1 of 1

DISTRIBUTION SHEET

To PFP OPERATIONS D. M. Bogen	From CIVIL/STRUCTURAL ENGINEERING E. C. Ocoma	Page 1 of 1 Date 2/14/95
Project Title/Work Order WALKDOWN PROCEDURE SEISMIC ADEQUACY REVIEW OF SAFETY CLASS 3 AND 4 COMMODITIES IN 2736-Z & -ZB BUILDINGS AT PFP FACILITY		EDT No. 611545 ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./Appendix Only	EDT/ECN Only
D. M. Bogen	R3-50	X			
E. P. Bonadie	T5-55	X			
T. J. Conrads	H5-55	X			
S. K. Farnworth	H5-57	X			
G. A. Glover	T4-20	X			
J. L. Mejia	T5-08	X			
E. C. Ocoma (2)	H5-57	X			
L. H. Rodgers	T5-54	X			
M. S. Ruben	E6-46	X			
A. K. Sharma	H5-60	X			
R. W. Szempruch	T4-18	X			
R. J. Thomas	T4-20	X			
E. C. Vogt	T5-50	X			
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RELEASE AUTHORIZATION

Document Number: WHC-SD-CP-SA-028, Rev. 0

Document Title: WALKDOWN PROCEDURE - SEISMIC ADEQUACY REVIEW OF
SAFETY CLASS 3 AND NON-SAFETY CLASS 4 COMMODITIES IN
2736-Z AND ZB BUILDINGS AT THE PFP FACILITY

Release Date: 3/29/95

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Chris Willingham
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3/29/95

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SUPPORTING DOCUMENT		1. Total Pages 78
2. Title Walkdown Procedure Seismic Adequacy Review of Safety Class 3 & 4 Commodities in 2736-Z & -ZB Buildings at PFP Facility	3. Number WHC-SD-CP-SA-028	4. Rev No. 0
5. Key Words Seismic Walkdown 3/1 SQUG/EPRI 2736-Z & -ZB	6. Author Name: E. C. Ocoma <i>E. C. Ocoma</i> Signature Organization/Charge Code 57200/K6058	
7. Abstract <p>Field walkdowns of potential PFP seismic deficiencies associated with structural failure and falling will be performed using the DOE SQUG/EPRI methodology. Potential proximity interactions are also addressed in this program.</p> <p>Areas for which these procedures are to be applied are determined prior to the walkdown. The structural integrity of SC 3 and non-SC 4 commodities during and following a Design Basis Earthquake (DBE) will be reviewed if they are within the seismic zone of influence of the SC 1 items.</p> <p>The objective of the walkdown is to qualify as much of the equipment as practical and to identify candidates for further evaluation. The seismic adequacy of the candidates will be demonstrated by performing bounding evaluation for groups of similar commodities or outlier evaluation for unique commodities which are judged not to have adequate seismic capacity. In-scope commodities which are not selected as candidates (Non-Candidates) are judged to have adequate seismic capacity or are bounded by candidates. Individual commodities are not specifically identified as meeting the acceptance criteria in this procedure. Completion of a walkdown of a particular area may result in the identification of commodities for further evaluation. All other in-scope commodities are thus accepted as adequate in that area.</p>		
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		8. RELEASE STAMP <div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: 250px;"> OFFICIAL RELEASE BY WHC DATE MAR 29 1996 <i>Sta. 21</i> </div>

WALKDOWN PROCEDURE
SEISMIC ADEQUACY REVIEW
OF SAFETY CLASS 3 AND
NON-SAFETY CLASS 4 COMMODITIES
IN 2736-Z AND 2736-ZB BUILDINGS
AT THE PFP FACILITY

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Hanford Operations and Engineering Contractor
for the Department of Energy

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ATTACHMENTS

A	Evaluation Forms
B	Guidelines for Identifying Safety Related Commodities
C	Piping and Tubing Screening Guidelines
D	Raceways Screening Guidelines
E	HVAC Screening Guidelines
F	Control and Electrical Panels Anchorage Screening Guidelines
G	Miscellaneous Commodities, Structural Items and Architectural Features Screening Guidelines
H	Anchorage Screening Guidelines

1.0 INTRODUCTION

The seismic evaluation of existing safety class (SC) 3 and non-SC 4 commodities at the Plutonium Finishing Plant (PFP) facility is integrated into an area walkdown program. Field walkdowns of potential PFP seismic deficiencies associated with structural failure and falling will be performed. Potential proximity interactions are also addressed in this program.

