u>. The support structure for circuit breakers of the drawout type should have side-to-side restraint to limit relative motion with respect to the cabinet. The concern is to prevent damage or disconnection of secondary contacts. Restraint may be provided by the breaker support structure or by a special lateral restraint device.

<u>LVS/BS Caveat 4 - Adjacent Cabinets Bolted Together</u>. Adjacent cabinets which are close enough to impact each other and sections of multi-bay cabinet assemblies should be bolted together if any of these cabinets contain essential relays as defined in Section 6. The concern addressed in this caveat is that unbolted cabinets could respond out of phase to one another and impact each other during an earthquake. This would cause additional impact loadings and high frequency vibration loadings which could cause any essential relays to chatter.

<u>LVS/BS Caveat 5 - Attached Weight of 100 Pounds or Less</u>. Equipment and their enclosures (but not conduit) mounted externally to cabinets and supported by them should have a weight less than about 100 pounds for a cabinet assembly, [2]i.e., a combination or a lineup of a number

of individual adjacent cabinets, bays, or frames. The concern is that the center of gravity of the cabinet will be raised too high, the total weight of the cabinets will be too large, or large eccentric weights will introduce excessive torsion. The concern is directed primarily for equipment not normally supplied with the switchgear and thereby possibly not included in the earthquake experience equipment class. The load path of the attached component through the cabinet should be carefully examined. In addition, its attachment should be reviewed to ascertain whether the attached component may become a seismic interaction hazard source. Conduit was deleted from the caveat since conduit supported above switchgear is well represented by the earthquake experience data. Additional support of the cabinet and attached equipment will alleviate these concerns and satisfy the intent of this caveat.

For the purposes of anchorage checking, the effective weight of any attached conduit and equipment should be included in the cabinet weight.

<u>LVS/BS Caveat 6 - Externally Attached Items Rigidly Anchored</u>. Externally attached items should be rigidly attached to the cabinet. The concern addressed by this caveat is that these items could impact the cabinet and possibly lead to relay chatter, or impact other components of the switchgear as a seismic interaction hazard. As an example, some electrical cabinets have small, externally attached panels mounted on hinges to the main cabinet frame. During seismic motion the externally attached panel may swing and cause significant impact loading to the electrical panel.

<u>LVS/BS Caveat 7 - General Configuration Similar to ANSI C37.20 Standards</u>. The general configuration of the cabinets should be similar to those constructed to ANSI C37.20 Standards. The switchgear does not have to conform exactly to ANSI standards but should be similar with regard to the gage of the steel, internal structure and support. This caveat is intended to preclude unusual designs not covered by the equipment class (thin gage material, flimsy internal structure, etc.) In general, cabinets manufactured by the major manufacturers of switchgear conform to this caveat if they have not been modified.

<u>LVS/BS Caveat 8 - Cutouts Not Large</u>. Cutouts in the lower half of cabinet sheathing should be less than 30% of the width of the side panel, and the height of the cutout should be less then 60% of the width of the side panel. This caveat also applies to side panels between multi-bay cabinets. Cutout restrictions do not apply to the bus transfer compartment if the remaining part of the enclosure conforms with the cutout limitation. The concern of this caveat is that the shear load from the earthquake will not be able to be transferred through the shear walls to the anchorage. Reinforcement around the cutout with additional plate or steel members may alleviate the concern of shear transfer.

<u>LVS/BS Caveat 9 - Doors Secured</u>. All doors should be secured by a latch or fastener. The concern addressed by this caveat is that loose doors could repeatedly impact the housing and be damaged or cause internal components such as relays to malfunction or chatter.

<u>LVS/BS Caveat 10 - Adequate Anchorage</u>. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

<u>LVS/BS Caveat 11 - Potential Chatter of Essential Relays Evaluated</u>. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

LVS/BS Caveat 12 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the switchgear as described in Section 4.3.

B.2.2 GERS - Low Voltage Switchgear

[1]The seismic capacity for the equipment class of LVS may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes steel enclosures containing several draw-out type circuit breakers, bus bars, protective/auxiliary relays, and meters. Units have a maximum rating of 600 VAC or 250 VDC. The metal enclosure sections are typically 20 to 30 inches wide, 60 inches deep, and 80 to 90 inches high. They are fabricated of 14 gage (0.0747 inches thick) or heavier steel sheet metal and framed with angles or other formed members, with anchorage provisions included in the base frame. The weight per section of the switchgear assembly ranges from 1000 to 1600 pounds. The units should be mounted within ANSI-type metal enclosures with either welded or bolted anchorage. To exclude specialty-type switchgear, the equipment class is limited to the following three manufacturers: ITE/Brown Boveri, Westinghouse, or General Electric.

The GERS represent the seismic capacity of a Low Voltage Switchgear (LVS) if the switchgear meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

LVS/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The low voltage switchgear should be similar to and bounded by the LVS class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

LVS/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The switchgear should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

LVS/GERS Caveat 3 - Floor-Mounted Switchgear. The low voltage switchgear must be housed within a floor-mounted ANSI-type enclosure. This ensures consistency with enclosures included in the generic seismic testing equipment class.

LVS/GERS Caveat 4 - No Specially Designed Switchgear. The GERS are not applicable to specially designed or custom-made switchgear, such as those which have been used in some reactor trip systems. To preclude their use, the switchgear should be manufactured by [4]ITE/Brown Boveri, Westinghouse, or General Electric. These are the manufacturers which produced the switchgear included in the generic seismic testing equipment class.

LVS/GERS Caveat 5 - Weight Per Section Less than 1600 Pounds. The maximum weight per section should be less than about 1600 pounds. This is the upper bound weight limit of LVS in the generic seismic testing equipment class.

LVS/GERS Caveat 6 - Base Anchorage Evaluation. The switchgear should be base anchored and the installed anchorage should be evaluated as described in Section 4. This caveat ensures consistency with the generic seismic testing equipment class.

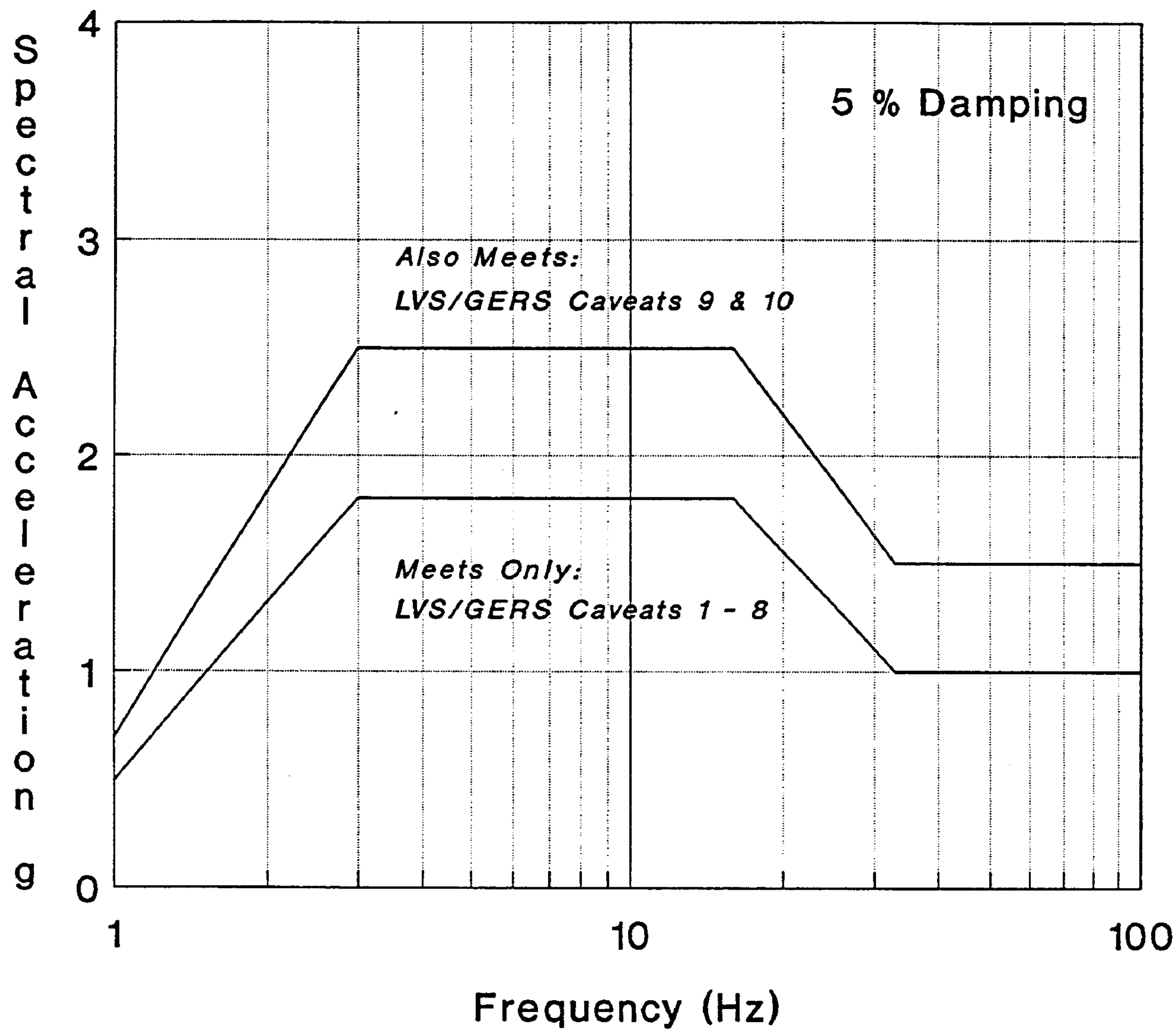
LVS/GERS Caveat 7 - Breaker Function Relays Should Not Be On Low Ruggedness Relays List. Relays which control switchgear operation should not appear on the Low Ruggedness Relays list (given in Reference 8).

LVS/GERS Caveat 8 - Relay Screening Required for Other Functions. A separate relay screening evaluation is required only for those relays in the switchgear which are essential to other equipment or will cause an unacceptable lockout of equipment function. Relays which control switchgear operation are addressed in LVS/GERS Caveat 7. The guidelines for identifying and evaluating switchgear relays are summarized in Section 6 and described in Reference 8.

LVS/GERS Caveat 9 - Vertical Restraint in the Form of Stops or Brackets. To utilize the 2.5g GERS level, vertical restraint in the form of stops or brackets should be provided to prevent uplift of the circuit breaker so that the wheels do not come disengaged from rails.

LVS/GERS Caveat 10 - Reinforcement of Outside Corners of End Units. To utilize the 2.5g GERS level, the outside base frame corners of the outer switchgear cabinets in a lineup should have certain enhancements to improve their seismic ruggedness. For Westinghouse type switchgear, the outside base frame corners of the outer switchgear cabinets in a lineup should be reinforced. For the other types of switchgear, the manufacturers (GE, ITE) should be consulted to determine what enhancements, if any, should be included in their switchgear cabinets to give them this seismic ruggedness level and then check whether these enhancements have been included on these units.

[3]LVS/GERS Caveat 11 – Adjacent Cabinets Bolted Together. Adjacent cabinets and sections of a multi-bay cabinet assembly should be bolted together, including those that do not contain essential relays. Adjacent cabinets and sections of multi-bay cabinet assemblies were bolted together when tested for this generic seismic testing equipment class.



Frequency (Hz)	1	3	16	33
Meets LVS/GERS Caveats 1 - 10 (g)	0.7	2.5	2.5	1.5
Meets LVS/GERS Caveats 1 - 8 (g)	0.5	1.8	1.8	1.0

Figure B.2-1. Generic Equipment Ruggedness Spectra (GERS) for Low Voltage Switchgear (Source: Reference 6)

B.3 MEDIUM VOLTAGE SWITCHGEAR

B.3.1 Bounding Spectrum - Medium Voltage Switchgear (MVS)

[1]The seismic capacity for the equipment class of medium voltage switchgear (MVS) assemblies may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of one or more circuit breakers and associated control relays and instrumentation mounted in a sheet metal enclosure. The equipment class includes electrical switching and fault protection circuit breakers for systems powered between 2400 and 4160 volts. Medium voltage circuit breakers are mounted in sheet metal cabinets which are bolted together, side-by-side, to form a switchgear assembly.

Medium voltage circuit breakers or load interrupter switches are often integrated into unit substations that may include a transformer (typically 4160/480 volt), a set of low voltage switchgear, or a distribution switchboard. The switchgear assembly also may include internal transformers, junction boxes, and attached conduit and cables. The basic component of a medium voltage switchgear assembly is a metal-clad enclosure, typically containing a circuit breaker compartment in a lower section and a metering compartment in an upper section. The rear of the enclosure is a separate compartment for primary electrical connections. The enclosure consists of sheet metal panels welded to a supporting frame of steel angles or channels. Individual enclosures are typically 90 inches in height and approximately 90 inches in depth. The width of an enclosure typically varies from 24 to 36 inches, depending on the size of the circuit breaker within. The weight of a metal-clad enclosure ranges from 2000 to 3000 pounds, with the circuit breaker itself weighing from 600 to 1200 pounds.

Electro-mechanical relays are mounted either to the swinging doors at the front of the enclosure, or to the interior of the metering compartment. Relays are typically inserted through cutouts in the door and secured by screws through a mounting flange into the sheet metal. The metering compartment may also contain components such as ammeters, voltmeters, hand switches, and small transformers.

The medium voltage circuit breakers commonly used in power plant applications include the drawout-type air-magnetic circuit breakers, and stationary load interrupter switches. Each type is discussed in this section.

Drawout, air-magnetic circuit breakers are mounted on rollers to allow them to be wheeled in and out of their individual sheet metal enclosures. There are two general types of drawout circuit breakers: the horizontally racked model and the vertically racked model.

The <u>horizontally racked</u> model has clamping bus connections at its rear. It is racked into operating position by a mechanical jack that rolls the circuit breaker into contact with the bus connections at the rear of its enclosure and secures it in place. The weight of the circuit breaker rests on the floor.

<u>Vertically racked</u> circuit breakers roll into position within their enclosure and are then engaged by a jack built into the walls of the enclosure. The jack lifts the circuit breaker several inches above the floor, until the clamping connections atop the circuit breaker contact the bus connections at the top of the enclosure. The weight of the circuit breaker is then supported on the framework of the sheet metal enclosure. Lateral restraint of the circuit breaker should be provided by the cabinet framing and not solely by the jack lifts.

Air-magnetic circuit breakers typically include the following types of components: spring-actuated contacts, tripping devices, auxiliary switches, and fuses. Typical capacities for medium voltage circuit breakers range from 1200 to 3000 amperes.

Load interrupter switches perform the load connecting and interrupting function of circuit breakers, but do not include the same capabilities of electrical fault protection. Interrupter switches are bolted into sheet metal enclosures and are therefore designated as stationary devices. Like air-magnetic circuit breakers, interrupter switches usually operate with spring-actuated contacts to ensure quick opening of the primary circuit.

The Bounding Spectrum (BS) represents the seismic capacity of a Medium Voltage Switchgear (MVS) if the switchgear meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

MVS/BS Caveat 1 - Earthquake Experience Equipment Class. The switchgear should be similar to and bounded by the MVS class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MVS/BS Caveat 2 - Rating between 2.4 kV and 4.16 kV. The switchgear should have a rating between 2.4 kV and 4.16 kV. This is the typical voltage range of MVS of this earthquake experience equipment class.

MVS/BS Caveat 3 - Transformers Restrained from Relative Motion. Potential transformers and/or control power transformers mounted on the switchgear should have restraints that limit relative motion of the transformers to prevent damage or disconnection of contacts. In particular, trunnion-mounted transformers should have positive vertical restraint to keep the trunnion pin in its cradle. Positive vertical restraint of the trunnion pin is not required if the seismic demand at the base of the switchgear cabinet is less than or equal to about l/2 of 1.5 x Bounding Spectrum, i.e., less than 0.75 x Bounding Spectrum.

MVS/BS Caveat 4 - Adjacent Cabinets Bolted Together. Adjacent cabinets which are close enough to impact each other and sections of multi-bay cabinet assemblies should be bolted together if any of these cabinets contain essential relays as defined in Section 6. The concern addressed in this caveat is that unbolted cabinets could respond out of phase to one another and impact each other during an earthquake. This would cause additional impact loadings and high frequency vibration loadings which could cause the essential relays to chatter.

MVS/BS Cave at 5 - Attached Weight of 100 Pounds or Less. Equipment and their enclosures (but not conduit) mounted externally to cabinets and supported by them should have a weight less than about 100 pounds for a cabinet assembly, [2]i.e., a combination or a lineup of a number of individual adjacent cabinets, bays, or frames. The concern is that the center of gravity of the cabinet will be raised too high, the total weight of the cabinets will be too large, or large eccentric weights will introduce excessive torsion. The concern is directed primarily for equipment not normally supplied with the switchgear and thereby possibly not included in the earthquake experience equipment class. The load path for the attached component through the cabinet should be carefully examined. In addition, its attachment should be reviewed to ascertain whether the attached component may become a seismic interaction hazard source. Conduit was deleted from the caveat since conduit supported above switchgear is well represented in the seismic experience database. Additional support of the cabinet and attached equipment will alleviate these concerns and satisfy the intent of this caveat.

For the purposes of anchorage checking, the effective weight of any attached conduit and equipment should be included in the cabinet weight.

MVS/BS Caveat 6 - Externally Attached Items Rigidly Anchored. Externally attached items should be rigidly attached to the cabinet. The concern addressed by this caveat is that these items could impact the cabinet and possibly lead to relay chatter or impact other components of the switchgear as a seismic interaction hazard. As an example, some electrical cabinets have small, externally attached panels mounted on hinges to the main cabinet frame. During seismic motion the externally attached panel may swing and cause significant impact loading to the electrical panel.

MVS/BS Caveat 7 - General Configuration Similar to ANSI C37.20 Standards. The general configuration of the cabinets should be similar to those constructed to ANSI C37.20 Standards. The switchgear does not have to conform exactly to ANSI standards but should be similar with regard to the gage of the steel, internal structure, and support. This caveat is intended to preclude unusual designs not covered by the equipment class (thin gage material, flimsy internal structure, etc.). In general, cabinets manufactured by the major manufacturers of switchgear conform to this caveat if they have not been modified.

MVS/BS Caveat 8 - Cutouts Not Large. Cutouts in the lower half of cabinet sheathing should be less than 30% of the width of the side panel, and the height of the cutout should be less than 60% of the width of the side panel. This caveat also applies to side panels between multi-bay cabinets. Cutout restrictions do not apply to the bus transfer compartment if the remaining part of the enclosure conforms [4]to the cutout limitations. The concern of this caveat is that the shear load from the earthquake will not be able to be transferred through the shear walls to the anchorage. Reinforcement around the cutout with additional plate or steel members may alleviate the concern of shear transfer.

MVS/BS Caveat 9 - Doors Secured. All doors should be secured by a latch or fastener. The concern addressed by this caveat is that the doors could open during an earthquake, and the loose door could repeatedly impact the housing and be damaged or cause internal components such as relays to malfunction or chatter.

MVS/BS Caveat 10 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

MVS/BS Caveat 11 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

MVS/BS Caveat 12 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the switchgear as described in Section 4.3.

B.3.2 GERS - Medium Voltage Switchgear

[1]The seismic capacity for the equipment class of metal clad medium-voltage switchgear may be based on generic testing data (as described in Section 4.2), provided the intent of each of the

caveats listed below is met. This equipment class includes steel panel enclosures containing several wheel-mounted draw-out type circuit breakers, bus bars, auxiliary/ protective relays, transformers, switches, and meters. Units are medium voltage rated at 5000 VAC. Circuit breakers which must be jacked up to engage (vertical lift) into the connected position are not included in this class. The equipment in the GERS equipment class include ANSI C37.20 enclosures whose nominal section sizes are 30 inches wide, 60 inches deep, and 90 inches high. They are fabricated of 12 gage (0.1046 inches thick) or heavier steel sheet metal and framed with angles or other formed members, with anchorage provisions included in the base frame. Widths of MVS can range between 24 inches and 42 inches. Some cubicles can be essentially empty, while other cubicles can house very heavy circuit breaker units. In general, a single cubicle which houses a circuit breaker can typically weigh between 3000 and 5000 pounds. The MVS GERS equipment class covers most medium voltage switchgear used in power plants for overcurrent protection in primary voltage (normally 4160 VAC) distribution systems.

The GERS represent the seismic capacity of a Medium Voltage Switchgear (MVS) if the switchgear meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

MVS/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The switchgear should be similar to, and bounded by, the MVS class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MVS/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The switchgear should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

MVS/GERS Caveat 3 - Floor-Mounted Switchgear. The medium-voltage switchgear should be housed within a floor-mounted ANSI-type enclosure. This ensures consistency with the enclosures included in the generic seismic testing equipment class.

MVS/GERS Caveat 4 - No Specially Designed Switchgear. The GERS are not applicable to specially designed or custom-made switchgear, such as those which have been used in some reactor trip systems. Specially designed switchgear are not included in the generic seismic testing equipment class.

MVS/GERS Caveat 5 - No Jack-Up or Vertical-Lift Type Breakers. The breakers should be the wheel-mounted type and not a jack-up or vertical-lift type. This is the only breaker configuration represented in the generic seismic testing equipment class.

MVS/GERS Caveat 6 - Weight Per Section Less than 5000 Pounds. The maximum weight per vertical breaker section should be less than about 5000 pounds (review of manufacturer's generic seismic testing equipment class.

MVS/GERS Caveat 7 - Base Anchorage Evaluation. The switchgear should be base anchored and the installed anchorage should be evaluated as described in Section 4. This caveat ensures consistency with the generic seismic testing equipment class.

MVS/GERS Caveat 8 - Breaker Function Relays Should Not Be On Low-Ruggedness Relays List. Relays which control switchgear operation should not appear on the Low Ruggedness Relays list (given in Reference 8).

MVS/GERS Caveat 9 - Relay Screening Required for Other Functions. A separate relay screening evaluation is required only for those relays in the switchgear which are essential to other equipment or will cause an unacceptable lockout of equipment function. Relays which control switchgear operation are addressed in MVS/GERS Caveat 8. The guidelines for identifying and evaluating switchgear relays are summarized in Section 6 and described in Reference 8.

MVS/GERS Caveat 10 - Vertical Restraint of Breaker. To utilize the 2.5g GERS level, vertical restraint in the form of stops or brackets should be provided to prevent uplift of the circuit breaker so that the wheels do not become disengaged from the rails.

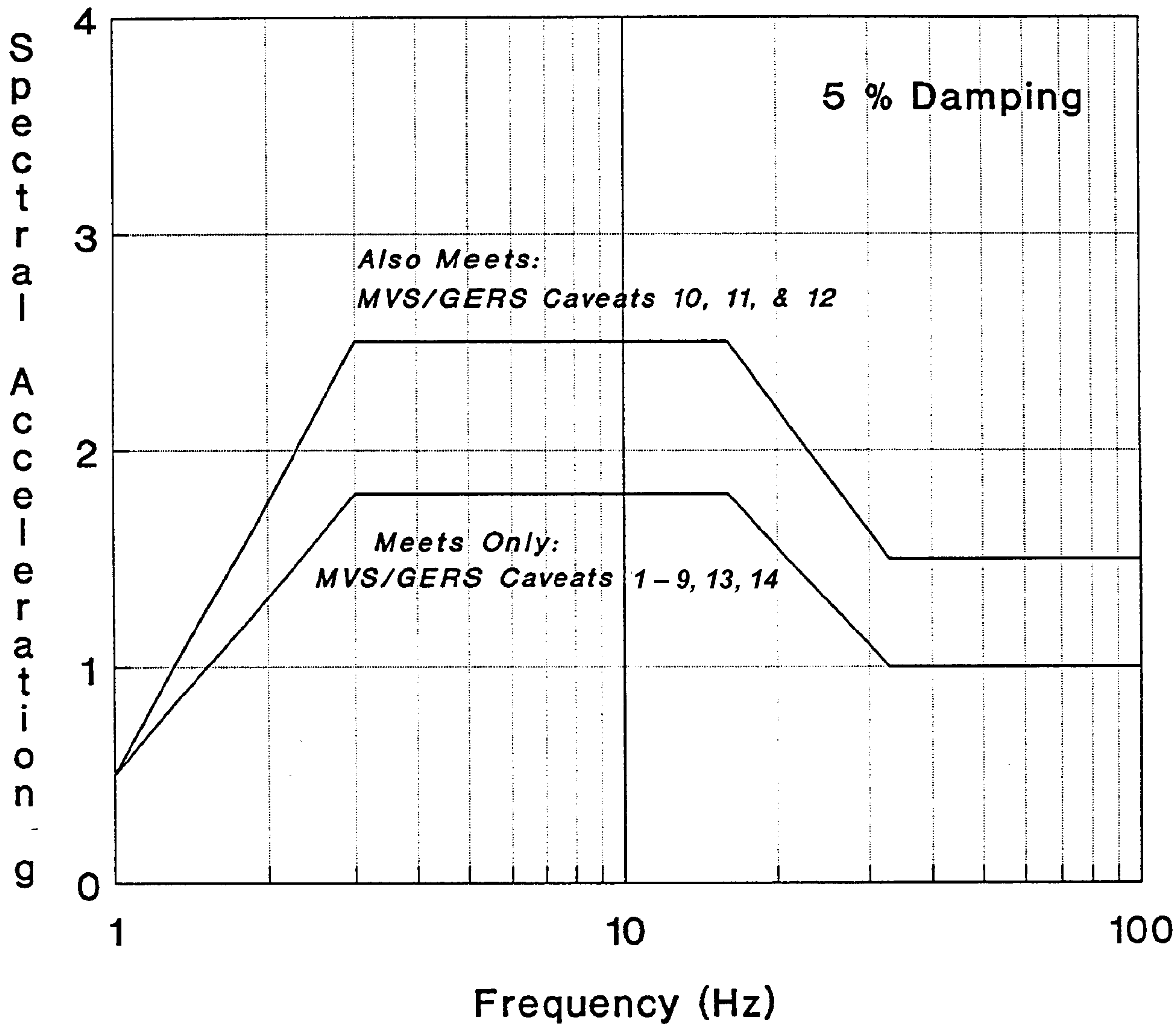
MVS/GERS Caveat 11 - Horizontal Restraint of Arc Chutes. To utilize the 2.5g GERS level, horizontal restraint of the circuit breaker arc chutes should be provided. This restraint may take the form of blocks between adjacent arc chutes and between arc chutes and the wall or frame of the cabinet.

MVS/GERS Caveat 12 - Relay Model Excluded. The 2.5g level GERS can not be used for Westinghouse medium-voltage switchgear if the “Y” anti-pump relay is a Beaver Type Z.

MVS/GERS Caveat 13 - Separate Evaluation of Racking Mechanism. Breaker positioning or racking mechanisms should be evaluated. There should be side-to-side restraint of the breaker to prevent secondary/auxiliary breaker contacts from opening. The evaluation may consist of a visual inspection by the Seismic Capability Engineers. This caveat is intended to address potential damage or operational problems due to excessive relative motion between the drawout breaker and the switchgear cabinet frame as observed in an example from the generic seismic test data.

[3]MVS/GERS Caveat 14 – Adjacent Cabinets Bolted Together. Adjacent cabinets and sections of a multi-bay cabinet assembly should be bolted together, including those that do not contain essential relays. Adjacent cabinets and sections of multi-bay cabinet assemblies were bolted together when tested for this generic seismic testing equipment class.

GERS-MVS/LVS.7 (Medium Voltage)
2/1/91



Frequency (Hz)	1	3	16	33
Meets MVS/GERS Caveats 1 – 14 (g)	0.5	2.5	2.5	1.5
Meets MVS/GERS Caveats 1 – 9, 13, 14 (g)	0.5	1.8	1.8	1.0

Figure B.3-1. Generic Equipment Ruggedness Spectra (GERS) for Medium Voltage Switchgear[3]
(Source: Reference 6)

B.4 TRANSFORMERS

B.4.1 Bounding Spectrum - Transformers (TRN)

[1]The seismic capacity for the equipment class of transformers (TRN) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes the unit substation type, typically 4160/480 volts, and the distribution type, typically 480/120 volts. Main power transformers with primary voltages greater than about 13,800 volts are not included in this equipment class. Small transformers that are components of electrical equipment, such as motor control centers or control panels, are also not included in this equipment class but are addressed as components of other classes of electrical equipment.

Unit substation transformers step power down from the medium voltage levels (typically 4160 volts for use in large mechanical equipment) to lower voltage levels (typically 480 volts) for use in smaller equipment. Distribution transformers usually step power from the 480 volt level to the 120 to 240 volt level to operate small mechanical equipment, battery chargers, or lighting systems.

Unit substation transformers included in the equipment class can be freestanding or attached to motor control centers or switchgear assemblies. They typically have primary voltages of 2400 to 4160 volts, and secondary voltages of 480 volts. This transformer type may be either liquid- or air-cooled. Liquid-cooled units typically consist of a rectangular steel tank filled with oil or a similar insulating fluid. The transformer coils are submerged in a liquid bath which provides cooling and insulation within the steel tank casing. Most liquid-filled transformers have one or more radiator coils attached to the side of the transformer.

Air-cooled or dry-type unit substation transformers are similar in size and construction to liquid-cooled units, except the transformer coils are mounted in a ventilated steel enclosure, rather than a liquid bath. Larger air-cooled unit substation transformers may have small fans mounted to their enclosures for forced air-cooling.

The casings of both liquid-cooled and air-cooled unit substation transformers have typical overall dimensions of 60 to 100 inches in height, and 40 to 100 inches in width and depth. The weights of these units range from 2000 to 15,000 pounds.

Distribution transformers typically have primary voltages of 480 volts stepping down to secondary voltages of 120 to 240 volts. This type of transformer is almost always air-cooled. The construction of distribution transformers is essentially the same as that of unit substation transformers, except for a difference in size. The sizes of typical distribution transformers range from small wall-mounted or cabinet-mounted units that have overall dimensions of about 10 inches in height, width, and depth, and weights of 50 to 100 pounds; to larger units that are typically floor-mounted with dimensions ranging up to the size of unit substation transformers and weights ranging up to 5000 pounds.

The transformer equipment class includes the enclosure along with the internals and attached cable and conduit.

The Bounding Spectrum (BS) represents the seismic capacity of a Transformer (TRN) if the transformer meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>TRN/BS Caveat 1 - Earthquake Experience Equipment Class</u>. The transformer should be similar to and bounded by the TRN class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

<u>TRN/BS Caveat 2 - Rating of 4.16 kV or Less</u>. The transformer should have a 4.16 kV rating or less. This is the upper bound voltage rating of transformers included in the earthquake experience equipment class.

<u>TRN/BS Caveat 3 - Transformer Coils Positively Restrained Within Cabinet</u>. For floor-mounted dry- and oil-type units, the transformer coils should be positively restrained within their cabinet so that relative sliding and rocking motions between the transformer coil and their cabinet is kept to an acceptable level. The concern is that excessive relative motions may damage the wiring

yoke, or that the coils may come in contact with their cabinet which may result in a short circuit or damage to the electrical insulation. This caveat especially applies to transformers whose installation procedure recommends that bolts used to anchor the coils during shipping be removed. If the unit is factory-sealed or constructed so that removing shipping anchors is precluded, no internal inspection is necessary.

TRN/BS Caveat 4 - Coils Top-Braced or Analyzed for Large Transformers. Large transformers of 750 kVA or larger should also have the top of the coils braced by a structural frame or should be analyzed for adequate restraint. If the unit is factory-sealed or constructed so that removing shipping anchors is precluded, no internal inspection is necessary.

TRN/BS Caveat 5 - Clearance Between Energized Component and Cabinet. For 750 kVA transformers and larger, there should be at least a 2-inch gap between the energized component and the upper portion of the transformer cabinet. If the gap is less than 2 inches, it should be verified by analysis that there is sufficient gap and/or there should be provisions for relative lateral displacement to preclude contact between the energized component and the cabinet. The concern is that without adequate clearance, transformers could be shorted out during the earthquake and thereby rendered inoperable.

TRN/BS Caveat 6 - Adequate Slack in High Voltage Leads. For 750 kVA transformers and larger, the connection between the high voltage leads and the first anchor point should accommodate at least a 3-inch relative displacement, or should be analyzed for adequate slack for relative displacement.

TRN/BS Caveat 7 - Wall-Mounted Units Anchored Close to Enclosure Support. The transformer coil contained in wall-mounted units should have engineered anchorage and be anchored to its enclosure near the enclosure support surface. The concern is that a well-engineered load path should exist for earthquake loadings from the transformer coil (which is relatively massive), through the enclosure, and to the enclosure support. If the transformer coil is not anchored to the enclosure near the enclosure support surface, a calculation can be performed to show that the earthquake loadings can be transferred to the anchorage.

TRN/BS Caveat 8 - Weak-Way Bending. The base assembly of floor-mounted units should be properly braced or stiffened such that lateral forces in any direction do not rely on weak-way bending of sheet metal or thin webs of structural steel shapes. If unbraced or unstiffened steel webs are used, they should be specially evaluated so that adequate strength and stiffness is ensured.

TRN/BS Caveat 9 - Adjacent Cabinets Bolted Together. Adjacent cabinets which are close enough to impact each other, and sections of multi-bay cabinet assemblies should be bolted together if any of these cabinets contains essential relays as defined in Section 6. The concern addressed in this caveat is that unbolted cabinets could respond out of phase to one another and cause impact loadings and high frequency vibration loadings which could cause any impact sensitive essential relays to chatter.

TRN/BS Caveat 10 - Doors Secured. All doors should be secured by a latch or fastener. The concern addressed by this caveat is that the doors could open during an earthquake, and the loose door could repeatedly impact the housing and be damaged or cause internal components such as relays to malfunction or chatter.

TRN/BS Caveat 11 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

TRN/BS Caveat 12 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

TRN/BS Caveat 13 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the transformer as described in Section 4.3.

B.4.2 GERS - Transformers

[1]The seismic capacity for the equipment class of Transformers may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes only dry-type transformers. The equipment in the GERS equipment class is limited to units which range from 7.5 to 225 kVA capacity with either single- or three-phase voltage ratings of 120-480 volts AC. These transformers are housed in NEMA-type metal enclosures which can be either wall-mounted or floor-mounted.

The GERS represent the seismic capacity of a Transformer (TRN) if the transformer meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

TRN/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The transformer should be similar to and bounded by the TRN class described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

TRN/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The transformer should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

TRN/GERS Caveat 3 - Only Dry-Type Transformer. The transformer should be a dry-type unit. Oil-filled units are excluded, as they are not included in the generic seismic testing equipment class.

TRN/GERS Caveat 4 - NEMA-Type Enclosure. The transformer should be housed within a wall- or floor-mounted NEMA-type enclosure (review of manufacturer's submittals is sufficient). This is the enclosure type represented by the generic seismic testing equipment class.

TRN/GERS Caveat 5 - Voltage Rating of 120-480 VAC. The transformer should have a single- or three-phase voltage rating of 120-480 volts AC (review of manufacturer's submittals or transformer nameplate is sufficient).

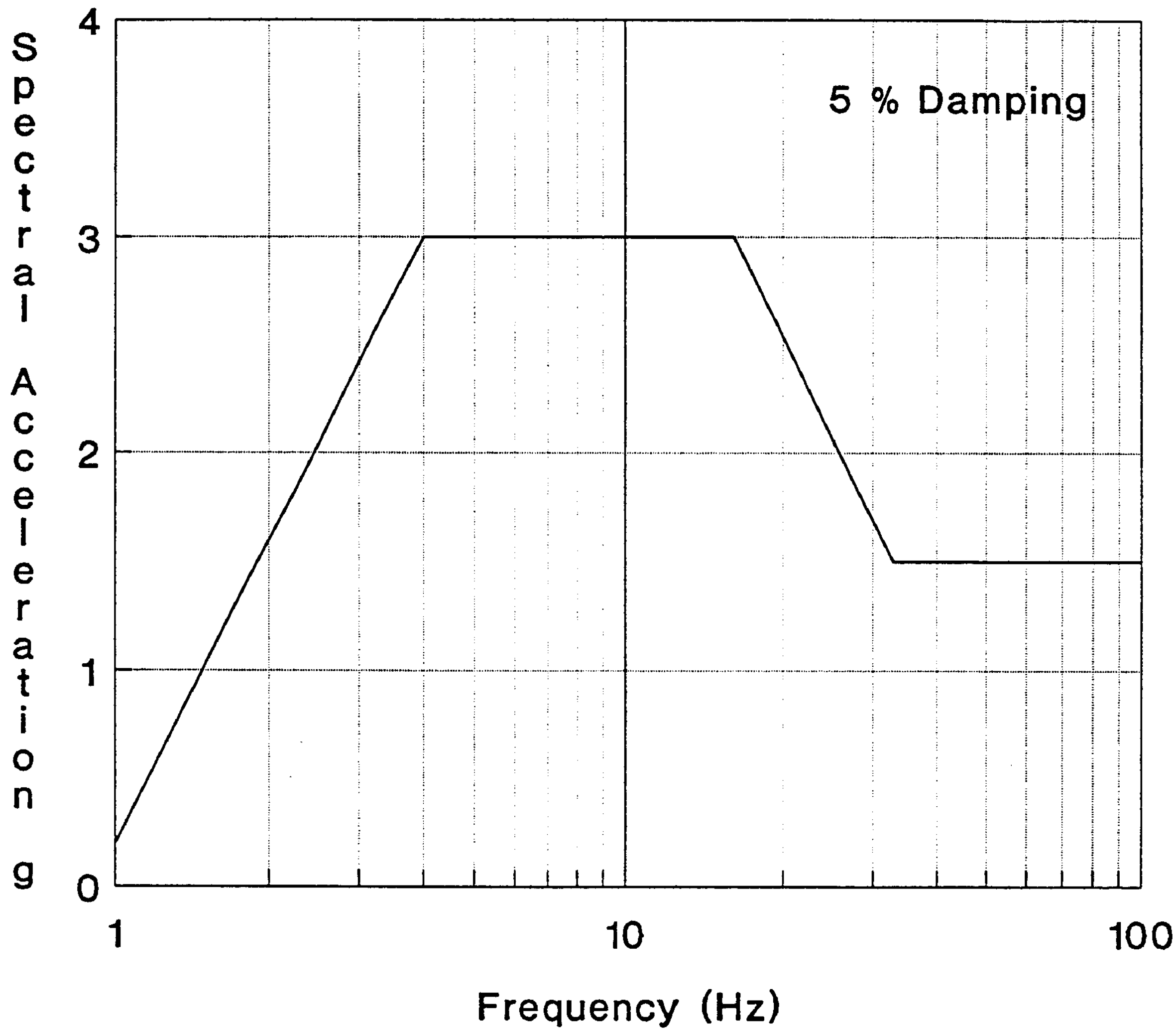
TRN/GERS Caveat 6 - Capacity of 7.5 to 225 kVA. The transformer should have a capacity of 7.5 to 225 kVA (review of manufacturer's submittals or transformer nameplate is sufficient).

TRN/GERS Caveat 7 - Weight of 180-2000 Pounds. The transformer should weigh between 180 and 2000 pounds (review of the manufacturer's submittals or transformer nameplate is sufficient).

TRN/GERS Caveat 8 - Transformer Internal Supports. The internal supports should provide positive attachment of the transformer components (a force transfer path for seismic loads is necessary).

TRN/GERS Caveat 9 - Clearance Between Bare Conductors and Enclosure. The clearance between any bare conductor and the transformer enclosure should be at least 3/8 inch. The concern is that without adequate clearance, transformers could be shorted out during the earthquake and thereby rendered inoperable.

[3]TRN/GERS Caveat 10 - Adjacent Cabinets Bolted Together. Adjacent cabinets and sections of a multi-bay cabinet assembly should be bolted together, including those that do not contain essential relays. Adjacent cabinets and sections of multi-bay cabinet assemblies were bolted together when tested for this generic seismic testing equipment class.



Frequency (Hz)	1	4	16	33
Dry-Type Transformers (g)	0.2	3.0	3.0	1.5

Figure B.4-1. Generic Equipment Ruggedness Spectra (GERS) for Dry-Type Transformers (Source: Reference 6)

B.5 HORIZONTAL PUMPS

B.5.1 Bounding Spectrum - Horizontal Pumps (HP)

[1]The seismic capacity for the equipment class of Horizontal Pumps (HP) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes all pumps commonly found in power plant applications which have their axes aligned horizontally. The class includes pumps driven by electric motors, reciprocating piston engines, and steam turbines. The common peripheral components such as conduit, instrumentation, and suction and discharge lines up to their first support on the building or nearby structure are included in this equipment class.

Pumps can generally be categorized as either kinetic (rotary impeller) or positive displacement types. Kinetic pumps move fluid using the kinetic energy of a rotating impeller. Positive displacement pumps move fluid by volumetric displacement.

Single-stage kinetic pumps typically include a single impeller that moves fluid primarily by centrifugal force. The suction port is normally mounted along or near the impeller axis, and the discharge port is mounted near the periphery. Pumps may range in size from fractional horsepower units, with capacities of a few gallons per minute (gpm), to units requiring several thousand horsepower, with capacities of tens of thousands of gpm.

Multi-stage kinetic pumps include two or more impellers working in series on a single shaft. Depending on the impeller design, multi-stage pumps move fluid using either centrifugal force toward the periphery of the impeller, or propeller force along the axis of the impeller. The impeller is surrounded by a stationary casing or volute that directs the flow from the discharge of one impeller to the intake of the next.

Kinetic pumps are usually powered by electric motors with the pump and motor sharing the same shaft through a close-coupled connection. Larger multi-stage pumps sometimes couple the motor and pump through a gearbox, which allows the pump and motor to turn at different speeds. Single-stage pumps are occasionally belt-driven, with the motor mounted to the side, or even atop the pump casing. Smaller, single-stage pumps sometimes mount the motor and impeller within the same casing. Larger pumps, both single- and multi-stage, normally have the motor and pump in separate casings, with both casings anchored to the same steel skid. Kinetic pumps may also be powered by engines or steam turbines.

Reciprocating-piston positive displacement pumps are similar in design to reciprocating-piston air compressors. They include an electric motor that powers a set of piston impellers through a shaft or belt connection. The piston impellers are usually mounted within a cast block that also contains the piston crank shaft and valve mechanism.

Rotary-screw positive displacement pumps are somewhat similar to multi-stage kinetic pumps, except that the screw impeller moves fluid axially through volume displacement rather than through a transfer of kinetic energy from the impeller to the fluid. The screw impeller is normally powered by an electric motor through a close-coupled shaft.

Kinetic and positive displacement horizontal pumps driven by electric motors, engines, and turbines are represented in the range from 5 to 2300 hp and 45 to 36,000 gpm. Submersible pumps are not included in this equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Horizontal Pump (HP) if the pump meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>HP/BS Caveat 1 - Earthquake Experience Equipment Class</u>. The horizontal pump should be similar to and bounded by the HP class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

<u>HP/BS Caveat 2 - Driver and Pump on Rigid Skid</u>. The driver and pump should be connected by a rigid base or common skid. The concern is that differential displacement between the pump

and driver may cause shaft misalignment. If they are not mounted on a rigid skid, the potential for differential displacement between the driver and pump should be specially evaluated.

HP/BS Caveat 3 - Thrust Bearings in Both Axial Directions. Thrust restraint of the shaft in both axial directions should exist. The concern arose from shake table testing on pumps without thrust bearings that performed poorly. In general, pumps from U.S. manufacturers have such axial thrust restraint so that explicit verification is not necessary; however, any indication to the contrary should be investigated.

HP/BS Caveat 4 - Check of Long Unsupported Piping. Brief consideration should be given to identify situations where the horizontal pump may be affected by gross pipe motion, differential displacement, and excessive nozzle loads. The concern is that excessive force on pump nozzles could potentially break the pump nozzle or cause sufficient pump case distortion to cause binding, or fail the anchorage. These excessive forces are uncommon and need only be considered if there is a long section of unsupported pipe or a heavy valve attached to the pipe near the pump.

HP/BS Caveat 5 - Base Vibration Isolation System Checked. If the unit is mounted on vibration isolators, the adequacy of the vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

HP/BS Caveat 6 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

HP/BS Caveat 7 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

HJ/BS Caveat 8 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

HP/BS Caveat 9 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the pump as described in Section 4.3.

B.5.2 GERS - Horizontal Pumps

There are no GERS for Horizontal Pumps.

B.6 VERTICAL PUMPS

B.6.1 Bounding Spectrum - Vertical Pumps

[1]The seismic capacity for the equipment class of Vertical Pumps (VP) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes pumps with the impeller drive shaft mounted in a vertical (as opposed to horizontal) direction. Vertical pumps are typically powered by an electric drive motor, vertically aligned, and mounted atop a steel or cast-iron support frame that is anchored to a concrete base pad.

The two general types of vertical pumps represented in the earthquake experience equipment class are deep-well pumps and centrifugal pumps. Motor sizes range from 5 to 7000 hp and flow rates range from 95 to 16,000 gpm.

Deep-well turbine type pumps have the pump impeller attached to the bottom of a long vertical drive shaft extending beneath the pump base plate. The pump drive shaft is enclosed in a steel or cast iron casing which extends below the pump base plate. The pump impeller is mounted in a contoured housing or bowl at the base of the casing. The casing or suction pipe is immersed in a well and opened at the bottom for fluid inlet.

A variation of the deep-well turbine pump is the can-type pump. The casing that encloses the impeller drive shaft is, in turn, enclosed by an outer casing or can. Fluid feed to the pump flows through an inlet line, usually mounted in the support frame above the pump base plate. The can forms an annular reservoir of fluid that is drawn into the impeller at the base of the inner casing.

Deep-well pumps range in size from fractional horsepower units to pumps of several thousand horsepower. The casings, cantilevered below the base plate, have typical lengths of 10 to 20 feet. The most massive component of the pump is normally the drive motor, which may weigh several tons.

Single-stage centrifugal pumps are configured with the impeller mounted above the base plate, directly beneath the drive motor. The impeller is housed in a casing that is usually part of the support frame for the drive motor. Instead of drawing fluid from a well or can beneath the pump base plate, the fluid inlet is a piping attachment aligned with a centerline of the impeller drive shaft. The discharge line is tangential to the periphery of the centrifugal impeller casing. Smaller centrifugal pumps are sometimes mounted directly on the piping system they serve.