Areas for which these procedures are to be applied are determined prior to the walkdown. Specific areas to be assessed include areas where higher SC commodities (e.g., SC 1 and 2) are located. The structural integrity of SC 3 and non-SC 4 commodities during and following a Design Basis Earthquake (DBE) will be reviewed if they are within the seismic zone of influence of the SC 1 items. The seismic demand of new SC 3 and non-SC 4 commodities to be installed in a SC 1 facility must be evaluated to ensure that their structural integrity will be maintained during and after a DBE as needed to not adversely impact SC 1 equipment.

The objective of the walkdown is to qualify as much of the equipment as practical and to identify candidates for further evaluation. The seismic adequacy of the candidates will be demonstrated by performing bounding evaluation for groups of similar commodities or outlier evaluation for unique commodities which are judged not to have adequate seismic capacity. Evaluation of candidates is not addressed in this procedure. In-scope commodities which are not selected as candidates (Non-Candidates) are judged to have adequate seismic capacity or are bounded by candidates. Individual commodities are not specifically identified as meeting the acceptance criteria in this procedure. Completion of a walkdown of a particular area may result in the identification of commodities for further evaluation. All other in-scope commodities are thus accepted as adequate in that area.

2.0 SCOPE

The scope of the seismic adequacy walkdown is to review existing or in-progress construction of SC 3 and non-SC 4 commodities relative to DBE induced structural failure and falling. Commodities installed, or modified following the area walkdown are not covered by this program. New commodity installation is performed to procedures that assure compliance with seismic criteria. Candidates will be selected for further evaluation. This procedure applies to the following existing commodities located in buildings 2736-Z rooms 1, 2, 3, and 4 and 2736-ZB room 636 only:

- a. Piping.
- b. Conduit.
- c. SC 3 and non-SC 4 HVAC ducting and related HVAC equipment.
- d. SC 3 and non-SC 4 equipment (mechanical, electrical, miscellaneous structural items, etc.).

The SC 1 items are as follows:

- 1. Repackaging glovebox in building 2736-ZB, room 636. All other items in the room are SC 3 or 4.

- 2. In building 2736-Z

Room 1 - The new configuration concrete cubicles.

- The pedestals bolted inside the cubicles.
- The storage cans on the pedestals.

Room 2 - The lard cans and the metal storage racks.

- The 7-inch can and the metal storage racks.

Rooms 3 & 4 - The old configuration concrete cubicles.

- The pedestals welded to embeds inside the cubicles.
- The storage cans on the pedestals.

All other items in the rooms are SC 3 & 4.

3.0 ACCEPTANCE CRITERIA

Seismic acceptance of commodities screened by this procedure is based upon recommendations of the guidelines of References 9.1 and 9.8. Specific screening rules for common commodities are provided in attachments to this procedure. Screening rules are necessarily conservative to facilitate applicability of the rules to a majority of commodities. As a result, this procedure results in two commodity classifications, those that meet criteria for seismic loading and those that require further evaluation. The SC equipment identified in this procedure are not any of the 20 classes of safe shutdown equipment that are required to operate/function during and after an SSE as described in the Seismic Qualification Utility Group/Electric Power Research Institute (SQUG/EPRI) Generic Implementation Procedure (GIP). The SC equipment requiring seismic interaction walkdown are not required to operate during and after a DBE. The glovebox, metal racks, pedestals and cubicles are required to be standing up after the DBE in order to maintain their safety function. Other criteria are as follows:

- ▶ In room 636, building 2736-ZB
 - Potential seismic interaction items shall not cause the glovebox to overturn.
- ▶ In rooms 1, 3, & 4, building 2736-Z
 - Potential seismic interaction items shall not penetrate the cubicle walls and/or the storage cans.
- ▶ In room 2, building 2736-Z
 - Potential seismic interaction items shall not puncture the storage cans.

4.0 RESPONSIBILITIES

4.1 WALKDOWN TEAM LEADER

Responsible for conducting the walkdown in accordance with this procedure. Responsible for the selection of candidates, walkdown completeness and walkdown documentation. Signs walkdown forms to acknowledge acceptance of walkdown findings.