The pump, drive motor, associated instrumentation and controls attached to the pump, and attached piping and conduit up to their first support on the building or nearby structure are included in the vertical pump equipment class. The equipment class does not include submersible pumps.

The Bounding Spectrum Pump (BS) represents the seismic capacity of a Vertical (VP) if the pump meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

VP/BS Caveat 1 – Earthquake Experience Equipment Class. The vertical pump should be similar to and bounded by the VP class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

VP/BS Caveat 2 - Cantilever Impeller Shaft Less Than 20 Feet Long. The impeller shaft and casing should not be cantilevered more than 20 feet below the pump mounting flange. This type of cantilever vertical pump should have a radial bearing at the bottom of the casing to support the impeller shaft. Twenty (20) feet represents the upper bound length of cantilever shafts of vertical pumps in the earthquake experience equipment class. The concern is that pumps with longer lengths may be subject to misalignment and bearing damage due to excessive lateral loads, damage to the impeller due to excessive displacement, and damage due to interfloor displacement on multi-floor supported pumps. Either individual analysis or use of another method as a means of evaluating vertical pumps should be used when the shaft cantilever length exceeds 20 feet. The evaluation should address the concerns of excessive shaft and casing stresses and deflection of the impeller drive shaft.

VP/BS Caveat 3 - Check of Long Unsupported Piping. Brief consideration should be given to identify situations where the vertical pump may be affected by gross pipe motion, differential displacement, and excessive nozzle loads. The concern is that excessive force on pump nozzles could potentially break the pump nozzle or cause sufficient pump case distortion to cause binding, or fail the anchorage. These excessive forces are uncommon and need only be considered if there is a long section of unsupported pipe or a heavy valve attached to the pipe near the pump.

VP/BS Caveat 4 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

VP/BS Caveat 5 - Adequate Anchorage. The unit should be properly anchored in accordance with the requirements of Section 4.4.

VP/BS Caveat 6 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

VP/BS Caveat 7 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the pump as described in Section 4.3.

B.6.2 GERS - Vertical Pumps

There are no GERS for Vertical Pumps.

B.7 FLUID-OPERATED VALVES

B.7.1 Bounding Spectrum - Fluid-Operated Valves

[1]The seismic capacity for the equipment class of Fluid-Operated Valves (FOV) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes a wide diversity of valve sizes, types, and applications, which are actuated by air, water, or oil. Liquid-operated (i.e., hydraulic) piston valves are not included in the FOV class of equipment because they have not been reviewed in sufficient detail to be included.

The main types of fluid-operated valves are diaphragm-operated, piston- operated, and pressure relief valves. The most common type of fluid-operated valve found in power plant applications is a spring-opposed, diaphragm-operated pneumatic valve. The bell housing contains a diaphragm (usually a thin, steel membrane) which forms a pressure barrier between the top and bottom sections of the housing. The position of the actuated rod (or valve stem) is controlled by a return spring and the differential pressure across the diaphragm. The actuated rod position, in turn, controls the position of the valve. A yoke supports the bell housing and connects it to the valve body. A solenoid valve or, on larger valves, a pneumatic relay controls the air pressure difference across the diaphragm. This solenoid valve or pneumatic relay is often mounted directly to the operator yoke.

Piston-operated valves are similar to diaphragm-operated valves, with a piston replacing the diaphragm as the valve actuator. The piston typically acts in opposition to a spring to control the position of the valve.

Pressure relief valves are also included in this equipment class. Pressure relief valves balance confined fluid pressure against the force of a spring. The actuating force in a pressure relief valve is supplied by the fluid that is confined by the valve. Fluid-operators are typically cantilevered either above or to the side of the valves they serve. The valve and actuator can form a continuous body, or the actuator can be attached to the valve through a flanged, threaded, or ring clamp connection.

The valve, the operator, the inlet and outlet lines up to their first support on the building or nearby structure, and peripheral attachments (air lines, pneumatic relays, control solenoids, and conduit) are included in the Fluid-Operated Valve equipment class. The valve may be of any type, size, or orientation.

The Bounding Spectrum (BS) represents the seismic capacity of a Fluid-Operated Valve (FOV) if the valve meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

FOV/BS Caveat 1 - Earthquake Experience Equipment Class. The valve should be similar to and bounded by the FOV class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

FOV/BS Caveat 2 - Valve Body Not of Cast Iron. The valve body should not be made of cast iron. The intent of this caveat is to avoid the brittle failure mode of cast iron as evidenced by the poor performance of some cast iron components in past earthquakes. Cast iron is not common in such applications in nuclear plants; therefore, it is not necessary to determine the material of the valve body unless it appears to the Seismic Capability Engineers that the body is made of cast iron. It is suggested that the material of a flanged valve be checked. In such cases, if the valve is indeed cast iron, the intent of this caveat is satisfied if seismic stresses in the valve body due to piping loads are low (for example, less than 20% of specified minimum ultimate tensile strength).

FOV/BS Caveat 3 - Valve Yoke Not of Cast Iron for Piston-Operated Valves and Spring-Operated Pressure Relief Valves. The yoke of piston-operated valves and spring-operated pressure relief valves should not be made of cast iron. The intent of this caveat is to avoid the brittle failure mode of cast iron as evidenced by the poor performance of some cast iron components in past earthquakes. Cast iron is not common in such applications in nuclear plants; therefore, it is not necessary to determine the material of the valve yoke unless it appears to the Seismic Capability Engineers that the yoke is made of cast iron. In such cases, if the yoke is indeed cast iron, this caveat may be satisfied by performing a stress analysis of the valve for a 3g load applied at the center of gravity of the operator in the yoke's weakest direction. If the yoke stress is low (for example, less than 20% of specified minimum ultimate strength), then the intent of the caveat is satisfied.

FOV/BS Caveat 4 - Mounted on l-Inch Diameter Pipe Line or Greater. The valve should be mounted on a pipe line of at least l-inch diameter. This is the lower bound pipe size supporting FOVs in the earthquake experience equipment class. The concern is that valves with heavy operators on small lines may cause an overstressed condition in the adjacent piping. To satisfy the intent of this caveat a stress analysis (that accounts for the valve operator eccentricity) may be used to show that the pipe stress adjacent to the valve is low. There is no concern if the valve, the operator, and the line (if smaller than 1 inch) are well supported and anchored to the same support structure.

FOV/BS Caveat 5 - Valve Operator Cantilever Length for Air-Operated Diaphragm Valves, Spring-Operated Pressure Relief Valves, and Light Weight Piston-Operated Valves. The distance from the centerline of the pipe to the top of the operator or cylinder should not exceed the distance given in Figure B.7-1 corresponding to the diameter of the pipe. This figure bounds the pipe diameter and operator length combinations included in the earthquake experience equipment class. The concern is that longer operator lengths may lead to excessive valve yoke stress.

As a second screen to evaluate the operator weight and length, Figure B.7-2 may be used instead of the limits given in Figure B.7-1 provided: (1) the yoke is not of cast iron (Caveat 3 applies), and (2) the operator length does not exceed about 30% beyond the limits of Figure B.7-1.

As a third option, this caveat may also be satisfied by performing a stress analysis consisting of applying a 3g load at the center of gravity of the operator in the yoke's weakest direction. If the yoke stresses are low and the relative deflections are small (to ensure that shaft binding will not occur) then the caveat is satisfied.

Alternately, an in-situ static test may be conducted to demonstrate seismic adequacy. In these tests, a static force equal to three times the operator weight should be applied approximately at the center of gravity of the operator, in each of the three orthogonal principal axes of the yoke (non-concurrently). Such tests should include demonstration of operability; i.e., the valve can open and close, following the application of the static loads. Note that all of the other limitations still apply.

A mockup test stand may be used provided that the details are similar to those in the plant. If there are numerous valves, a rational test program may be developed to envelop the valve configurations in the plant.

FOV/BS Caveat 6 - Valve Operator Cantilever Length for Substantial Piston-Operated Valves. For piston-operated valves which are of substantial weight, the distance from the centerline of the pipe to the top of the operator or cylinder and the weight of the operator should not exceed the values given in Figure B.7-2 corresponding to the diameter of the pipe. This figure represents the pipe diameter and operator weight/length combinations included in the earthquake experience equipment class. The concern is that longer operator lengths or heavier operator weights may lead to excessive valve yoke stress.

To meet the intent of this caveat the operator length or weight may be extrapolated by as much as 30% beyond that given in Figure B.7-2 provided the product of the weight times the length from pipe center to operator top does not exceed the limits of Figure B.7-2.

If the ground motion spectra for the site is below the Bounding Spectrum, given in Figure 4-2, over the entire frequency range possible for the piping and valve network, the operator weight or distance to the top of the operator can be increased by the ratio of the spectra. The cantilever length or the operator weight should not be increased by more than about 30% beyond the limits of Figure B.7-2.

Another option for satisfying this caveat is to perform a stress analysis that consists of applying a 3g load at the center of gravity of the operator in the yoke's weakest direction. If the yoke stresses are low and the relative deflections are small (to ensure that shaft binding will not occur) then the caveat is satisfied. Alternately, as discussed in FOV/BS Caveat 5, above, a static test may be performed.

<u>FOV/BS Caveat 7 - Actuator and Yoke Not Independently Braced</u>. The valve actuator and yoke should not be independently braced to the structure or supported by the structure unless the pipe is also braced to the same structure immediately adjacent to the valve. The concern is that if the operator is independently supported from the valve and attached piping, then the operator may act as a pipe support during seismic motion and attract considerable load through the yoke and possibly fail the yoke or bind the shaft. In addition, if both the operator and the valve/pipe are restrained, and if they are both not tied back to the same structure, then differential motion of support points may lead to high seismic loads and possible binding of the shaft. If either of these concerns [4]is noted, then a special evaluation should be conducted to demonstrate low stress and small deflections.

<u>FOV/BS Caveat 8 - Sufficient Slack and Flexibility of Attached Lines</u>. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

<u>FOV/BS Caveat 9 - Any Other Concerns</u>? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the valve as described in Section 4.3.

Light Valve Operator
Cantilever Limits

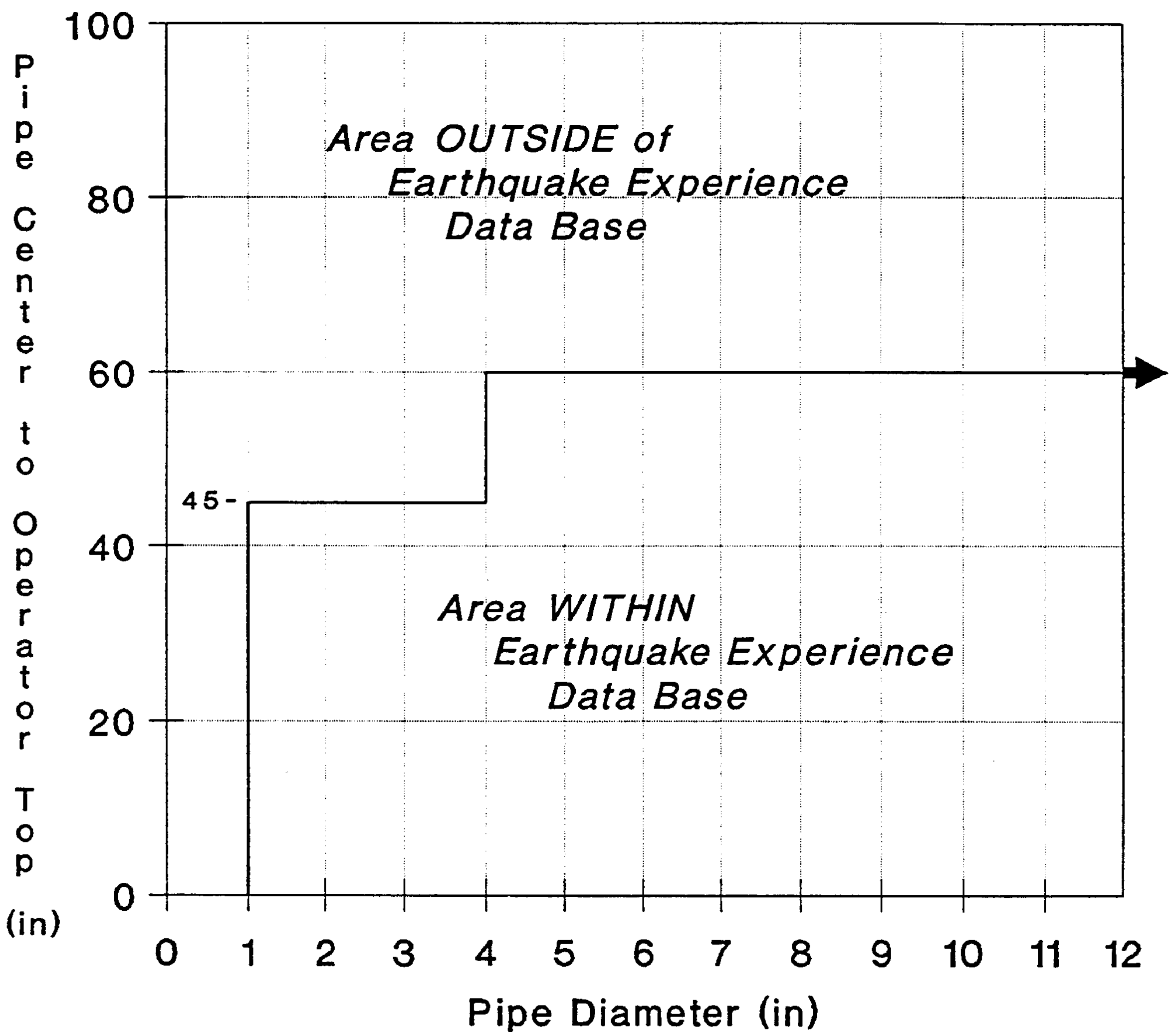
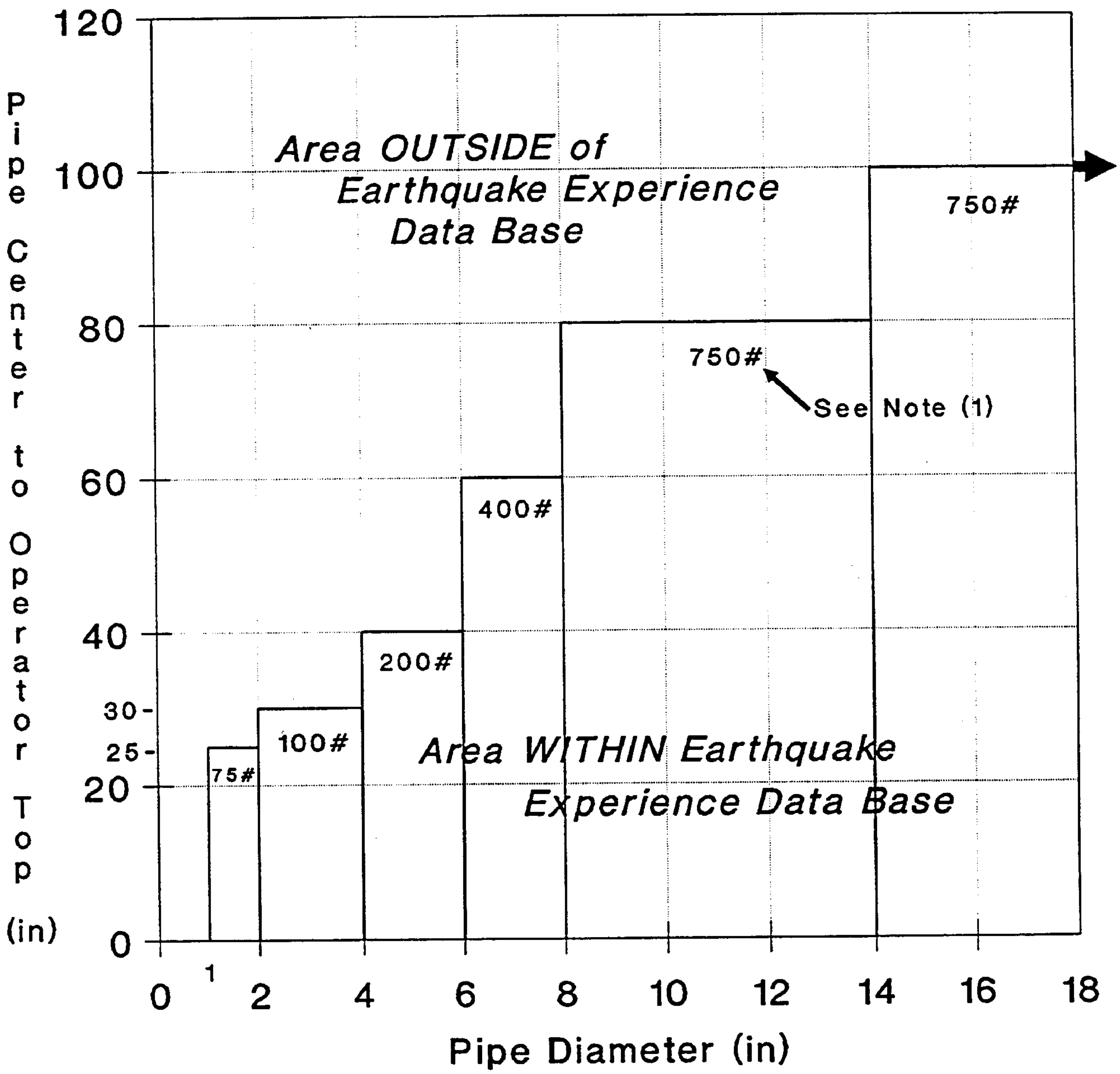


Figure B.7-1. Valve Operator Cantilever Length Limits for Air-Operated Diaphragm Valves, Spring-Operated Pressure Relief Valves and Piston-Operated Valves of Light Weight Construction
(Source: Reference 5)

Heavy Valve Operator
Cantilever Limits



(1) Approximate Maximum Operator Weights Given for Various Ranges of Pipe Diameter

Figure B.7-2. Valve Operator Cantilever Length Limits for Piston-Operated Valves of Substantial Weight and Construction (Source: Reference 5)

B.7.2 GERS - Air-Operated Valves (AOV)

[1]The seismic capacity for the equipment class of air-operated valves may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of spring-opposed, diaphragm-type pneumatic actuators which are designed to operate both gate and globe valves. They range in size from 12 to 40 inches in height (pipe centerline is reference position) with weights up to 500 pounds. The valves within this class are for 3-inch and smaller pipe sizes with design pressures less than 2,500 psi. A pneumatic actuator generally consists of a reinforced rubber diaphragm enclosed in a steel housing. The valve stem and diaphragm are attached so that any diaphragm movement results in valve movement. A solenoid valve controls the admission of high pressure air (100 to 150 psi) to the diaphragm housing. A return spring supplies sufficient counter force to close or open the valve when air pressure is not pushing on the diaphragm. The yoke of this class of pneumatic actuator is an integral part of the unit which is directly bolted to the valve bonnet. The valve body, bonnet, and yoke material should be carbon steel. The active components of the actuator are the solenoid valve, limit switches, and a pressure regulator, all of which are yoke-mounted appurtenances. This equipment class covers virtually all air-operated diaphragm valves used in small bore power plant piping systems.

The GERS represent the seismic capacity of an Air-Operated Valve (AOV) if the valve meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>AOV/GERS Caveat 1 - Generic Seismic Testing Equipment Class</u>. The valve should be similar to and bounded by the AOV class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

<u>AOV/GERS Caveat 2 - Bounding Spectrum Caveats Apply</u>. The valve should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

AOV/GERS Caveat 3 - Only Diaphragm-Type Air Operated Valves. The air-operated gate or globe valve should have a spring-opposed, diaphragm-type pneumatic actuator. This equipment class does not include piston-operated, pressure relief valves, or other diaphragm-type valves powered by fluids other than air. These valve types are the only types included in the generic seismic testing equipment class.

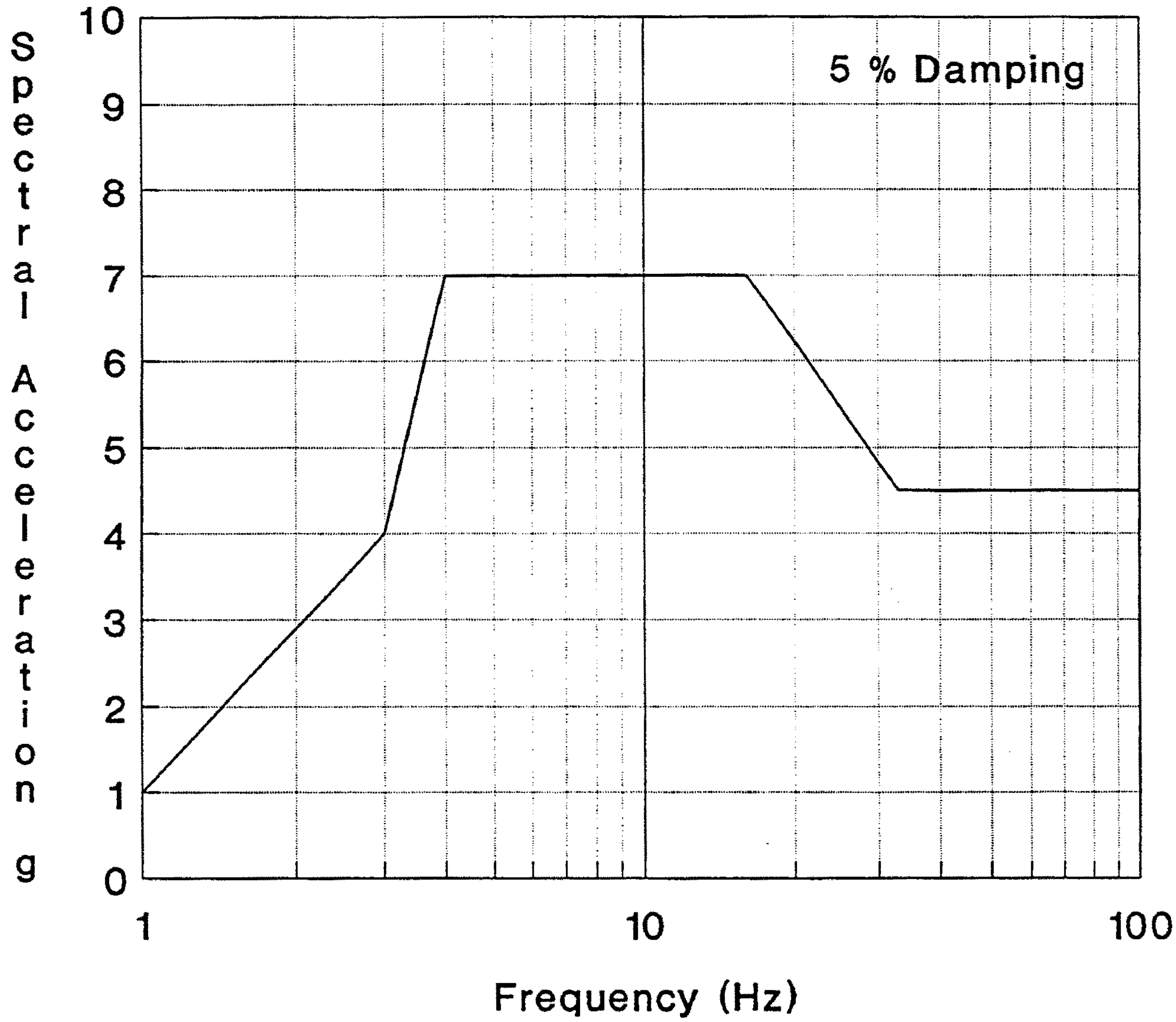
AOV/GERS Caveat 4 - Evaluation of Amplified Response. The valves and operators were tested with the valve fixed to the shake table. Therefore realistic amplification through the piping system should be included when determining the amplified response of the valve-to-pipe interface for comparison to the GERS.

AOV/GERS Caveat 5 - No Impact Allowed. A separate evaluation should be done to assure that the valve and operator will not impact surrounding structures and components as a result of pipe flexibility. The concern is that impact may damage the valve, operator, yoke, stem, or attached components. This type of damage has occurred in past earthquakes and is also identified as a seismic interaction concern (Section 4.5).

AOV/GERS Caveat 6 - Nominal Pipe Size 1 to 3 Inches. The nominal pipe size of the valve should be within the range of 1 to 3 inches. This is the pipe size range included in the generic seismic testing equipment class.

AOV/GERS Caveat 7 - Carbon Steel Valve Body, Bonnet, and Yoke. The valve body, bonnet, and yoke should all be carbon steel. Cast iron components are not covered by the GERS. Since cast iron is not commonly used in safe shutdown systems of nuclear plants, it is not necessary to determine the material used for the valve body, bonnet, or yoke unless it appears to the Seismic Capability Engineers that cast iron may have been used.

GERS-AOV.4
12/1/90



Frequency (Hz)	1	3	4	16	33
Air-Operated Valves (g)	1.0	4.0	7.0	7.0	4.5

Figure B.7-3. Generic Equipment Ruggedness Spectra (GERS) for Air-Operated Valves (Source: Reference 6)

B.8A MOTOR-OPERATED VALVES

B.8A.1 Bounding Spectrum - Motor-Operated Valves

[1]The seismic capacity for the equipment class of Motor-Operated Valves (MOV) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes a wide diversity of sizes, types, and applications.

Components of a motor-operated valve include a motor operator with a control box, gearbox, and drive motor. The gearbox includes the gears which link the valve actuation to the drive motor shaft. Local controls typically include a relay for actuating the primary circuit to the motor, and torque and limit switches for coordinating the drive motor and the valve position. Valve operators may have a local motor controller built into the operator housing. The valve actuator shaft typically passes through the steel support frame or yoke. The valve which is actuated by a motor operator may be of any type, size, or orientation.

Motor operators may be mounted in any position (e.g., cantilevered vertically above, below, or to the side of the valve). The yoke, which connects the operator to the valve body, may take the form of a steel pipe enclosing the actuator shaft or a frame of welded beams. The attachments of the motor-gearbox to the yoke and the yoke to the valve are typically bolted flange connections, threaded connections, or ring clamps. In some applications, motor operators are mounted at a remote location above the valve.

The equipment class of motor-operated valves includes all valves actuated by an electric motor. The valve, the operator, and the inlet and outlet lines and attached conduit up to their first support on the building or nearby structure are included in the Motor-Operated Valve equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Motor-Operated Valve (MOV) if the valve meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

MOV/BS Caveat 1 - Earthquake Experience Equipment Class. The valve should be similar to and bounded by the MOV class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MOV/BS Caveat 2 - Valve Body Not of Cast Iron. The valve body should not be made of cast iron. The intent of this caveat is to avoid the brittle failure mode of cast iron as evidenced by the poor performance of some cast iron components in past earthquakes. Cast iron is not common in such applications in nuclear plants; therefore, it is not necessary to determine the material of the valve body unless it appears to the Seismic Capability Engineers to be made of cast iron. It is suggested that the material of flanged valves be checked. In such cases, if the valve is indeed cast iron, the intent of this caveat is satisfied if seismic stresses in the valve body due to piping loads are low (for example, less than 20% of specified minimum ultimate tensile strength).

MOV/BS Caveat 3 - Valve Yoke Not of Cast Iron. The yoke of the motor-operated valve should not be made of cast iron. The intent of this caveat is to avoid the brittle failure mode of cast iron as evidenced by the poor performance of some cast iron components in past earthquakes. Cast iron is not common in such applications in nuclear plants; therefore, it is not necessary to determine the material of the valve yoke unless it appears to be cast iron to the Seismic Capability Engineers. In such cases, if the yoke is indeed cast iron, this caveat may be satisfied by performing a stress analysis of the valve for a 3g load applied at the center of gravity of the operator in the yoke's weakest direction. If the yoke stress is low (for example, less than 20% of specified minimum ultimate strength), then the intent of the caveat is satisfied.

MOV/BS Caveat 4 - Mounted on l-Inch Diameter Pine Line or Greater. The valve should be mounted on a pipe line of at least l-inch diameter. This is the lower bound pipe size supporting MOVs in the earthquake experience equipment class. The concern is that valves with heavy operators on small lines may cause an overstressed condition in the adjacent piping. To satisfy the intent of this caveat a stress analysis (that accounts for the valve operator eccentricity) may be used to show that the pipe stress adjacent to the valve is low. There is no concern if the valve, the operator, and the line (if smaller than 1 inch) are well supported and anchored to the same support structure. This caveat does not apply to SOVs, which typically are installed on air lines smaller than 1 inch.

MOV/BS Caveat 5 - Valve Operator Cantilever Length for Motor-Operated Valves. The distance from the centerline of the pipe to the top of the operator or cylinder and the weight of the operator should not exceed the values given in Figure B.8A-1 corresponding to the diameter of the pipe. This bounds the earthquake experience equipment class. The concern is that longer operator lengths may lead to excessive valve yoke stress.

To meet the intent of this caveat the operator length or weight may be extrapolated by as much as 30% beyond that given in Figure B.8A-1 provided the product of the weight times the length from pipe center to operator top does not exceed the limits of Figure B.8A-1.

If the ground motion spectra for the site is below the Bounding Spectrum, given in Figure 4-2, over the entire frequency range possible for the piping and valve network, the operator weight or distance to the top of the operator can be increased by the ratio of the spectra. The cantilever length or the operator weight should not be increased by more than about 30% beyond the limits of Figure B.8A-1.

As an option, this caveat may also be satisfied by performing a stress analysis consisting of applying a 3g load at the center of gravity of the operator in the yoke's weakest direction. If the yoke stresses are low and the relative deflections are small (to ensure that shaft binding will not occur) then the caveat may be shown to be satisfied.

Alternatively, an in-situ static test may be conducted to demonstrate seismic adequacy. In these tests, a static force equal to three times the operator weight should be applied approximately at the center of gravity of the operator, non-concurrently in each of the three orthogonal principal axes of the yoke. Such tests should include demonstration of operability, i.e., the valve can open and close, following the application of the static loads. Note that all of the other limitations still apply.

A mockup test stand may be used provided that the details are similar to those in the plant. If there are numerous valves, a rational test program may be developed to envelop the valve configurations in the plant.

<u>MOV/BS Caveat 6 - Actuator and Yoke Not Independently Braced</u>. The valve actuator and yoke should not be independently braced to the structure or supported by the structure unless the pipe is also braced to the same structure immediately adjacent to the valve. The concern is that if the operator is independently supported from the valve and attached piping, then the operator may act as a pipe support during seismic motion and attract considerable load through the yoke and possibly fail the yoke or bind the shaft. In addition, if both the operator and the valve/pipe are restrained, and if they are both not tied back to the same structure, then differential motion of support points may lead to high seismic loads and possible binding of the shaft. If either of these concerns [4]is noted, then a special evaluation should be conducted to demonstrate low stress and small deflections.

<u>MOV/BS Caveat 7 - Sufficient Slack and Flexibility of Attached Lines</u>. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

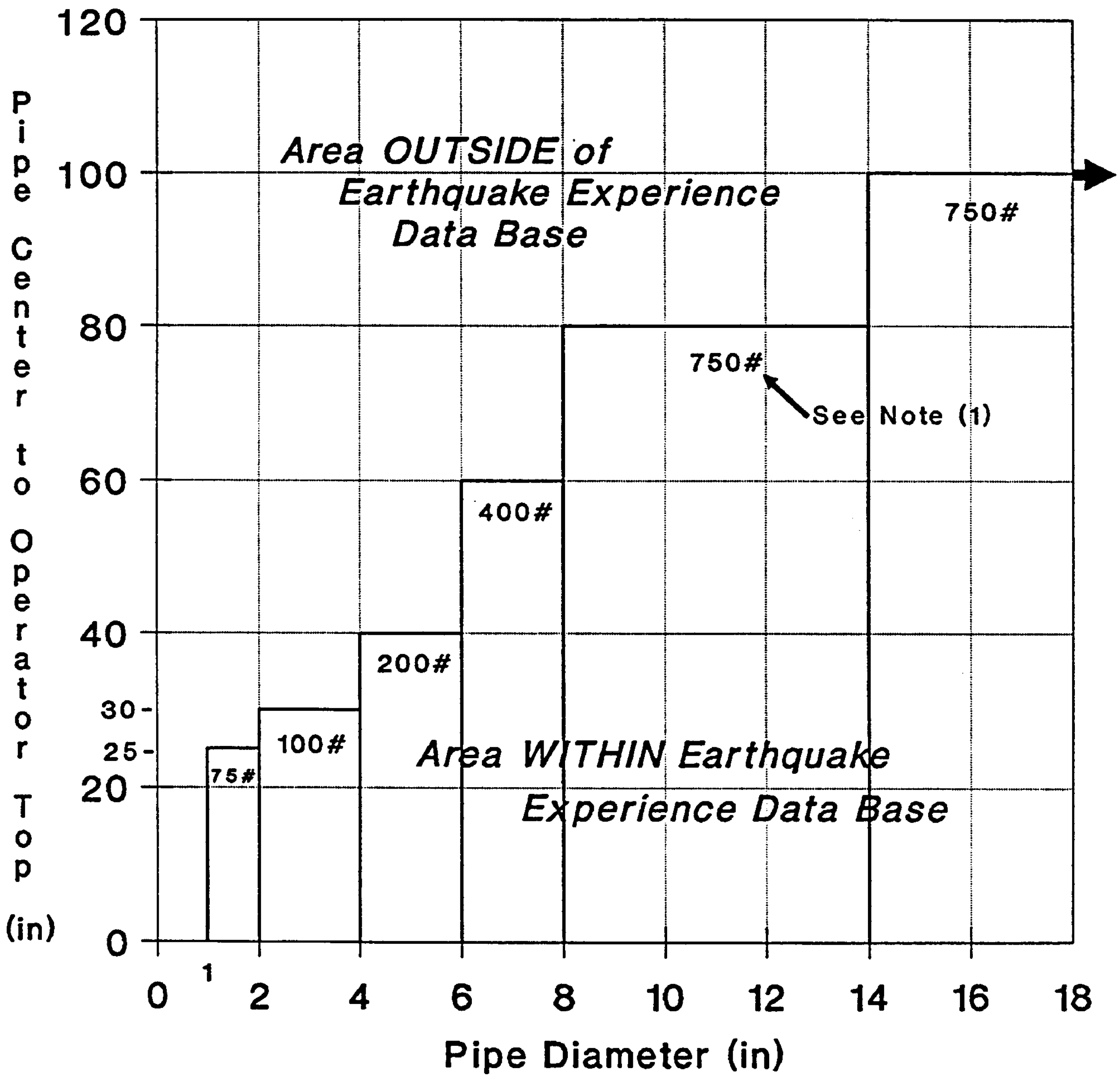
<u>MOV/BS Caveat 8 - Any Other Concerns</u>? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the valve as described in Section 4.3.

B.8A.2 GERS - Motors Operators for Valves

[1]The seismic capacity for the equipment class of electric motor operators for valves (MOV) may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes operators designed to control the five major types of valves (gate, globe, plug, ball, and butterfly). They range in weight from 150 up to 3,500 pounds. A valve operator consists of a metal housing which connects to the valve body by a flange or yoke and contains limit switches, a torque switch, an electric motor, a clutch, gears, and bearings. For this class of equipment, the motor controls (reversing starter, overload relays, and push-button station) should be located in a remote location (usually a motor control center). For some valve configurations, the valve actuators are mounted on secondary reducers resulting in the actuator being eccentric and cantilevered from the valve body. For these configurations, a special seismic bracket supplied by the manufacturer is required. The mounting position of the valve operator is with the motor horizontal and the limit switch compartment horizontal or vertical as specified by the manufacturer. These positions will [4]ensure the proper distribution of lubricants through the internal working component of the units. This equipment class covers virtually all motor-driven valve operators used in power plants.

The MOV GERS represent the seismic capacity of an electric Motor Operator for a Valve (MOV) if the operator meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

Heavy Valve Operator
Cantilever Limits



(1) Approximate Maximum Operator Weights Given for Various Ranges of Pipe Diameter

Figure B.8A-1. Valve Operator Cantilever Length Limits for Motor-Operated Valves (Source: Reference 5)

MOV/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The electric motor-driven valve operator should be similar to and bounded by the MOV class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MOV/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The operator should meet all the caveats given for the Bounding Spectrum for the MOV class of equipment. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

MOV/GERS Caveat 3 - Evaluation of Amplified Response. The GERS were based on tests in which the operators were mounted directly to the shake table and not on a valve yoke structure or a valve. Therefore realistic amplification through the piping system and valve should be included when determining the seismic demand at the operator-to-valve interface for comparison to the GERS. Note also that the MOV GERS apply only to the operator; the seismic adequacy of the valve and its yoke should be evaluated separately.

MOV/GERS Caveat 4 - Motor Axis Horizontal. The motor axis should be horizontal and the limit switch compartment should be horizontal or vertical (definition of orientation directions provided in manufacturer's submittals). These were the positions of the motor axis and limit switch compartment in the generic seismic testing equipment class shake table tests.

MOV/GERS Caveat 5 - No Impact Allowed. A separate evaluation should be done to assure that the operator will not impact surrounding structures and components as a result of pipe flexibility. The concern is that impact may damage the operator, yoke, stem, or attached components. This type of damage has occurred in past earthquakes and is also identified as a seismic interaction concern (Section 4.5).

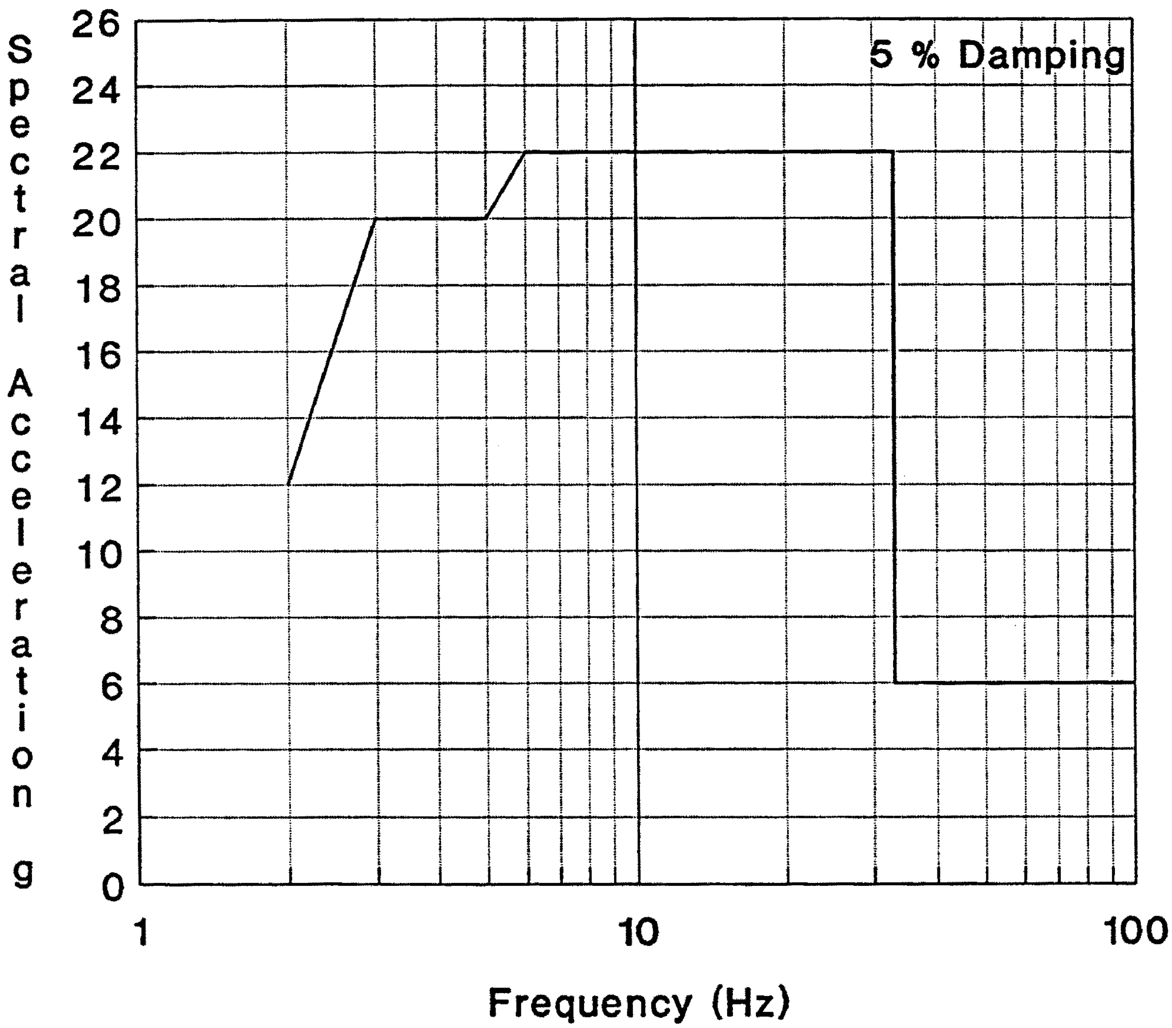
MOV/GERS Caveat 6 - Motor Controls Remotely Located. The motor controls (reversing starter, overload relays, and push-button station) should be remotely located and separately evaluated. The motor controls were not located on the valve operators during the GERS testing and are therefore not included in the generic seismic testing equipment class.

MOV/GERS Caveat 7 - Seismic Brackets for Side-Mounted Actuators. Side-mounted valve actuators attached to secondary reducers should have seismic brackets as supplied by the manufacturer (review of manufacturer's submittals is sufficient). The actuators in the GERS tests that were tested in this orientation had seismic brackets.

MOV/GERS Caveat 8 - Manufactured by Limitorque or Rotork. The operator should be manufactured by either Limitorque or Rotork. These are the MOV manufacturers included in the generic seismic testing equipment class.

MOV/GERS Caveat 9 - Tighten Loose Valve-to-Operator Bolts. Any missing or loose valve-to-operator bolts which are noticed during the walkdown should be replaced or retightened; a tightness check is not required.

GERS-MOV.4
12/1/90



Frequency (Hz)	2	3	5	6	33	33
Motor Operators for Valves (g)	12	20	20	22	22	6

Figure B.8A-2. Generic Equipment Ruggedness Spectra (GERS) for Motor Operators on Valves[5]
(Source: Reference 6)

B.8B SOLENOID-OPERATED VALVES

B.8B.1 Bounding Spectrum - Solenoid-Operated Valves

[1]The seismic capacity for the equipment class of Solenoid-Operated Valves (SOV) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes a wide diversity of sizes, types, and applications.

Solenoid operators are smaller and lighter than motor operators. Solenoid-operated valves are actuated by passing an electrical current through a coil, thereby creating a magnetic field which opens or closes the valve. Solenoid operators are generally more compact than motor operators with less of a cantilevered mass supported from the valve body. In addition, solenoid-operated valves are typically mounted on smaller diameter lines than MOVs.

The equipment class of solenoid-operated valves includes all valves actuated by a solenoid. The valve, the operator, and the inlet and outlet lines and attached conduit up to their first support on the building or nearby structure are included in the Solenoid-Operated Valve equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Solenoid-Operated Valve (SOV) if the valve meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>SOV/BS Caveat 1 - Earthquake Experience Equipment Class</u>. The valve should be similar to and bounded by the SOV class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

<u>SOV/BS Caveat 2 - Valve Body Not of Cast Iron</u>. The valve body should not be made of cast iron. The intent of this caveat is to avoid the brittle failure mode of cast iron as evidenced by the poor performance of some cast iron components in past earthquakes. Cast iron is not common in such applications in nuclear plants; therefore, it is not necessary to determine the material of the valve body unless it appears to the Seismic Capability Engineers to be made of cast iron. It is

suggested that the material of flanged valves be checked. In such cases, if the valve is indeed cast iron, the intent of this caveat is satisfied if seismic stresses in the valve body due to piping loads are low (for example, less than 20% of specified minimum ultimate tensile strength).

SOV/BS Caveat 3 - Valve Yoke Not of Cast Iron. The yoke of the solenoid-operated valve should not be made of cast iron. The intent of this caveat is to avoid the brittle failure mode of cast iron as evidenced by the poor performance of some cast iron components in past earthquakes. Cast iron is not common in such applications in nuclear plants; therefore, it is not necessary to determine the material of the valve yoke unless it appears to be cast iron to the Seismic Capability Engineers. In such cases, if the yoke is indeed cast iron, this caveat may be satisfied by performing a stress analysis of the valve for a 3g load applied at the center of gravity of the operator in the yoke's weakest direction. If the yoke stress is low (for example, less than 20% of specified minimum ultimate strength), then the intent of the caveat is satisfied.

SOV/BS Caveat 4 - Valve Operator Cantilever Length for Solenoid-Operated Valves. The distance from the centerline of the pipe to the top of the operator or cylinder and the weight of the operator should not exceed the values given in Figure B.8B-l corresponding to the diameter of the pipe. This applies to SOVs mounted on l-inch diameter and larger pipe lines. This bounds the earthquake experience equipment class. The concern is that longer operator lengths may lead to excessive valve yoke stress.

To meet the intent of this caveat the operator length or weight may be extrapolated by as much as 30% beyond that given in Figure B.8B-l provided the product of the weight times the length from pipe center to operator top does not exceed the limits of Figure B.8B-1.

If the ground motion spectra for the site is below the Bounding Spectrum, given in Figure 4-2, over the entire frequency range possible for the piping and valve network, the operator weight or distance to the top of the operator can be increased by the ratio of the spectra. The cantilever length or the operator weight should not be increased by more than about 30% beyond the limits of Figure B.8B-1.

As an option, this caveat may also be satisfied by performing a stress analysis consisting of applying a 3g load at the center of gravity of the operator in the yoke's weakest direction. If the yoke stresses are low and the relative deflections are small (to ensure that shaft binding will not occur) then the caveat may be shown to be satisfied.

Alternatively, an in-situ static test may be conducted to demonstrate seismic adequacy. In these tests, a static force equal to three times the operator weight should be applied approximately at the center of gravity of the operator, non-concurrently in each of the three orthogonal principal axes of the yoke. Such tests should include demonstration of operability, i.e., the valve can open and close, following the application of the static loads. Note that all of the other limitations still apply.

A mockup test stand may be used provided that the details are similar to those in the plant. If there are numerous valves, a rational test program may be developed to envelop the valve configurations in the plant.