4.2 WALKDOWN TEAM MEMBER

Responsible for assisting the Team Leader in the selection of candidates, assuring walkdown completeness and walkdown documentation in accordance with this procedure. Team Members may participate in all or portions (i.e., specific commodity reviews) of the walkdown. Team Member signature on walkdown forms signifies concurrence with the selection of candidates (as applicable) and all other entries on the form.

4.3 REVIEWER

Responsible for consistency in content and for the completeness of the walkdown packages. Performs discretionary walkdowns to verify candidate selection.

5.0 METHODS/INSTRUCTIONS

Walkdowns shall be performed on an area basis. In-scope areas are those that contain SC 1 and 2 commodities, areas required for personnel access or egress following an earthquake and areas occupied by key operations personnel. Identification of SC 1 systems should be done prior to initiating the walkdown. Information can be gathered from equipment layout drawings, safety equipment lists and consultation with SCE. The area list is necessary to evaluate the level of effort associated with a facility walkdown and a tool in tracking walkdown progress in terms of completed versus outstanding areas.

The area walkdowns are source oriented, thus it is not necessary to determine the spatial relationships between SC 3 and non-SC 4 and SC 1 commodities. It is intended for the walkdown team to concentrate on the seismic adequacy review of area commodities without excessive effort expended on identifying the SC of specific commodities. To accomplish this objective, it is recommended that the walkdown team review all commodities which can not be clearly identified as SC 1 by visual inspection. Guidelines for identifying safety class 1 items are provided in Attachment B.

5.1 WALKDOWN PREPARATION

The walkdown team should verify the area walkdown package contains a full set of walkdown forms. General information such as elevations and input accelerations should be entered in the headings of the walkdown forms prior to starting the walkdowns.

5.2 WALKDOWN PERFORMANCE

The walkdown shall be directed by the Walkdown Team Leader to ensure the review is complete, consistent, and performed with emphasis on quality. The commodities may be reviewed concurrently or on a commodity specific basis, depending on the most efficient approach considering the area size, congestion, balance of commodities and walkdown team preference. Large areas may be broken into smaller sections, providing the boundaries are clearly identified in the walkdown package (for example, include maps showing boundaries if areas are broken into smaller sections).

The walkdown evaluation forms listed in Section 6.1 and included in Attachment A shall be completed, as applicable. The comment sections of the walkdown sheets should document pertinent attributes of the walkdown in such a manner that a Reviewer can review the documentation package and understand the general walkdown logic. Use continuation sheets to expand comments when appropriate. Comments may include general information applicable to the area walkdown and may also provide specific information resulting from the walkdown. For example, a note indicating that a specific commodity located in the area is enveloped by similar commodities located at higher elevations with greater input acceleration may be included in the Comments block. Example: *"The horizontal seismic acceleration of 5.32g used in Reference 9.1 for PFP duct level floor to generate the allowable support spans for piping and conduit envelopes the .6g x 1.5 = .9g which is applicable to the 2736-Z building at the roof elevation."*

5.3 CANDIDATE SELECTION

Commodities listed in Section 2.0 shall be reviewed by the walkdown team. Bounding configuration commodities shall be identified as candidates for further evaluation. A bounding configuration is a commodity which is judged to be less rugged than similar commodities. Attributes such as anchorage support configuration, input seismic accelerations, physical size and flexibility are examples of the parameters for consideration when selecting the bounding configurations. Guidelines for selecting candidates are included in Attachments B through F for specific commodities and/or attributes. Unique commodities which are judged not to have adequate seismic capacity shall also be identified as candidates. Commodities listed in Section 2.0 which are not selected as candidates are judged to have adequate seismic capacity or are bounded by candidates.

The selection of candidates should consider more than just the population of commodities within the area under consideration. For example, it is possible that no piping candidates would be selected if the area under consideration is relatively small and the piping is well supported. Several piping candidates may be selected in other areas which have multiple relatively low seismic capacity systems. It is not necessary to select candidates in each area. The team may consider previous areas reviewed, for a larger population of comparable commodities.