SOV/BS Caveat 5 - Actuator and Yoke Not Independently Braced. The valve actuator and yoke should not be independently braced to the structure or supported by the structure unless the pipe is also braced to the same structure immediately adjacent to the valve. The concern is that if the operator is independently supported from the valve and attached piping, then the operator may act as a pipe support during seismic motion and attract considerable load through the yoke and possibly fail the yoke or bind the shaft. In addition, if both the operator and the valve/pipe are restrained, and if they are both not tied back to the same structure, then differential motion of support points may lead to high seismic loads and possible binding of the shaft. If either of these concerns [4]is noted, then a special evaluation should be conducted to demonstrate low stress and small deflections.

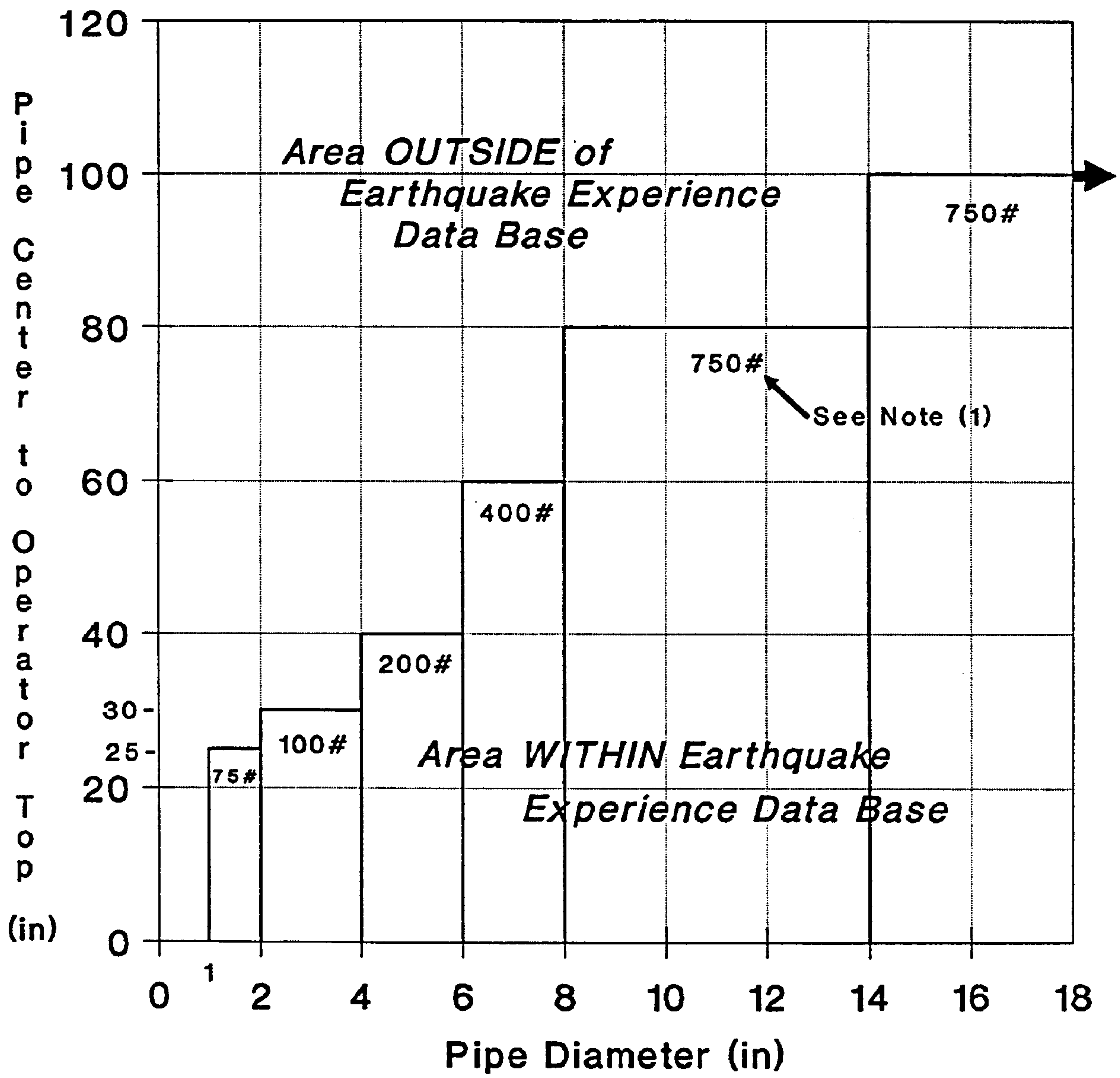
SOV/BS Caveat 6 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

SOV/BS Caveat 7 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the valve as described in Section 4.3.

B.8B.2 GERS - Solenoid-Operated Valves

[1]The seismic capacity for the equipment class of solenoid-operated valves (SOV) may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of a combination of two basic functional units: 1) a solenoid actuator (electro-magnet) with its plunger (or core), and 2) a valve body containing an orifice in which a disc or plug is positioned to stop or allow flow. The valve is opened or closed by movement of the magnetic plunger which is drawn into the solenoid when the coil is energized. Solenoid valves can be two-way, three-way or four-way valves. In the direct acting two-way solenoid valve, the solenoid acts directly on the valve stem to open or close the valve. Three-way solenoid valves are principally used in power plants as pilot valves to alternately apply pressure to and exhaust pressure from a diaphragm valve actuator. Four-way solenoid valves are often used for controlling double-acting pneumatic or hydraulic cylinders. The valves range in weight from a few pounds to 45 pounds and are made of either forged brass or steel. The valves within this class are for pipe sizes which are 1 inch or less in diameter and for design pressures less than 600 psi. This equipment class covers virtually all solenoid-operated valves used in small bore power plant piping or process air systems.

[6]Heavy Valve Operator
Cantilever Limits



(1) Approximate Maximum Operator Weights Given for Various Ranges of Pipe Diameter

Figure B.8B-1. Valve Operator Cantilever Length Limits for Solenoid-Operated Valves (Source: Reference 5)

The SOV GERS represent the seismic capacity of a Solenoid-Operated Valve if the valve meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

SOV/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The valve should be similar to and bounded by the SOV class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

SOV/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The valve should meet all the caveats given for the Bounding Spectrum for the SOV class of equipment. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

SOV/GERS Caveat 3 - Evaluation of Amplified Response. The valves and operators were tested with the valve fixed to the shake table. Therefore realistic amplification through the piping system should be included when determining the amplified response of the valve-to-pipe interface for comparison to the GERS.

SOV/GERS Caveat 4 - No Impact Allowed. A separate evaluation should be done to assure that the valve and operator will not impact surrounding structures and components as a result of pipe flexibility. The concern is that impact may damage the valve, operator, yoke, stem, or attached components. This type of damage has occurred in past earthquakes and is also identified as a seismic interaction action concern (Section 4.5).

SOV/GERS Caveat 5 - Nominal Pipe Size 1 Inch or Less. The nominal pipe size of the valve should be 1 inch or less. This is the upper bound pipe size included in the generic seismic testing equipment class.

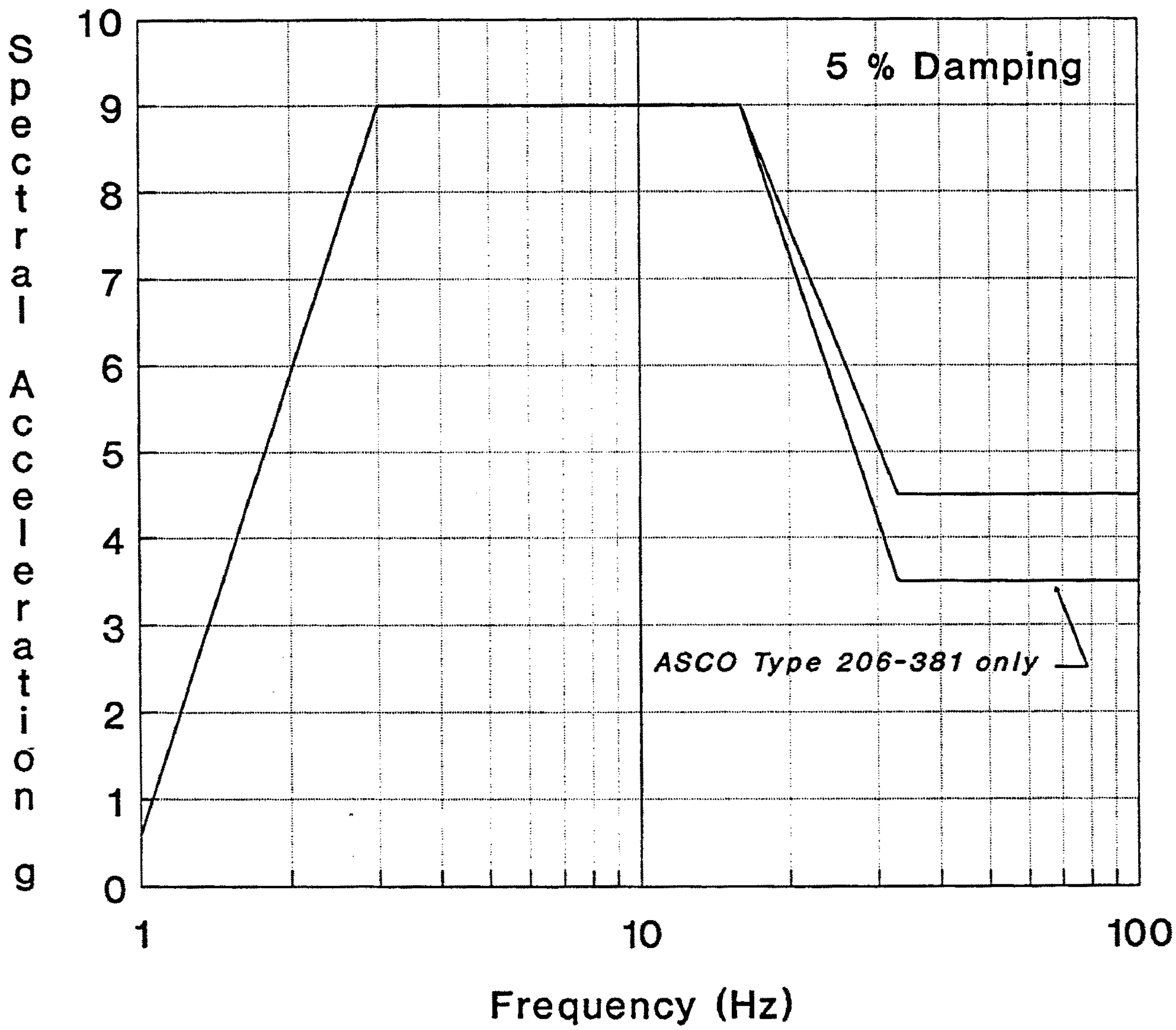
SOV/GERS Caveat 6 - Forged Brass or Steel Valve Body. The valve body should be made of either forged brass or steel. Other materials are not covered by the generic seismic testing equipment class.

SOV/GERS Caveat 7 - Orientation of Solenoid Housing. The solenoid housing should be oriented in accordance with the manufacturer's recommendations for the specific model (review of manufacturer's submittals is sufficient). GERS testing was performed with the solenoid housing in the recommended orientation.

SOV/GERS Caveat 8 - Overall Height Not to Exceed 12 Inches. The overall height of the valve (pipe centerline to top of solenoid housing) should not exceed 12 inches. This is the upper bound height limit included in the generic seismic testing equipment class.

SOV/GERS Caveat 9 - Separate Evaluation of Main Valve Controlled by SOV. When the Solenoid-Operated Valve is a pilot valve in a valve assembly, the main valve should be evaluated separately. Note that the amplified response spectra at the attachment point of the SOV should be used in the SOV evaluation as discussed in SOV/GERS Caveat 3.

SOV/GERS Caveat 10 - Lower ZPA for ASCO Type 206-381. For ASCO Type 206-381 solenoid valves, the GERS with a 3.5g ZPA should be used.



Frequency (Hz)	1	3	16	33
Solenoid Valves - General (g)	0.6	9.0	9.0	4.5
ASCO Type 206-381 only (g)	0.6	9.0	9.0	3.5

Figure B.8B-2. Generic Equipment Ruggedness Spectra (GERS) for Solenoid-Operated Valves (Source: Reference 6)

B.9 FANS

B.9.1 Bounding Spectrum - Fans

[1]The seismic capacity for the equipment class of Fans (FAN) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes both freestanding and duct-mounted fans. Fans that are components of other classes of equipment such as air handlers are handled by other respective equipment classes and need not be specifically evaluated here. Blowers and exhausters are included in this equipment class.

Typical differential pressures for fan range from l/2 inch to 5 inches of water. Some centrifugal fans can have differential pressures ranging up to 12 inches of water. Air flow rates typically range from less than 1000 cubic feet per minute (cfm) to flows on the order of 50,000 cfm. Corresponding fan drive motors typically range from 1 hp to 200 hp. Typical weights of fan units range from 100 to 1000 pounds, depending on capacity and design details. The two basic types of fans in this equipment class include axial fans and centrifugal fans.

Axial fans are used in relatively low pressure applications such as building HVAC systems or cooling towers. Propeller fans and vane-axial fans are the two major types of axial fans. Propeller axial fans consist of two or more blades assembled on a central shaft and revolving within a narrow mounting-ring. Propeller fans are often mounted to a wall or ceiling. Vane-axial fans have an impeller wheel, typically with four to eight blades, mounted to a central shaft within a cylindrical casing. Vane-axial fans are generally used in higher pressure, higher flow applications than propeller fans. Vane-axial fans include a set of guide vanes mounted either before or after the impeller that streamline the air flow for greater efficiency. A variation of vane-axial design is the tube-axial fan, which includes the higher pressure impeller wheel mounted within a cylindrical casing, but without the provision of vanes.

Certain axial fan designs include multiple impellers for increased pressure boost. Axial-flow fans are normally mounted inside cylindrical ducting, supported by radial struts running from the duct wall to the duct centerline. Electric drive motors are usually mounted along the duct centerline immediately upstream of the impeller. The impeller and drive shaft are normally cantilevered from the motor. Alternate designs mount the motor on the outside of the duct with a belt connection between the motor and the impeller drive shaft.

Centrifugal fans are divided into three major categories depending upon the position of their blades. The three blade positions are forward-curved, radial, and backward-inclined. Forward-curved centrifugals have blades inclined toward the direction of rotation at the tip. These fans produce high flow volumes at low static pressures. Radial-blade centrifugals have their blades positioned on the radii extending from their axis of rotation. Backward-inclined fans are a type of centrifugal fan and have their blades inclined opposite to the direction of rotation at the tip.

Centrifugal fans typically have a cylindrical intake duct centered on the fan shaft and a square discharge duct directed tangentially from the periphery of the fan. A variation of the centrifugal fan is the tubular centrifugal fan which redirects the discharged air in the axial direction. As with axial-flow fans, centrifugal fans can have the electrical drive motor mounted either directly on the fan shaft, or outside of the fan casing with a belt drive to the fan. The impeller and drive shaft may have either a single-point, where they are cantilevered from the motor, or a two-point support, where the shaft is supported both at the motor and at an end bearing.

The fan impeller and its enclosure, drive motor, attached ducting, mounted louvers, and attached conduit and instrumentation lines are included in the Fan equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Fan (FAN) if the fan meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

FAN/BS Caveat 1 - Earthquake Experience Equipment Class. The fan should be similar to and bounded by the FAN class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

FAN/BS Caveat 2 - Drive Motor and Fan Mounted on Common Base. The driver and fan should be connected by a common base or attached in a way to limit differential displacement. The concern is that differential displacement between the driver motor and fan may cause shaft misalignment. If the driver motor and fan are not mounted on a common base, then the potential for differential displacement should be specially evaluated.

FAN/BS Caveat 3 - Long Shafts Should be Supported at Fan and at Motor. Axial fans with long shafts between the motor and fan should have the shaft supported at the fan and at the motor. The concern is shaft misalignment. If the shaft is not supported in both locations, then a special evaluation should be conducted. The potential earthquake displacement of the shaft should be determined and compared to the operability displacement limits of the fan.

FAN/BS Caveat 4 - No Possibility of Excessive Duct Distortion Causing Binding or Misalignment of Fan. The possibility of excessive duct distortion during an earthquake should be considered for its effect on binding or misalignment of the fan. This need only be considered in cases of long unsupported ducts near the fan or relatively stiff ducts subjected to significant relative support motion. A special evaluation should be conducted to evaluate for this failure mode if these conditions are considered to be significant by the Seismic Capability Engineers.

FAN/BS Caveat 5 - Base Vibration Isolation System Checked. If the unit is mounted on vibration isolators, the adequacy of the vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

FAN/BS Caveat 6 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

FAN/BS Caveat 7 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

FAN/BS Caveat 8 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the fan as described in Section 4.3.

B.9.2 GERS - Fans

There are no GERS for Fans.

B.10 AIR HANDLERS

B.10.1 Bounding Spectrum - Air Handlers

[1]The seismic capacity for the equipment class of Air Handlers (AH) may be based on earthquake experience data, (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes sheet metal enclosures containing (as a minimum) a fan and a heat exchanger. Air handlers are used for heating, dehumidifying or chilling, and distributing air.

The basic components of an air handler include a fan and a coil section. Small capacity, simple air handlers are often referred to as fan-coil units. Additional components such as filters, air-mixing boxes, and dampers are included in more elaborate air handlers. Fans (normally centrifugal) produce air flow across the coil for heat transfer. Coils act as heat exchangers in an air handler. Cooling coils are typically rectangular arrays of tubing with fins attached. Filters are typically mounted in steel frames which are bolted together as part of a modular system. Mixing boxes are used as a plenum for combining two airstreams before channeling the resulting blend into the air handler unit. Dampers are rotating flaps provided in the inlet or outlet sides of the air handler to control the flow of air into or out of the fan.

Air handlers are typically classified as being either a draw-through or a blow-through type. Draw-through air handlers have the heat exchanger (coil) upstream of the fan, whereas the blow-through design locates the coil downstream. Air handler enclosures normally consist of sheet metal welded to a framework of steel angles or channels. Typical enclosures range in size from two feet to over ten feet on a side, with weights ranging from a few hundred pounds to several thousand pounds. Large components, such as fans and coils, are typically bolted to internal frames which are welded to the enclosure framing. Fans may be located in a variety of orientations with respect to the coil unit.

Air handlers typically include a system of attached ducts which provide for the intake and discharge of air. Additional attachments to air handlers include piping and cooling water or refrigerant, electrical conduit, and instrumentation lines. Self-contained air conditioning units are a variation of air handlers, in which the sheet metal enclosure includes a small refrigeration unit. Note that large centralized chillers are addressed as a separate equipment class (B.11).

Air handler configurations range from large floor-mounted units to smaller units suspended on rod hangers from ceilings. The sheet metal enclosure, fans and motors, heat exchanger coils, air filters, mixing boxes, dampers, attached ducts, instrument lines, and conduit are included in the Air Handler equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of an Air Handler (AH) if the air handler meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

AH/BS Caveat 1 - Earthquake Experience Equipment Class. The air handler should be similar to and bounded by the AH class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

AH/BS Caveat 2 - Anchorage of Internal Component. In addition to reviewing the (adequacy of the unit's base anchorage, the attachment of heavy internal equipment of the air handler must be assessed. Seismic Capability Engineers may exercise considerable engineering judgment when performing this review. Internal vibration isolators should meet the requirements for base isolators in Section 4.

AH/BS Caveat 3 - Doors Secured. All doors should be secured by a latch or fastener. The concern addressed by this caveat is that the doors could open during an earthquake, and the loose door could repeatedly impact the housing and be damaged or cause internal components such as relays to malfunction or chatter. In addition, the door may act as an integral structural member and may need to be latched to provide both stiffness and strength to the unit.

AH/BS Caveat 4 - No Possibility of Excessive Duct Distortion Causing Binding or Misalignment of Internal Fan. If the air handling unit contains a fan, then the possibility of excessive duct distortion during an earthquake should be considered for its effect on binding or misalignment of the fan. This need only be considered in cases of long unsupported ducts near the air handling unit or relatively stiff ducts subjected to significant relative motion. A special evaluation should be conducted to evaluate for this failure mode if these conditions are considered to be significant by the Seismic Capability Engineers.

AH/BS Caveat 5 - Base Vibration Isolation System Checked. If the unit is mounted on vibration isolators, the adequacy of the vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

AH/BS Caveat 6 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

AH/BS Caveat 7 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

AH/BS Caveat 8 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

AH/BS Caveat 9 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the air handler as described in Section 4.3.

B.10.2 GERS - Air Handlers

There are no GERS for Air Handlers.

B.11 CHILLERS

B.11.1 Bounding Spectrum - Chillers

[1]The seismic capacity for the equipment class of Chillers (CHL) may be based on earthquake experience data (as described Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes skid-mounted units comprised of components such as a compressor, a condenser, an evaporator, and a control and instrumentation panel. Chillers condense refrigerant or chill water for indoor climate-control systems which supply conditioned air for equipment operating environments and for personnel comfort.

Compressors draw vaporized refrigerant from the evaporator and force it into the condenser. The compressor of a chiller unit may be either the centrifugal or the reciprocating piston type. Condensers are heat exchangers which reduce the refrigerant from a vapor to a liquid state. Chiller condensers are usually shell- and tube-type heat exchangers, with refrigerant on the shell side. Evaporators are tube bundles over which refrigerant is sprayed and evaporated, the inverse function of the condenser. Evaporator tubes can have either finned or plain surfaces. Control panels provide local chiller system monitoring and control functions. Typical components include: oil level switches/gauges, temperature switches/gauges, pressure switches/gauges, undervoltage and phase protection relays, and compressor motor circuit breakers.

Chiller components may be arranged in a variety of configurations. Typically the evaporator and condenser are mounted in a stacked configuration, one above the other, with the compressor and the control panel mounted on the side. Variations of this arrangement include the side-by-side configuration, with the compressor usually mounted above the condenser and evaporator, or a configuration with all components mounted side by side on the skid. Components are usually bolted to a supporting steel skid, which is, in turn, bolted to a concrete pad. Attachments to chillers include piping for routing cooling water or refrigerant to the unit, electrical conduit, and instrumentation and control lines. Chiller weights range up to about 40,000 lbs.

The compressor, condenser, evaporator, local control panel, support framing, and attached piping, instrument lines, and conduit which are attached to the same skid are included in the Chiller equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Chiller (CHL) if the chiller meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

CHL/BS Caveat 1 - Earthquake Experience Equipment Class. The chiller should be similar to and bounded by the CHL class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

CHL/BS Caveat 2 - No Reliance on Weak-Way Bending of Steel Plate or Structural Steel Shapes. The evaporator and condenser tanks should be reasonably braced between themselves for lateral forces parallel to the axis of the tanks without relying on weak-way bending of steel plate or webs of structural steel shapes. The concern is that in weak-way bending the structure will not be capable of transferring the lateral earthquake loads. If weak-way steel plate bending must be relied on to brace the upper tank, then the adequacy of the steel components should be specially evaluated for adequate strength and stiffness.

CHL/BS Caveat 3 - Check Vibration Isolation Systems. Some chiller units are mounted on base vibration isolation systems and/or are equipped with vibration isolators in the mountings of the compressors and/or motors to the evaporators or condensers. The adequacy of these vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

CHL/BS Caveat 4 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

CHL/BS Caveat 5 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

CHL/BS Caveat 6 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the chiller as described in Section 4.3.

B.11.2 GERS- Chillers

There are no GERS for Chiller units.

B.12 AIR COMPRESSORS

B.12.1 Bounding Spectrum - Air Compressors

[1]The seismic capacity for the equipment class of Air Compressor (AC) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes freestanding air compressors together with attached components such as air intakes, air receiver tanks, local control panels, conduit, and discharge lines. Air compressors can be generally categorized as reciprocating piston or rotary screw. The equipment class of air compressors encompasses a wide range of sizes, configurations, and applications. Air compressors typically include as components: electric drive motor, piston- or impeller-driven compressor, air receiver tank, air intake filter, air aftercooler, moisture separator, lubrication system, and the control and instrument panel. Large compressors typically include water jackets to cool the compressor casing and the air aftercoolers, while smaller units are typically cooled by natural or fan-assisted convection to the surrounding air.

Air compressors supply operating pressure to pneumatic instrumentation and control systems, in particular to diaphragm-operated valves. Air compressors also charge pressurized air receiver tanks that serve the pneumatic starting systems for emergency engine-generators.

Compressor configurations in the equipment class include air receiver tank-mounted reciprocating piston or rotary screw compressors, skid-mounted reciprocating piston or rotary screw compressors, and freestanding reciprocating piston compressors.

Reciprocating piston compressors are constructed much like an automobile engine, with pistons encased in cast steel cylinders compressing the gas, and a system of timed valves controlling the inlet and discharge. Drive motor sizes typically range from fractional horsepower to over 100 horsepower. Piston air compressors generally have one or two cylinders but may include more. Cylinders are normally supported on a cast iron crankcase, which encloses the rotating crankshaft, linked either directly to the electric motor through a drive shaft, or indirectly through a belt linkage. Smaller reciprocating piston compressors are commonly mounted atop an air receiver tank.

Rotary screw compressors replace the reciprocating piston with a set of helical screws, typically encased in a cast iron block. The components and attachments of the air compressor are similar to reciprocating piston units except that the system of timed intake and discharge valves are not required. The most common configuration has the air compressor mounted on top of its air receiver tank. The units are usually not large, ranging in capacity from about 1 to 100 cfm (cubic feet per minute of discharge air), with drive motors typically ranging from fractional horsepower up to 30 hp. Tank-mounted rotary screw compressors typically range in weight from about 200 to 2500 pounds.

Reciprocating piston and rotary screw compressors may also be mounted on a steel skid. The skid may be either open or enclosed in a sheet metal housing. The skid is normally constructed of a welded steel frame with the compressor, drive motor, receiver tank, control panel, and other components bolted to the frame in some convenient configuration. Skid-mounted compressors typically range in capacity up to about 2000 cfm, with drive motors of up to about 300 hp. Skid-mounted compressors typically range in weight from about 2000 to 8000 pounds.

Freestanding compressors are usually the reciprocating piston type with one or two cylinders normally cantilevered from a crankcase. The crankcase may form the primary support for all components, or it may be mounted on a steel or cast iron pedestal. Freestanding compressors include the largest units typically found in power plant applications, ranging in capacity up to about 4000 cfm, with drive motors up to about 1000 hp. Freestanding compressors range in weight from small units on the order of about 500 pounds to units as large as 10 tons.

The Air Compressor equipment class includes the piston- or impeller-driven compressor, drive motor, air receiver tank, and attached cooling coils and air intakes, attached air discharge lines, instrument lines, and attached conduit (up to the first support away from the unit).

The Bounding Spectrum (BS) represents the seismic capacity of an Air Compressor (AC) if the compressor meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

AC/BS Caveat 1 - Earthquake Experience Equipment Class. The air compressor should be similar to and bounded by the AC class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

AC/BS Caveat 2 - Check Vibration Isolation Systems. Some compressor units are mounted on base vibration isolation systems and/or are equipped with vibration isolators in the compressor or drive motor mountings (e.g., if the compressor is mounted atop an air receiver tank). The adequacy of these vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

AC/BS Caveat 3 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

AC/BS Caveat 4 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

AC/BS Caveat 5 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

AC/BS Caveat 6 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the compressor as described in Section 4.3.

B.12.2 GERS - Air Compressors

There are no GERS for Air Compressors.

B.13 MOTOR-GENERATORS

B.13.1 Bounding Spectrum - Motor-Generators

[1]The seismic capacity for the equipment class of Motor-Generators (MG) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes motors and generators that are coupled into a motor-generator set (M-G set). Motor-generator sets are structurally similar to horizontal pumps, which consist of an electric motor connected to a pump through a shaft. Motor-generators are basically two motors connected through a common shaft. M-G sets normally include either an AC or DC motor attached through a direct drive shaft to an AC or DC generator. A large flywheel is often mounted at one end of the shaft for storage of rotational inertia, to prevent transient fluctuations in generator output. Usually, both the motor and generator in an M-G set are mounted to a common drive shaft and bolted to a steel skid. Smaller sets sometimes house the motor and generator within the same casing. Motor-generator sets typically range in weight from about 50 to 5000 pounds.

The motor, generator, flywheel, and attached conduit are included in the Motor-Generator equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of a Motor- Generator (MG) if the motor-generator meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

MG/BS Caveat 1 - Earthquake Experience Equipment Class. The motor- generator should be similar to and bounded by the MG class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

MG/BS Caveat 2 - Driver and Driven Component on Rigid Skid. The main driver and the driven component should be connected by a rigid base or common skid. The concern is that differential displacement between the driver and the driven component may bind the shaft or lead to excessive bearing wear. If they are not mounted on a rigid skid, the potential for differential displacement between the main driver and the driven component should be specially evaluated.

MG/BS Caveat 3 - Base Vibration Isolation System Checked. If the unit is mounted on vibration isolators, the adequacy of the vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

MG/BS Caveat 4 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

MG/BS Caveat 5 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

MG/BS Caveat 6 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

MG/BS Caveat 7 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the motor-generator as described in Section 4.3.

B.13.2 GERS – Motor-Generators

There are no GERS for Motor-Generator sets.

B.14 DISTRIBUTION PANELS

B.14.1 Bounding Spectrum - Distribution Panels

[1]The seismic capacity for the equipment class of Distribution Panels (DP) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of circuit breakers or fusible disconnect switches mounted in vertical stacks within sheet metal cabinets. The function of distribution panels is to distribute low voltage AC or DC power from a main circuit to branch circuits, and to provide overcurrent protection. Distribution panels typically serve AC power systems ranging up to 600 volts and DC power systems ranging up to 250 volts.

Two types of distribution panels are found in power plant electrical systems: switchboards and panelboards. Although switchboards and panelboards perform the same function, they differ in construction and application. Switchboards are typically floor-mounted assemblies, while panelboards are usually wall-mounted. Switchboards usually distribute larger quantities of power than panelboards.

Distribution switchboards are freestanding cabinets containing stacks of circuit breakers or fusible switches. They have assemblies of circuit breakers or switches mounted into shelf-like cubicles. Electrical connections are normally routed through enclosed cable compartments in the rear of the cabinet. A switchboard will sometimes include a main circuit breaker and a power metering section mounted in separate compartments within the cabinet. Switchboards are often incorporated into substation assemblies that include motor control centers, transformers, and switchgear. In typical power plant applications, the completely enclosed (safety) switchboard is almost exclusively used. These switchboards are completely enclosed in a sheet metal casing. Switchboard dimensions are standardized with individual sections ranging from 20 to 40 inches in depth and width. The height is generally 90 inches. Switchboard sections can weigh up to 500 pounds.

Distribution panelboards are defined by the National Electric Code (NEC) as panels which include buses, switches, and automatic protective devices designed for the control or distribution of power circuits. Panelboards are placed in a cabinet or cutout box which is mounted in or against a wall and accessible only from the front. The assembly of circuit breakers contained in a panelboard is normally bolted to a steel frame, which is in turn mounted to the rear or sides of the panelboard enclosure. Individual circuit breakers are either bolted or plugged into the steel chassis. A cable gutter typically runs along the side of the circuit breaker chassis. Panelboards have a wide range of cabinet sizes. Typical dimensions for wall-mounted units are 20 to 40 inches in height and width, and 6 to 12 inches in depth. Weights for wall-mounted panelboards typically range from 30 to 200 pounds.

Industry standards developed by the National Electrical Manufacturers Association and the Underwriters Laboratories (e.g., NEMA ICS-6, UL-SOS) are maintained for the construction of distribution panel enclosures. These standards determine the minimum structural framing and sheet metal thickness for distribution panel enclosures as a function of sheet metal area between supports or reinforcing.

The Distribution Panel equipment class includes the circuit breakers, fusible switches, metering compartments, switchboard/panelboard enclosure and internals, and attached conduit.

The Bounding Spectrum (BS) represents the seismic capacity of a Distribution Panel (DP) if the panel meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>DP/BS Caveat 1 - Earthquake Experience Equipment Class</u>. The distribution panel should be similar to and bounded by the DP class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

<u>DP/BS Caveat 2 - Contains only Circuit Breakers and Switches</u>. The distribution panel should only contain circuit breakers and switches. The concern is that other seismically vulnerable components not normally associated with a distribution panel may have been added. Other components contained within the panel should be evaluated on a case-by-case basis. This case-

by-case evaluation may include use of earthquake experience, test data or component specific qualification data as discussed in Section 5, Outlier Evaluation.

DP/BS Caveat 3 - Doors Secured. All doors, latches or screwdriver-operated door fasteners should be secured. The concern addressed by this caveat is that the doors could open during an earthquake and the loose door could repeatedly impact the housing and be damaged or cause internal components to malfunction or chatter.

DP/BS Caveat 4 - Adjacent Cabinets Bolted Together. Adjacent cabinets which are close enough to impact each other and sections of multi-bay cabinet assemblies should be bolted together if any of these cabinets contain essential relays as defined in Section 6. The concern addressed in this caveat is that unbolted cabinets could respond out of phase to one another and impact each other during an earthquake. This would cause additional impact loadings and high frequency vibration loadings which may result in malfunction or chatter of internal components.

DP/BS Caveat 5 - General Configuration Similar to NEMA Standards. The general configuration of the distribution panel should be similar to those constructed to NEMA Standards. The unit does not have to conform exactly to NEMA Standards, but should be similar with regard to the gage of steel, internal structure and support. This caveat is intended to preclude unusual designs not covered by the equipment class (thin gage material, flimsy internal structure, etc.). In general, units manufactured by the major manufacturers of distribution panels conform to this caveat if they have not been modified.

DP/BS Caveat 6 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

DP/BS Caveat 7 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

DP/BS Caveat 8 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the panel as described in Section 4.3.

B.14.2 GERS - Distribution Panels

[1]The seismic capacity for the equipment class of Distribution Panels (or load centers) may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of individual molded-case circuit breakers and fused disconnect switches housed in NEMA-type floor and wall enclosures. Units are low voltage rated at 600 VAC (480 VAC nominal) or 250 VDC. A distribution panel receives its electrical power from the plant distribution system and distributes this power to each of the circuit breakers and fused disconnect switches by an internal arrangement of vertical and horizontal bus bars. This equipment class covers distribution panels which contain circuit

breakers and switches. For panels which contain an occasional relay or motor starter, the GERS only applies to the remainder of the panel and components mounted on the panel, not to the relay or motor starter. The evaluation of relays and motor starters is covered in Section 6.

Floor-mounted (freestanding) distribution panels are denoted as Switchboards (NEMA Standard Publication No. PB2). The typical floor enclosure is 90 inches high, 36 inches wide, and 20 inches deep.

Wall-mounted (either flush or surface mount) distribution panels are denoted as Panelboards (National Electrical Code NFPA/ANSI No. 70). Wall-mounted enclosures vary in size, with nominal dimensions ranging up to 48 inches high, 24 inches wide, and 12 inches deep.

The GERS represent the seismic capacity of a Distribution Panel (DP) (Switchboard or Panelboard) if the panel meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

<u>DP/GERS Caveat 1 - Generic Seismic Testing Equipment Class</u>. The distribution panel should be similar to and bounded by the DP class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

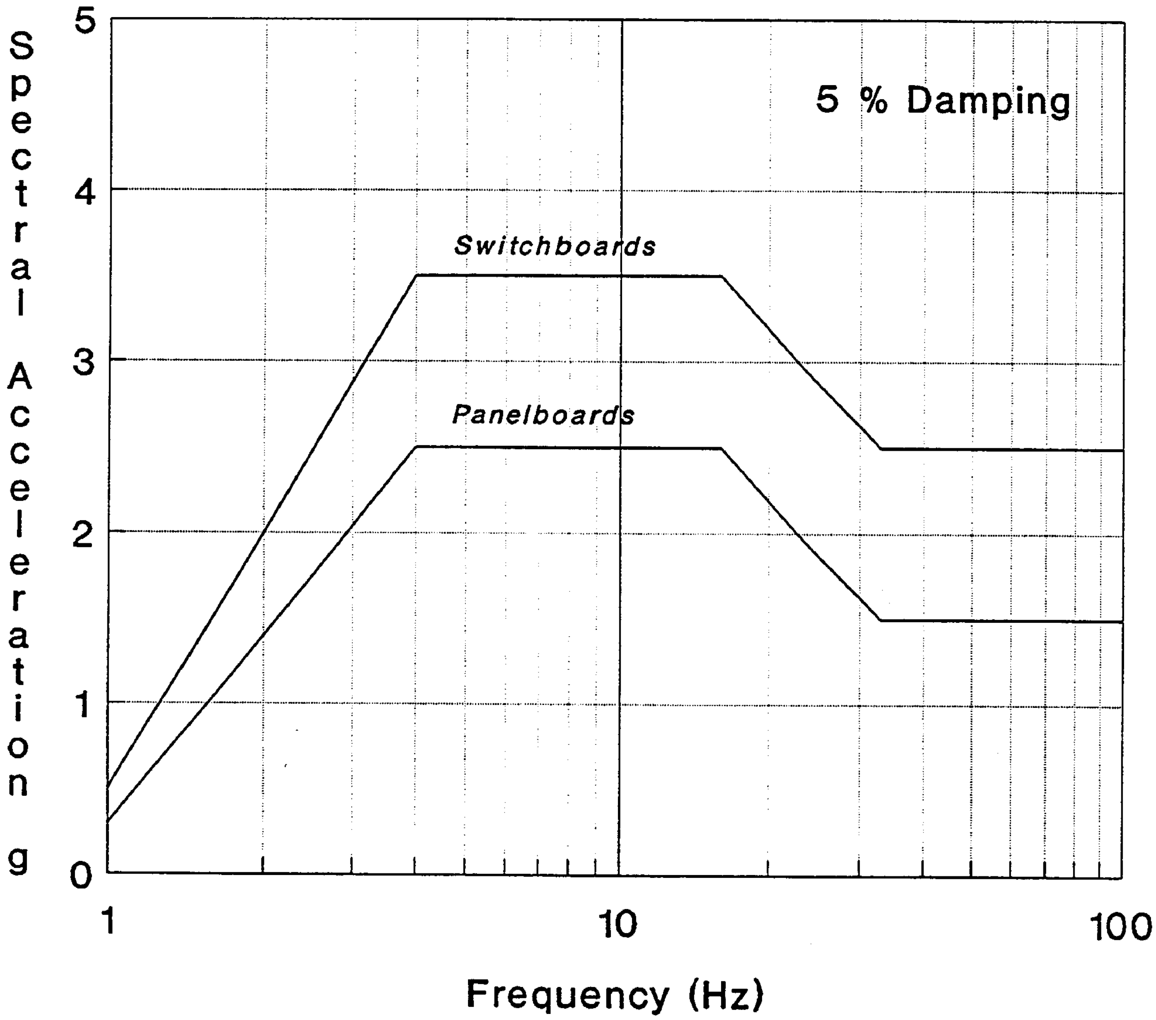
<u>DP/GERS Caveat 2 - Bounding Spectrum Caveats Apply</u>. The panel should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

<u>DP/GERS Caveat 3 - Freestanding, Designated Switchboard</u>. The Switchboard GERS can be used only if the unit is freestanding and designated as a switchboard by the manufacturer; otherwise the Panelboard GERS should be used. A review of manufacturer's submittals and parts list is sufficient. These two subclasses (Switchboard and Panelboard) have different seismic capacity based on the generic seismic test data.

<u>DP/GERS Caveat 4 - Circuit Breaker Model Excluded</u>. The GERS cannot be used for distribution panels that contain the Westinghouse “Quicklag” Type E circuit breakers. This circuit breaker model has been shown to trip at levels below the 2.5g GERS. A review of

manufacturer's submittals and parts listed is sufficient to determine whether this type of circuit breaker is used.

[3]DP/GERS Caveat 5 - Adjacent Cabinets Bolted Together. Adjacent cabinets and sections of a multi-bay cabinet assembly should be bolted together, including those that do not contain essential relays. Adjacent cabinets and sections of multi-bay cabinet assemblies were bolted together when tested for this generic seismic testing equipment class.



Frequency (Hz)	1	4	16	33
Switchboards (g)	0.5	3.5	3.5	2.5
Panelboards (g)	0.3	2.5	2.5	1.5

Figure B.14-1. Generic Equipment Ruggedness Spectra (GERS) for Distribution Switchboards and Panelboards (Source: Reference 6)

B.15 BATTERIES ON RACKS

B.15.1 Bounding Spectrum - Batteries on Racks

[1]The seismic capacity for the equipment class of Batteries on Racks (BAT) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes both storage batteries and their supporting structures. Most battery systems consist of lead-acid storage batteries mounted in series on steel-frame racks or wooden racks.

A battery is a group of electro-chemical cells interconnected to supply a specified voltage of DC power. Individual battery weights typically range from about 50 to 450 pounds. Batteries are used to supply a steady source of DC power for circuits in control and instrumentation systems, to power DC starter motors for emergency engine-generators, and to provide DC power to inverters for uninterruptible power systems.

Lead-acid storage batteries are the most prevalent type of battery and are the subject of this equipment class. The basic components of a lead-acid battery cell are the electrode element, cell cover, cell jar, electrolyte, and flame arrestor. The electrode elements are the key components of the battery system.

There are four basic types of lead-acid storage batteries which are distinguished by the construction of their positive plates. These four types are: calcium flat plate, PlantJ or Manchex, antimony flat plate, and tubular. Since there are no examples of antimony flat plate and tubular batteries in experience data, they are excluded from the equipment class. The PlantJ or Manchex battery is one of the older designs of batteries but still has limited use in the power industry. It is constructed of heavy lead plate with either a series of horizontal cross-ribs attached to the plate (PlantJ plate design), or a matrix of spiral buttons inserted into the plate (Manchex design).

Battery racks are normally frames of steel channels, angles, and struts that support the batteries above the floor. Racks can be multi-rowed, multi-tiered, or multi-stepped. Multi-rowed racks are adjacent rows of batteries all at the same level. Multi-tiered racks are vertical rows of batteries mounted directly above each other. Multi-stepped racks have each succeeding row of batteries located above and to the rear of the previous row.

The shelf that supports the batteries typically consists of steel channels running longitudinally that are, in turn, supported by transverse rectangular frames of steel angles. The racks are usually braced by diagonal struts along either the front or rear face for longitudinal support. The rack members are connected by a combination of welds and bolts.

Well-designed battery racks include a restraining rail running longitudinally along the front and the rear of the row of batteries and wrapping around the ends of the row. The rails are located at about mid-height of the battery, and can prevent accidental overturning of the batteries, or overturning from earthquake loadings.

The battery (including the cell jar and enclosed plates, the supporting rack, electrical connections between batteries (bus bar), and attached electrical cable) are included in the Batteries on Racks equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of Batteries on Racks (BAT) if the batteries and racks meet the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

BAT/BS Caveat 1 - Earthquake Experience Equipment Class. The batteries and racks should be similar to and bounded by the BAT class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

BAT/BS Caveat 2 - Plates of the Battery Cells Are Lead-Calcium Flat-Plate or They Are of PlantJ or Manchex Design. The plates of the battery must be of the lead-calcium flat-plate or the PlantJ or Manchex design. These are the only battery cell types included in the earthquake experience equipment class.

BAT/BS Caveat 3 - Each Individual Battery Weighs Less Than 450 Pounds. Individual battery cells should weigh less than about 450 pounds. This is the upper bound weight of the battery cells included in the earthquake experience equipment class.

BAT/BS Caveat 4 - Close-Fitting, Crush-Resistant Spacers Between Cells. There should be close-fitting, crush-resistant spacers between the cells, which fill about two-thirds of the vertical space between the cells. The concern is that the batteries without spacers can rock and collide during the earthquake causing malfunction and damage.

BAT/BS Caveat 5 - Batteries Restrained by Side and End Rails. The battery racks should have end and side rails incorporated in the design. The end and side rails should also be close fitting against the cells (with shims, if needed). The concern is that batteries on racks without end and side rails may tip or slide off the rack.

BAT/BS Caveat 6 - Battery Racks Have Longitudinal Cross Bracing. The racks should have longitudinal cross bracing unless engineering judgment or analysis shows that such bracing is not needed. The concern is that racks without cross bracing may not be able to transfer the lateral seismic loads to the base support. Simple bounding hand calculations are recommended to show that the structural components of the rack are capable of transferring these loads. The capacity of rack steel members may be calculated following AISC Part 2 allowable stresses.

BAT/BS Caveat 7 - Racks Constructed of Wood To Be Evaluated. Battery racks constructed of wood should be specially evaluated. The concern is that racks constructed of wood may be more vulnerable to seismic loads than steel racks. Evaluation of the rack should consider industry accepted structural design standards for wood construction, using extreme load allowable stresses as appropriate.

BAT/BS Caveat 8 - Batteries Greater Than 10 Years Old To Be Evaluated. Batteries that are more than 10 years old should be identified as outliers. The concern with the aging of batteries is that some models have been shown by shake table testing to be susceptible to structural and or metallurgical changes with time that result in either structural failure or reduced capacity after vibration.

BAT/BS Caveat 9 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

BAT/BS Caveat 10 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the batteries on racks as described in Section 4.3.

B.15.2 GERS - Batteries on Racks

[1]The seismic capacity for the equipment class of Batteries on Racks (BAT) may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes storage battery sets of the lead-calcium type supported on racks with rail restraints. Each battery set consists of multiple lead-acid cells

(nominal 2 volts each) interconnected by rigid bus connectors. Rows or groups of cells are connected by flexible bus connectors. The racks have either a two-step or single-tier configuration with longitudinal cross-braces. The racks have rail restraints to keep the batteries in place. There are snug-fitting spacers between the cells and, if needed, shims between the cells and rails. This equipment class covers typical stationary lead-acid battery cells used in power plants.

The GERS represent the seismic capacity of Batteries on Racks (BAT) if the batteries and racks meet the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

BAT/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The batteries and racks should be similar to and bounded by the BAT class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

BAT/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The batteries on racks should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

BAT/GERS Caveat 3 - Lead-Calcium Plates. The plates of the battery cell should be lead-calcium. Lead-calcium battery cells are the only type included in the generic seismic testing equipment class.

BAT/GERS Caveat 4 - Supported on Two-Step or Single-Tiered Racks with Longitudinal Cross-Braces. The batteries should be supported on two-step racks or single-tier racks which have longitudinal cross-braces as supplied by the battery manufacturer (review of manufacturer's submittals is sufficient). A row of batteries should be restrained by double rails in front, back and on the ends, symmetrically placed with respect to the cell center of gravity. The concerns addressed by this caveat are that racks may not be able to transfer the lateral seismic loads to the base support, and that the natural frequencies of the rack may be lower than those in the generic seismic testing equipment class.

If the battery rack is custom made and/or does not have longitudinal cross-braces supplied by the manufacturer, then the intent of this caveat can be satisfied by showing that the racks have adequate strength (i.e., within 1.6 times normal AISC allowable stress limits) and have natural frequencies above about 8 Hz horizontal and 20 Hz vertical. If the natural frequency of the rack is below these values, then a realistic amplification through the rack to the center of gravity of the batteries should be included when determining the amplified response of the batteries for comparison to the GERS (for this case the GERS represents the battery capacity).

If the racks only have a single rail, then this rail should be evaluated to determine whether it will hold the cells in place and prevent significant relative motion between cells.

GERS-BAT.4
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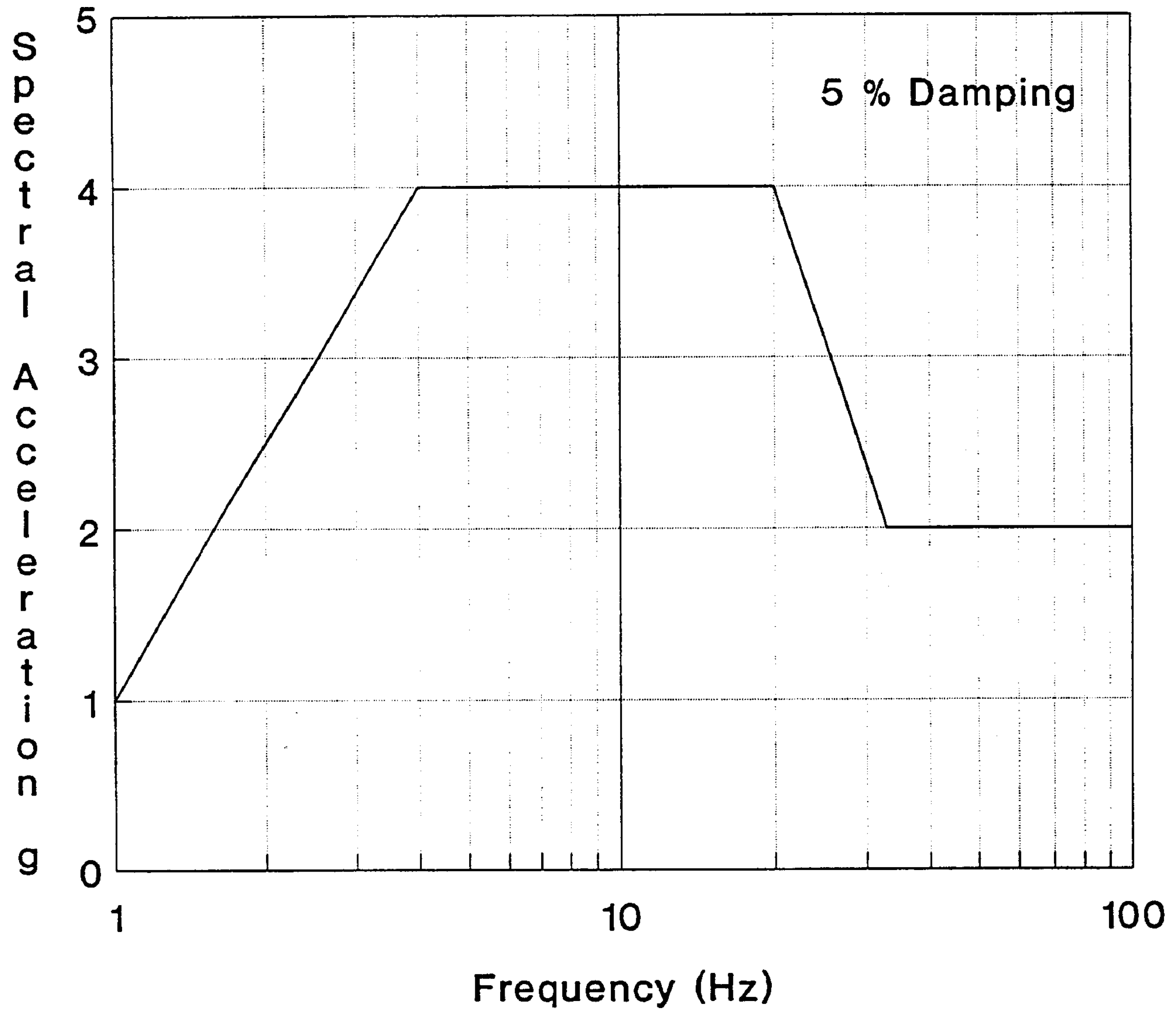


Frequency (Hz)	1	4	20	33
Batteries on Racks (g)	1.0	4.0	4.0	2.0

Figure B.15-1. Generic Equipment Ruggedness Spectra (GERS) for Batteries on Racks (Source: Reference 6)

B.16 BATTERY CHARGERS AND INVERTERS

B.16.1 Bounding Spectrum - Battery Chargers and Inverters

[1]The seismic capacity for the equipment class of Battery Chargers and Inverters (BCI) may be based on earthquake experience data, provided the intent of each of the caveats listed below is met. Chargers and Inverters are grouped into a single equipment class since they perform similar (although electrically inverse) functions, contain similar components, and are packaged in similar cabinets. Solid-state battery chargers are assemblies of electronic components whose function is to convert AC input into DC output. Inverters are assemblies whose function is to convert DC input into AC output. Battery chargers and inverters are normally housed in floor- or wall-mounted cabinets.

The most common applications for both battery chargers and inverters are as components of an uninterruptible power supply (UPS). A typical UPS consists of a solid-state inverter, a battery charger, a set of lead-acid storage batteries, and an automatic transfer switch. Chargers serve the station batteries which provide a DC power source to controls, instrumentation, and switchgear. A portion of the DC power from the batteries is routed through inverters which provide a source of AC power to critical equipment.

The primary electrical function of a battery charger is accomplished using a rectifier. Most battery chargers are based on solid-state rectifiers consisting of semiconductors. This equipment class is limited to solid-state battery chargers and inverters.

The primary components of battery chargers include solid-state diodes, transformer coils, capacitors, electronic filters, and resistors. In addition, the primary components are usually protected from electrical faults by molded case circuit breakers and fuses. The internal components are normally bolted either to the rear panel or walls of a cabinet, or to interior panels or steel frames mounted within a cabinet. The front panel of the cabinet typically contains instrumentation and controls, including ammeters, voltmeters, switches, alarms, and control relays. Inverters contain primary components similar to those found in battery chargers. Virtually all inverters use solid state components.

Battery chargers and inverters are typically mounted in separate cabinets, but they are sometimes supplied as an assembly of two adjoining cabinets. The smallest units are wall-mounted or rack-mounted with typical dimensions of 10 to 20 inches in height, width, and depth, and typical weights of 50 to 200 pounds. Typical cabinet dimensions for larger floor-mounted units are 20 to 40 inches in width and depth, and 60 to 80 inches in height. The weights of the floor-mounted chargers and inverters range from several hundred to several thousand pounds. Typical AC voltages to battery chargers and from inverters range from 120 to 480 volts. Voltages in DC power typically range from 24 to 240 volts.

Industry standards are maintained for the construction of cabinets by the National Electrical Manufacturers Association and Underwriters Laboratories. These standards determine the minimum structural framing and sheet metal thickness for charger and inverter cabinetry as a function of size.

Solid-state inverters and battery chargers are included in the equipment class in freestanding, rack-mounted, and wall-mounted configurations. The Battery Charger and Inverter equipment class includes the sheet metal enclosure, all internal components, junction boxes, and attached cable or conduit.

The Bounding Spectrum (BS) represents the seismic capacity of a Battery Charger or Inverter (BCI) if the equipment meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

BCI/BS Caveat 1 - Earthquake Experience Equipment Class. The battery charger or inverter should be similar to and bounded by the BCI class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

BCI/BS Caveat 2 – Solid-State Type. The battery charger or static inverter should be a solid-state type. The solid-state electrical construction is the primary type included in the earthquake experience equipment class. The concern is that electronics which are not of the solid-state variety (glass tubes, etc.) are vulnerable to earthquake damage.

BCI/BS Caveat 3 - Transformer Mounted Near Base of Floor-Mounted Units. For floor-mounted units, the transformer, which is the heaviest component of this equipment, should be positively anchored and mounted near the base of the cabinet. If not mounted near the base, then the load path should be specially evaluated. The concern is that the lateral earthquake loads on the transformer will not be properly transferred to the equipment base. The load path evaluation may use judgment or simple calculations to ensure that the structure can transfer these loads.

BCI/BS Caveat 4 - No Reliance on Weak-Way Bending of Steel Plate or Structural Steel Shapes. The base assembly of floor-mounted units should be properly braced or stiffened such that lateral forces in any direction do not rely on weak-way bending of sheet metal or thin webs of structural steel shapes. If such unbraced or unstiffened steel webs exist, they should be investigated and verified for adequacy by the Seismic Capability Engineers to check the strength and stiffness.

BCI/BS Caveat 5 - Load Path Check for Wall-Mounted Units. If the battery charger or inverter is a wall-mounted unit, the transformer supports and bracing should be visually reviewed for a proper load path to the rear cabinet wall. Lateral earthquake loads on the heavy transformer need to be properly transferred to the anchorage.

BCI/BS Caveat 6 - Doors Secured. All doors should be secured by a latch or fastener. The concern addressed by this caveat is that the doors could open during an earthquake and the loose door could impact the housing and be damaged or cause internal components to malfunction.

BCI/BS Caveat 7 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

BCI/BS Caveat 8 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

BCI/BS Caveat 9 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the battery charger or inverter as described in Section 4.3.

B.16.2 GERS - Battery Chargers and Inverters

[1]The seismic capacity for the equipment class of both Battery Chargers and Inverters may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. Battery charger units range from 25 to 600 amp capacity with either single- or three-phase voltage ratings of 24 to 250 volts DC and 120 to 480 Volts AC. The units utilize solid-state technology (silicon-controlled rectifier, SCR) in both the main circuits and the power controls. Major components include protective circuit breakers, transformers, power

supply, SCR, filter, and various alarm relays, and control circuits. The units are housed in NEMA-type floor- or wall-mounted enclosures. This equipment class includes typical battery chargers used in power plants for float charging of lead-acid storage battery sets.

DC to AC inverter units included in the GERS database range from 0.5 to 15 kVA capacity with either single- or three-phase voltage ratings of 120 volts DC and 120 to 480 volts AC. The units utilize solid-state technology (silicon-controlled rectifier, SCR), and have protective circuit breakers, transformers, frequency control circuitry, various alarm relays and SCR power control circuits as major components. The units are housed in NEMA-type floor-mounted enclosures. This equipment class covers typical 120 VDC inverters used in power plants for critical power supply.

The GERS represents the seismic capacity of a Battery Charger or Inverter (BCI) if the equipment meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

BCI/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The battery charger or inverter should be similar to and bounded by the BCS class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

BCI/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The battery charger or inverter should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

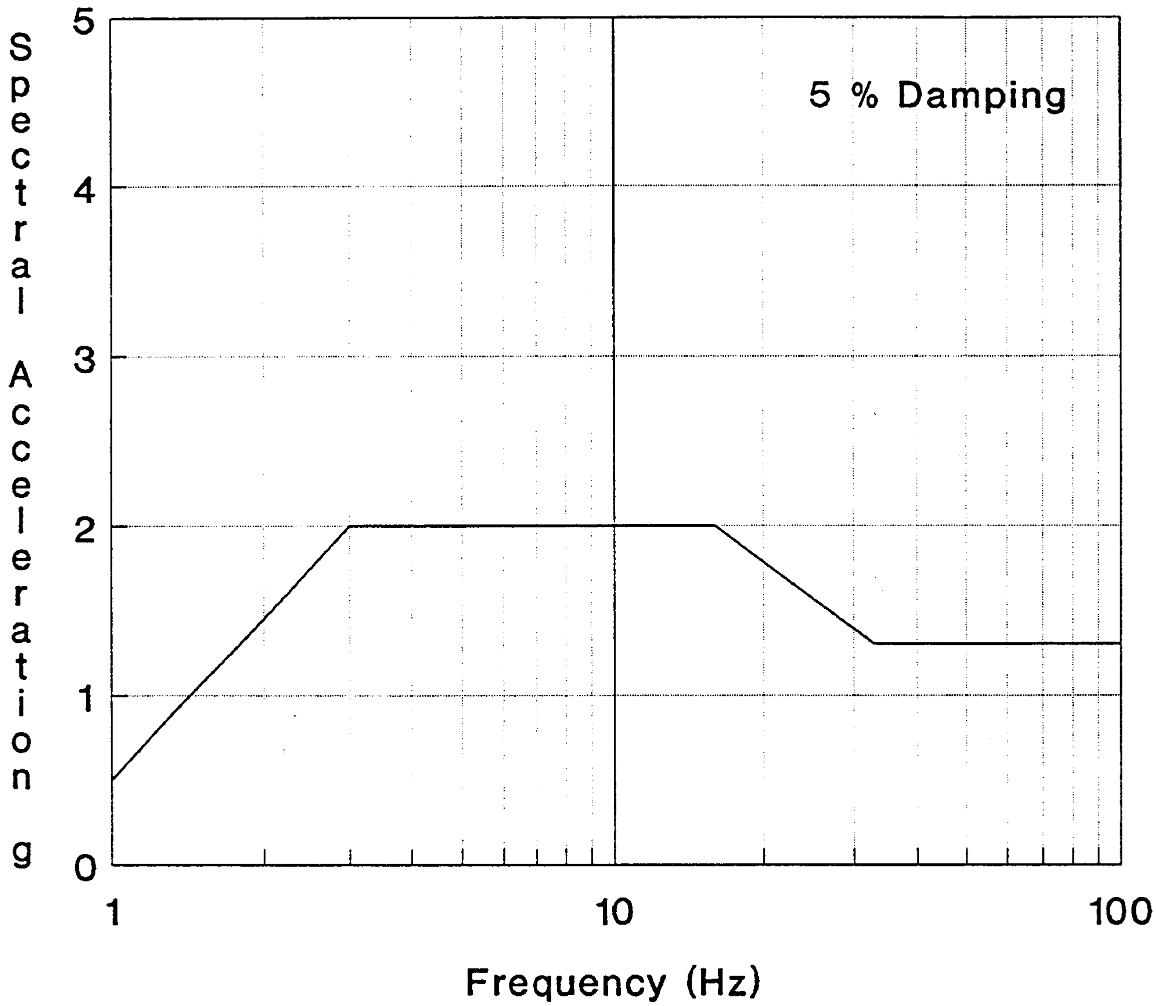
BCI/GERS Caveat 3 - SCR Power Controls Within NEMA-Type Enclosure. The battery charger or inverter should be a solid-state unit with SCR power controls (C&D, PCP, or Exide for battery chargers) (Elgar, Solid State Controls, Staticon for inverters). Battery charger units should be wall- or floor-mounted within a NEMA-type enclosure (review of manufacturer's submittals is sufficient). Only floor-mounted inverter units are permitted. The enclosure does not have to conform exactly to NEMA standards but should be similar with regard to the gage of the steel; internal structure and support. The purpose of this caveat is to ensure similarity with the power controls and enclosure type of the generic seismic testing equipment class.

<u>BCI/GERS Caveat 4 - Battery Charger Size and Capacity Range</u>. Battery Charger size and capacity should be within the following range: 24 to 250 VDC, 120 to 480 VAC, 25 to 600 amps; and weight in the range of 150 to 2,850 pounds with wall-mounted units limited to 600 pounds (review of manufacturer's submittals or Battery Charger nameplate is sufficient). This represents the size and capacity limits of the generic seismic testing equipment class.

<u>BCI/GERS Caveat 5 - Inverter Size and Capacity Range</u>. Inverter size and capacity should be within the following range: 120 VDC, 120 to 480 VAC, 0.5 to 15 kVA; and weight in the range of 300 to 2,000 pounds. (Review of manufacturer's submittals or inverter nameplate is sufficient.) This represents the size and capacity range of the generic seismic testing equipment class.

<u>BCI/GERS Caveat 6 - Cutouts Require Separate Evaluation</u>. Heavy components should, in general, be located in the lower half of the enclosure height and either supported from the base or rear panel. If cutouts are adjacent to support points for heavy internal components, a separate evaluation is required. The concern is that the seismic load will not be able to be transferred through the shear panels to the anchorage.

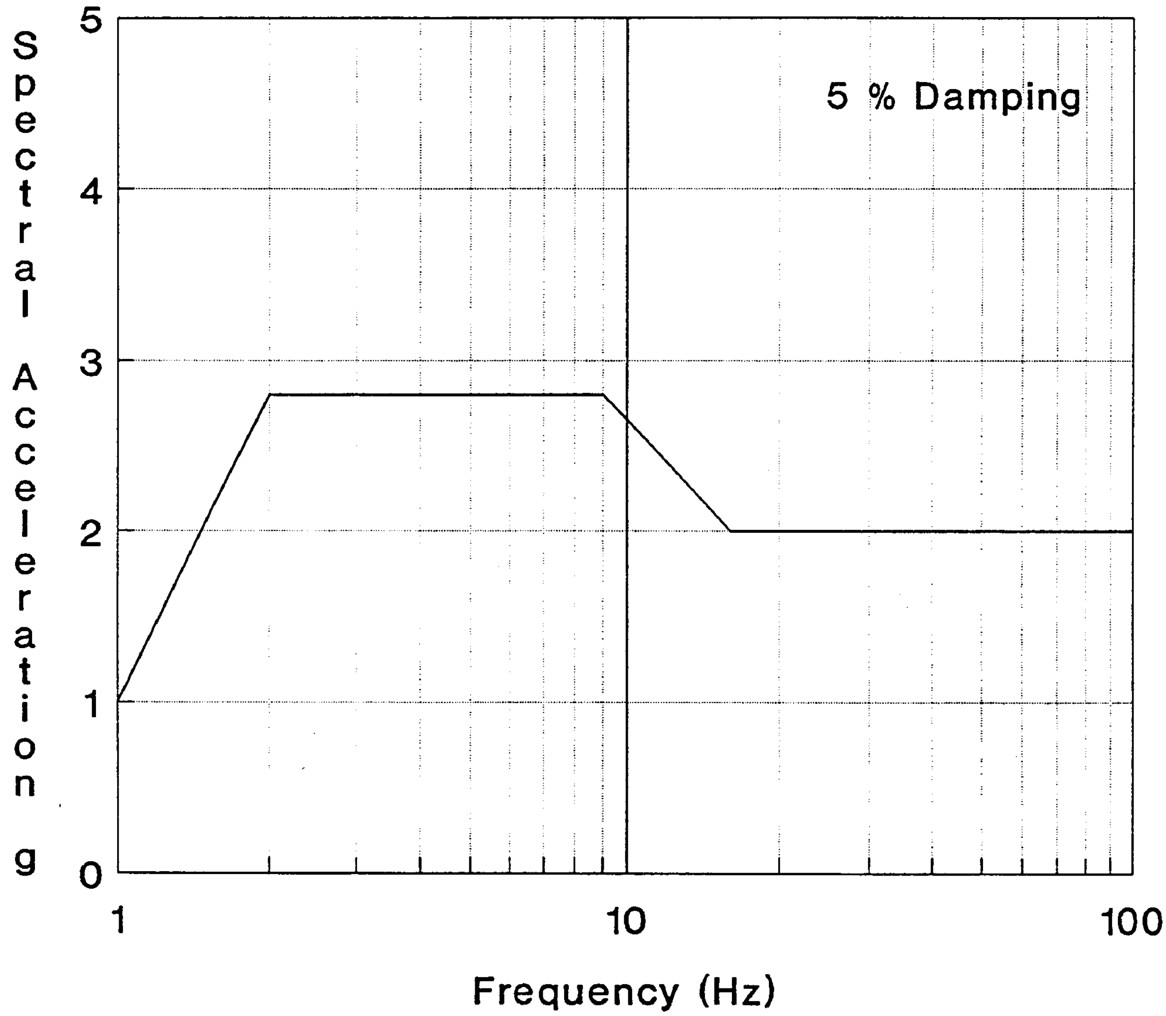
GERS-BC.3
6/1/88



Frequency (Hz)	1	3	16	33
Battery Chargers (g)	0.5	2.0	2.0	1.3

Figure B.16-1. Generic Equipment Ruggedness Spectra (GERS) for Batter Chargers (Source: Reference 6)

GERS-INV.4
6/1/88



Frequency (Hz)	1	2	9	16	33
Inverters (g)	1.0	2.8	2.8	2.0	2.0

Figure B.16-2. Generic Equipment Ruggedness Spectra (GERS) for Inverters (Source: Reference 6)

B.17 ENGINE-GENERATORS

B.17.1 Bounding Spectrum - Engine-Generators

[1]The seismic capacity for the equipment class of Engine-Generators (EG) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes a wide range of sizes and types of generators driven by piston engines. Turbine driven generators are not included in this equipment class. Engine-Generators are emergency power sources that provide bulk AC power in the event of loss of off-site power.

In typical power plant applications, generators range from 200 kVA to 5000 kVA; electrical output is normally at 480, 2400, or 4160 volts. Generators are typically the brushless rotating-field type with either a rotating rectifier exciter or a solid-state exciter and voltage regulator. Reciprocating-piston engines are normally diesel-fueled, although engines may operate on natural gas or oil. In typical applications piston engines range from tractor-size to locomotive-size, with corresponding horsepower ratings ranging from about 400 to 4000 horsepower.

Engine-generators normally include the piston engine and generator in a direct shaft connection, bolted to a common steel skid. The skid or the engine block also supports peripheral attachments such as conduit, piping, and a local control and instrumentation panel.

The engine-generator system also includes peripheral components for cooling, heating, starting, and monitoring operation, as well as supplying fuel, lubrication, and air. The peripheral components may or may not be mounted on or attached directly to the engine-generator skid. If they are not mounted on the skid, they should be evaluated separately.

The Bounding Spectrum (BS) represents the seismic capacity of an Engine-Generator (EG) if the generator meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

EG/BS Caveat 1 - Earthquake Experience Equipment Class. The engine-generator should be similar to and bounded by the EG class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

EG/BS Caveat 2 - Driver and Driven Component on Rigid Skid. The driver and the driven component should be connected by a rigid support or common skid. The concern is that differential displacement between the driver and the driven component may bind the shaft or lead to excessive bearing wear. If they are not mounted on a rigid skid, the potential for differential displacement between the driver motor and driven component should be evaluated.

EG/BS Caveat 3 - Base Vibration Isolation System Checked. If the unit is mounted on vibration isolators, the adequacy of the vibration isolators for seismic loads should be evaluated in accordance with Section 4.4.

EG/BS Caveat 4 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

EG/BS Caveat 5 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

EG/BS Caveat 6 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

EG/BS Caveat 7 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the engine-generator as described in Section 4.3.

B.17.2 GERS - Engine-Generators

There are no GERS for Engine-Generators.

B.18 INSTRUMENTS ON RACKS

B.18.1 Bounding Spectrum - Instruments on Racks

[1]The seismic capacity for the equipment class of Instruments on Racks (IR) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class consists of steel frames that provide mounting for local controls and instrumentation, such as signal transmitters to remote control panels. Instrument racks typically consolidate transducer or control signals from several equipment items in their immediate vicinity.

Instrument racks usually consist of steel members (typically steel angle, pipe, channel, or Unistrut) bolted or welded together into a frame. Components are attached either directly to the rack members or to metal panels that are welded or bolted to the rack. Floor-mounted instrument racks typically range from 4 to 8 feet in height, with widths varying from 3 to 10 feet, depending on the number of components supported on the rack. A simpler configuration of an instrument rack is a single floor-mounted post supporting one or two components. Wall-mounted and structural column-mounted racks are often used for supporting only a few components.

Control system components mounted on instrument racks may include electronic systems used for functions such as temperature monitoring, starting, stopping, and throttling electric motors, and monitoring electric power. Pneumatic system components mounted on instrument racks may be used for monitoring fluid pressure, liquid level, fluid flow, and for adjusting pneumatically-actuated control valves. Electronic control and instrumentation system components mounted on instrument racks include transmitters that convert a pneumatic signal from the transducer to an electric signal for transmission to the main control panel.

Typical components supported on instrument racks include pressure switches, transmitters, gauges, recorders, hand switches, manifold valves, and solenoid valves. Attachments to instrument racks include steel or plastic tubing, conduit, and junction boxes.

Freestanding, wall-mounted, and structural column-mounted instrument racks of bolted and welded steel construction are included in the equipment class along with the components mounted on them. Both pneumatic and electronic components, as well as associated tubing, wiring, and junction boxes, are included in the Instruments on Racks equipment class.

The Bounding Spectrum (BS) represents the seismic capacity of Instruments on Racks (IR) if the instruments and racks meet the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

IR/BS Caveat 1 - Earthquake Experience Equipment Class. The instruments and racks should be similar to and bounded by the IR class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

IR/BS Caveat 2 - Evaluate Computers and Programmable Controllers Separately. Computers and programmable controllers should be evaluated separately. The concern is that the subclass of computers and programmable controllers is so diverse that they may not be adequately represented by the earthquake experience equipment class. Computers and programmable controllers should therefore be evaluated on a case-by-case basis. Component specific test data for computers and programmable controllers may be used to resolve this concern.

IR/BS Caveat 3 - Structure Adequate. The steel frame and sheet metal structure should be evaluated in the walkdown for adequacy. Engineering judgment may be used to determine that an adequate load path exists to transfer the lateral earthquake loads to the foundation.

IR/BS Caveat 4 - Adjacent Racks Bolted Together. Adjacent racks which are close enough to impact each other and sections of multi-bay assemblies should be bolted together if any of these assemblies contain essential relays as defined in Section 6. The concern addressed in this caveat is that adjacent, unbolted racks could respond out of phase to one another and impact each other during an earthquake. This would cause additional impact loadings and high frequency vibration loadings which could cause essential relays to chatter.

IR/BS Caveat 5 - Natural Frequency Relative to 8 Hz Limit Considered. For slender unbraced racks, the lowest natural frequency should be estimated. For racks which have a natural frequency below about 8 Hz, the floor response spectrum should be compared to 1.5 times the Bounding Spectrum (see Table 4-1 of Section 4).

IR/BS Caveat 6 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support.

Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

IR/BS Caveat 7 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

IR/BS Caveat 8 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

IR/BS Caveat 9 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the instrument rack as described in Section 4.3.

B.18.2 GERS - Instruments on Racks

[1]The seismic capacity for the equipment class of Instruments on Racks may be based on generic testing data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes four kinds of transmitters: pressure, temperature, level, and flow. The racks for these instruments are not covered in the generic seismic testing equipment class. Transmitters are used in power plants to transmit signals received from transducers which monitor plant operating conditions. The transmitters send electric signals to control panels for use by safety systems, plant control systems, alarm systems and operator displays. Some transmitters are designed for remote rack or control panel mounting while others are mounted adjacent to the transducer. The term "transmitter" is also used for the transducer/signal conditioner combination when the transducer and signal conditioner are integral. This is the usual case for flow, pressure, and level transmitters. Temperature transmitters are usually remote from the transducer. In general, transmitters range in size from a few pounds to about 40 pounds: however, the majority of the transmitters weigh only a few pounds. The largest physical dimension of a transmitter is usually less than about 12 inches.

The GERS represent the seismic capacity of a pressure, temperature, level, or flow transmitter if the transmitter meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

IR/GERS Caveat 1 - Generic Seismic Testing Equipment Class. The transmitter should be similar to and bounded by the IR class of equipment described above. Seismic Capability The equipment class descriptions are general and the Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

IR/GERS Caveat 2 - Bounding Spectrum Caveats Apply. The transmitter and its supporting rack, when present, should meet all the caveats given for the Bounding Spectrum. This caveat is included to cover the vulnerabilities identified for the earthquake experience equipment class. Those GERS caveats which are the same as the Bounding Spectrum caveats are not repeated below.

IR/GERS Caveat 3 - Component is a Pressure, Temperature, Level, or Flow Transmitter. The component should be a pressure, temperature, level, or flow transmitter. These are the components included in the generic seismic testing equipment class.

IR/GERS Caveat 4 - Specific Transmitter Models Included. There is a wide diversity of transmitter types and mechanical properties. Specific manufacturer/models were tested for function during an earthquake. The tested transmitters in the generic seismic testing equipment class include: Foxboro E96, E13, E916; Devar 18-119; Rosemount 1151, 1152, 442; Robertshaw 161; Love 48, 54, 8100, 1106; Kepco PCX; Travis P8, P24.

This caveat may be satisfied for other models of transmitters by performing a case-by-case evaluation of similarity to one of the above models.

IR/GERS Caveat 5 - Seismic Induced System Changes Should Be Evaluated. Transmitters are sometimes sensitive to system perturbations. The concern is that the earthquake may induce system changes (i.e., pressure, flow, and level variation) which may have the same effect on the system being controlled as if the transmitter malfunctioned. For example, a level switch used to measure the oil level in the crankcase of an emergency diesel-generator (EDG) may be tripped during an earthquake when the oil is sloshing. This reading may inadvertently cause the EDG to trip off line. This caveat is also addressed in the Relay Functionality Review in Section 6.

IR/GERS Caveat 6 - No Vacuum Tubes. Vacuum tubes should not be used as internal electrical components. The concern is that glass tubes are especially vulnerable to earthquake damage.

IR/GERS Caveat 7 - All Mounting Bolts in Place. All external mounting bolts (transmitter to bracket and bracket to support) should be in place. This is the condition under which the transmitters were tested during the generic seismic tests.

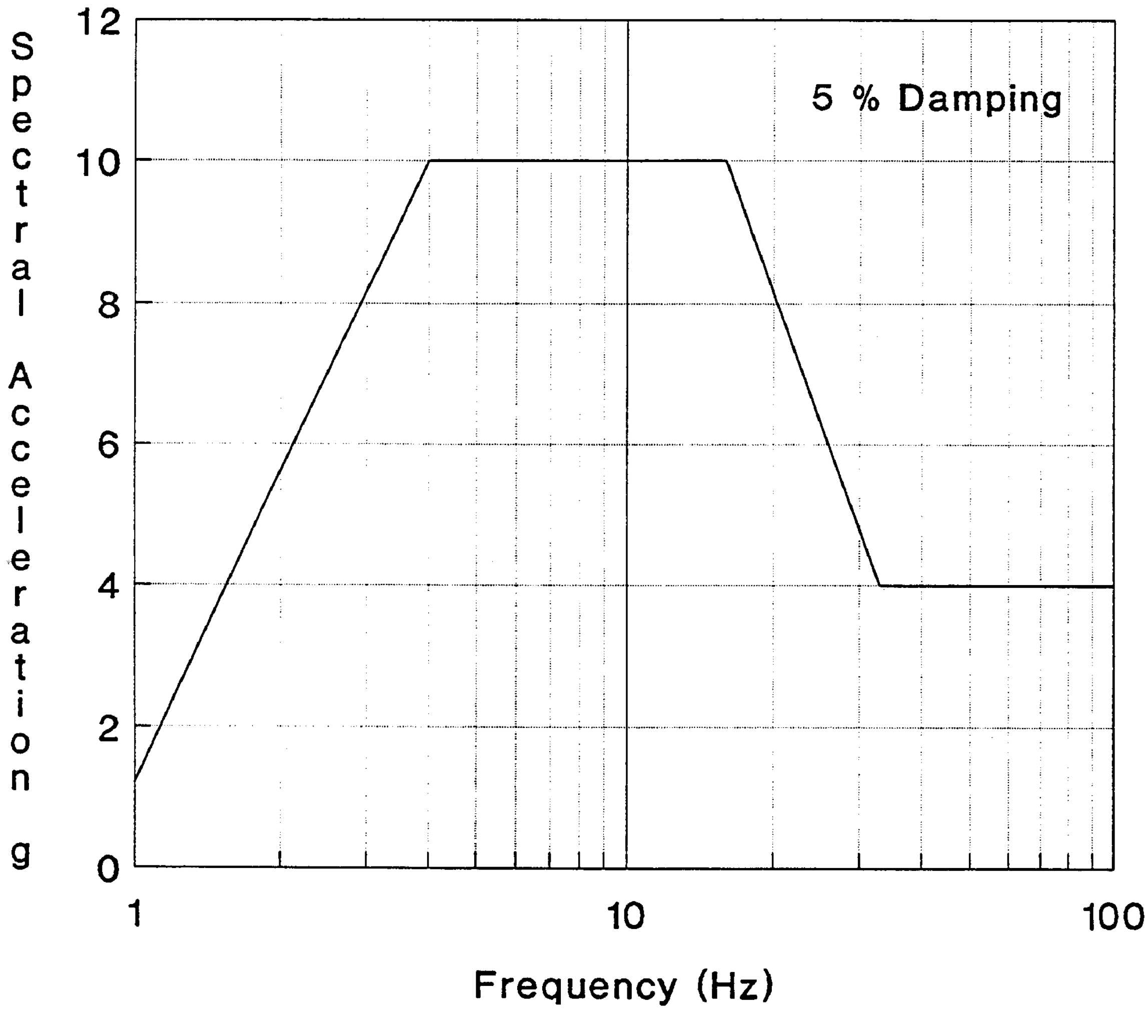
IR/GERS Caveat 8 - Evaluation of Amplified Response. The transmitters which were tested were attached directly to the shake table. Therefore realistic amplification through the rack (or other supporting structure) to the transmitter should be included when determining the amplified response of the transmitter-to-rack interface for comparison to the GERS. The basis for this amplification factor should be documented.

IR/GERS Caveat 9 - Rack Requires Separate Evaluation. The transmitters were tested separately from the rack, therefore in order use the GERS capacity curves which are higher than the

Bounding Spectrum, an evaluation of the rack should be made. The evaluation should show that the structural components of the rack are capable of transferring the earthquake loads to the anchorage. This evaluation may depend upon the engineering judgment of the Seismic Capability Engineers and may not require a formal calculation.

[3]<u>IR/GERS Caveat 10 - Adjacent Racks Bolted Together</u>. Adjacent racks and sections of multi-bay rack assemblies should be bolted together, including those that do not contain essential relays. Adjacent racks and sections of multibay rack assemblies were bolted together when tested for this generic seismic testing equipment class.

GERS-PT.4
6/1/88



Frequency (Hz)	1	4	16	33
Transmitters (g)	1.2	10	10	4

Figure B.18-1. Generic Equipment Ruggedness Spectra (GERS) for Transmitters (Source: Reference 6)

B.19 TEMPERATURE SENSORS

B.19.1 Bounding Spectrum - Temperature Sensors

[1]The seismic capacity for the equipment class of Temperature Sensors (TS) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes thermocouples and resistance temperature detectors (RTDs) that measure fluid temperature and typically are mounted within or on piping or tanks. Thermocouples are probes consisting of two dissimilar metal wires routed through a protective sleeve that produce a voltage output proportional to the difference in temperature between the hot junction and the lead wires (cold junction). RTDs are similar in construction to thermocouples, but their operation is based on variation in electrical resistance with temperature. RTDs and thermocouples are connected to pressure vessel boundaries (piping, tanks, heat exchangers, etc.) using threaded joints. The sensor's sheath will often be inserted into a thermowell or outer protective tube that is permanently mounted in the pipe or tank. A thermowell allows the thermocouple or RTD to be removed without breaking the pressure boundary of the pipe or tank.

Sensors are typically linked to transmitters mounted on nearby instrument racks, which amplify the electronic signal generated in the sensors, and transmit the signal to a remote instrument readout.

The Temperature Sensors equipment class includes the connection head, threaded fitting, sheath or protective tube, thermowell, and attached wires.

The Bounding Spectrum (BS) represents the seismic capacity of a Temperature Sensor (TS) if the sensor meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

TS/BS Caveat 1 - Earthquake Experience Equipment Class. The temperature sensor should be similar to and bounded by the TS class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

TS/BS Caveat 2 - No Possibility of Detrimental Differential Displacement. Detrimental differential displacement between the mounting of the connection head and the mounting of the temperature sensor should not occur. The concern is that the differential displacement may cause the wiring to be pulled out of the sensor.

TS/BS Caveat 3 - Solid State Electronics. The electronics associated with the temperature sensor should be solid state (i.e., no vacuum tubes). The earthquake experience equipment class only includes solid-state electronics for temperature sensors. The concern is that electronics that are not of the solid-state variety (glass tubes, etc.) are vulnerable to earthquake damage.

TS/BS Caveat 4 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

TS/BS Caveat 5 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the temperature sensor as described in Section 4.3.

B.19.2 GERS - Temperature Sensors

There are no GERS for Temperature Sensors.

B.20 INSTRUMENTATION AND CONTROL PANELS AND CABINETS

B.20.1 Bounding Spectrum - Instrumentation and Control Panels and Cabinets

[1]The seismic capacity for the equipment class of Instrumentation and Control Panels and Cabinets (I&C) may be based on earthquake experience data (as described in Section 4.2), provided the intent of each of the caveats listed below is met. This equipment class includes all types of electrical panels that support instrumentation and controls. This equipment class includes both the sheet metal enclosure and typical control and instrumentation components mounted on or inside the enclosure. Instrumentation and control panels and cabinets create a centralized location for the control and monitoring of electrical and mechanical systems. In addition to main control panels, local instrumentation and control panels are sometimes distributed throughout the facilities, close to the systems they serve.

Instrumentation and control panels and cabinets have a wide diversity of sizes, types, functions, and components. Panel and cabinet structures generally consist of a steel frame supporting sheet metal panels to which instrumentation and control components are bolted or clamped. Cabinet structures range from a single panel, braced against or built into a wall, to a freestanding cabinet enclosure. These enclosures are generally categorized as either switchboards or benchboards as described below.

A vertical switchboard is a single reinforced sheet metal instrument panel, which is either braced against an adjacent wall or built into it. An enclosed switchboard is a freestanding enclosed sheet metal cabinet with components mounted on the front face, and possibly on the interior walls. The front or rear panel is usually hinged as a single or double swinging door to allow access to the interior. A dual switchboard consists of two vertical panels braced against each other to form a freestanding structure, with components mounted to both front and rear panels. The sides are usually open, and the two panels are joined by cross members spanning between their tops. A duplex switchboard is similar to a dual switchboard, except that it consists of a panel fully enclosed by sheet metal on all sides, with access through doors in the two side panels.

A benchboard consists of a control desk with an attached vertical panel. A control desk has components mounted on the desk top, and interior access through swinging doors in the rear. The single panel is similar to a vertical switchboard and is normally braced against or built into a wall. A dual benchboard is similar to a dual switchboard, but the lower half of the front panel is a desk console. A duplex benchboard is similar to a duplex switchboard, a totally enclosed panel, but with a desk console in the lower half of the front panel.

Panel and cabinet enclosures normally consist of steel angles, channels, or square tubes welded together, with sheet metal siding attached by spot welds. Large panels are typically made of individual sections bolted together through adjoining framing. The cabinet may or may not include a sheet metal floor or ceiling.

Electronic or pneumatic instrumentation or control devices attached to sheet metal panels or within sheet metal cabinets are included in the equipment class. The Instrumentation and Control Panels and Cabinets equipment class includes the sheet metal enclosure, switches, push buttons, panel lights, indicators, annunciators, gauges, meters, recorders, relays (provided they meet relay requirements), controllers, solid-state circuit boards, power supplies, tubing, wiring, and terminal blocks.

The Bounding Spectrum (BS) represents the seismic capacity of Instrumentation and Control Panels and Cabinets (I&C) if the panel or cabinet meets the intent of the following inclusion and exclusion rules. Note, however, that when the specific wording of a caveat rule is not met, then a reason for concluding that the intent has been met should be provided on the SEWS.

I&C/BS Caveat 1 - Earthquake Experience Equipment Class. The panel or cabinet should be similar to and bounded by the I&C class of equipment described above. The equipment class descriptions are general and the Seismic Capability Engineers should be aware that worst case combinations of certain parameters may not be represented in the generic equipment class. These worst case combinations may have reduced seismic capacity and should be carefully evaluated on a case-by-case basis.

I&C/BS Caveat 2 - Evaluate Computers and Programmable Controllers Separately. Computers and programmable controllers should be evaluated separately. The concern is that the subclass of computers and programmable controllers is so diverse that they may not be adequately represented by the earthquake experience data. Computers and programmable controllers should therefore be evaluated on a case-by-case basis.

I&C/BS Caveat 3 - Evaluate Strip Chart Recorders Separately. Strip chart recorders should be evaluated separately. The concern is that long, narrow recorders which are cantilevered off the panel may not have adequate structural support. Strip chart recorders are commonly supported on compression-type mounting brackets supplied by the manufacturer. These types of support brackets are inherently rugged and generally adequate for transfer of seismic loads. If there are no support brackets, or the support system appears to be a custom design, or the Seismic Capability Engineers have any concerns regarding the adequacy of the bracket, then the support system should be subject to further evaluation.

I&C/BS Caveat 4 - Structural Adequacy. The steel frame and sheet metal should be evaluated for adequacy. Engineering judgment may be used to determine that an adequate load path exists to transfer the lateral earthquake loads to the foundation.

I&C/BS Caveat 5 - Adjacent Cabinets or Panels Bolted Together. Adjacent cabinets or panels which are close enough to impact each other and sections of multi-bay assemblies should be bolted together if any of these assemblies contain essential relays as defined in Section 6. The concern addressed in this caveat is that unbolted cabinets or panels could respond out of phase to one another and impact each other during an earthquake. This would cause additional impact loadings and high frequency vibration loadings which could cause any essential relays to chatter.

I&C/BS Caveat 6 - Drawers or Equipment on Slides Restrained. Drawers or equipment on slides should be restrained to prevent them from falling out during seismic motion. The concern is that the components in the drawer could slide and become damaged, or slide out and fall onto some other fragile essential component in the vicinity. A latch or fastener should secure these sliding components.

I&C/BS Caveat 7 - Doors Secured. All doors should be secured by a latch or fastener. The concern addressed by this caveat is that loose doors could repeatedly impact the housing and be damaged or cause internal components such as relays to malfunction or chatter.

I&C/BS Caveat 8 - Sufficient Slack and Flexibility of Attached Lines. Sufficient slack and flexibility should be present in attached lines (e.g., cooling, air, and electrical) to preclude a line breach due to differential seismic displacement of the equipment and the line's nearest support. Sufficient slack and flexibility of lines is also considered in the seismic interaction review (Section 4.5).

I&C/BS Caveat 9 - Adequate Anchorage. The unit should be properly anchored in accordance with the guidelines of Section 4.4.

I&C/BS Caveat 10 - Potential Chatter of Essential Relays Evaluated. If relays are mounted on the equipment, a relay functionality review in accordance with Section 6 should be performed.

I&C/BS Caveat 11 - Any Other Concerns? Seismic Capability Engineers should seek out suspicious details or uncommon situations not specifically covered by the caveats which could adversely affect the seismic capacity of the cabinet or panel as described in Section 4.3.

B.20.2 GERS - Instrumentation and Control Panels and Cabinets

There are no GERS for Instrumentation and Control Panels and Cabinets.

REASONS FOR CHANGES TO GIP, PART II, APPENDIX B

Listed below are the specific reasons for making the changes marked with a vertical line in the margin of this appendix to create GIP-3A from GIP-3, Updated 5/16/97. The endnote numbers listed below correspond to the bracketed numbers (e.g., [1]) located in the text of this appendix where the changes are made.

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1 SSER No. 2, Sec. III.2.1 – The Staff noted that throughout Appendix B there are statements such as "equipment determined to be seismically rugged" and the equipment "has been determined to be seismically rugged . . . provided the intent of each of the caveats listed below is met . . ." The Staff position is that in addition to meeting the caveats, the user of the GIP must demonstrate that the demand level is appropriately satisfied by the capacity level before the equipment can be considered to be rugged and acceptable for its application.

The GIP has been amended in each subsection of Appendix B to delete the phrase "has been determined to be seismically rugged" and to add a reference to Section 4.2 of the GIP, which discusses comparison of capacity to demand.

2 SSER No. 2, Sec. III.2.2 – The Staff clarified their understanding that when the GIP uses the term "a cabinet assembly," regarding an attachment weight of 100 pounds, that it means a combination or lineup of a number of individual cabinets, bays, or frames.

The GIP has been amended in Part II, Appendix B, Sections B.1.1, B.2.1, and B.3.1 to incorporate the Staff's clarification by adding a phrase after the term "cabinet assembly" as follows: ". . . i.e., a combination or a lineup of a number of individual adjacent cabinets, bay, or frames."

3 SSER No. 2, Sec. III.2.3 – The Staff position that sections of multi-bay cabinets should be bolted together, even if they do not contain essential relays, if the GERS capacities are used since sections of such cabinets were bolted together during testing.

The GIP has been amended in Part II, Appendix B, Sections B.1.2, B.2.2, B.3.2, B.4.2, B.14.2, and B.18.2 and in the SEWS in Appendix G for Equipment Classes 1, 2, 3, 4, 14, and 18 to include a GERS caveat requiring adjacent cabinets to be bolted together.

4 Typographical error corrected.

5 SSER No. 2, Sec. II.2.3 – The Staff suggested that the information presented in NUREG/CR-4659, Vol. 4 should be considered in the evaluation of motor operators on valves, especially for some earlier models, since the capacities levels in this report appear to be lower than the GERS levels in GIP Figure B.8A-2.

The seismic capacity levels reported in NUREG/CR-4659, Vol. 4 are not comparable to the GERS for motor operators on valves because the NUREG levels are for a more general class of "Valve Operators (Motor, Air, and Solenoid)", whereas the GERS levels are provided separately for motor operators and for air-operated and solenoid-operated valve assemblies. SQUG notes that the peak GERS levels for air-operated and solenoid-operated valve assemblies (7g and 9g, respectively, over 4 – 16 Hz) are significantly lower than the GERS level for motor operators on valves (20g to 22g). The NUREG does not provide the data for only motor operators. Because the NUREG data for only motor operators has not been compared to the GERS for motor operators on valves, no changes to the motor operator GERS or the guidance in the GIP are warranted at this time.

[6] Typographical error corrected. Figure B.8B-1 should be the same as Figure B.8-1 from GIP-2, i.e., “Heavy Valve Operator Cantilever Limits.”