Construction completion activities may be in-progress during area walkdowns. The walkdown team should not identify commodities as candidates if construction is in-progress. For example, an excessive span should not result in candidate identification if additional supports which would eliminate the concern are in-progress. The remainder of the system not affected by construction-in-progress shall be reviewed based on the existing configuration. If there are questions concerning construction completion activities, the walkdown team may discuss the configuration with Construction Engineering and/or review related documents. Items that are loose, missing, or broken that do not appear to be part of work in progress or part of area turnover scope shall be identified.

Candidates shall be documented on candidate identification forms (Attachment A, page A-8). Each candidate shall be assigned a unique identification number according to the format AAAA-BBBB-CCC-D-XXX, where:

AAAA is the four digit facility designation = PFP

BBBB is the four digit building designation = 2736Z or 2736ZB

CCC is the room number (may be more, or less, than three digits)
= 636 for 2736-ZB; 1, 2, 3, & 4 for 2736-Z

D is the commodity designator, with

P = Piping and tubing

R = Raceways

H = HVAC (and associated equipment)

E = Equipment (other than HVAC) and miscellaneous commodities

Candidates selected based on anchorage and miscellaneous attributes shall be designated according to the affected commodity type.

XXX is a sequential number beginning with 001 for each area commodity

For example, the first candidate piping system located in room 636 of building 2736-ZB in the PFP facility would be identified as PFP-2736ZB-636-P-001. If a system passes through multiple areas, the designator should list the first area where a candidate was noted.

Photographs should be taken of candidates during the walkdowns and included in separate, uncontrolled binders. The photographs should be referenced in the Comments block of the appropriate evaluation form by an identification number. The photographs are for information only and will not be part of the final SD. Photographs should be retained as a part of the permanent records.

5.4 WALKDOWN COMPLETION

When all commodities and attributes are reviewed and the forms listed in Section 8.1 are completed and signed by the walkdown team, the package shall be forwarded to the Reviewer.

The Reviewer shall review the walkdown package for completeness, content, and consistency. The Reviewer may perform a field walkdown to review the selection of candidates. Areas should be selected for Reviewer walkdowns based on content of the walkdown package, knowledge of facility areas, makeup of the walkdown teams, or other means at Reviewer's discretion.

Following comment resolution, if any, the Reviewer shall document the review by identifying if a reviewer walkdown was performed, and signing the Area Summary Sheet. The walkdown package is then labelled Revision 0.

6.0 DOCUMENTATION

Documentation requirements for area walkdowns are included in Section 6.1. Documentation requirements for control of the walkdown packages are included in Section 6.2. Any forms similar to the forms identified in this procedure may be used so long as attributes within the borders presented on the forms herein are included.

6.1 WALKDOWN DOCUMENTATION REQUIREMENTS

The walkdown shall be documented on an area/room basis using the forms included in Attachment A and listed below.

1. Area Summary Sheet
2. Piping and Tubing
3. Raceways
4. HVAC
5. Equipment and Miscellaneous Commodities
6. Anchorage and Miscellaneous Attributes
7. Candidate Identification Sheet (for candidates only)
8. Continuation Sheet (as required)

Form 1 is required to be completed for each area/room. Forms 2 through 5 are required for each area unless there are no commodities in a specific category (e.g., HVAC) or if all of the commodities in a specific category are identified as SC 1. A minimum of one Form 6 is required for each area. The Walkdown Team Leader may include more than one Form 6 in areas where it may be practical to review anchorage and miscellaneous attributes on a commodity specific basis. Form 7 is required for each candidate identified. Form 8 is used for the continuation of Forms 1 through 7, as required. Instructions for completing the review forms are also included in Attachment A.

An Area Walkdown Package is defined as an Area Summary Sheet (Form 1) with applicable commodity, candidate and continuation sheets attached (Forms 2 through 8).

6.2 AREA WALKDOWN PACKAGE CONTROL

Changes to completed walkdown packages may be incorporated, following completion, in accordance with the following guidelines:

Revisions to the area walkdown package shall be documented by adding a revised Area Summary Sheet. This sheet shall describe the revision in the Description of Revision block. The revised Area Summary Sheet shall be signed by two engineers qualified per Section 7.0. One of the engineers shall meet the qualifications of Walkdown Team Leader.

7.0 PERSONNEL QUALIFICATIONS AND TRAINING

7.1 PERSONNEL QUALIFICATIONS

The walkdown teams shall be comprised of a minimum of 2 engineers with one Team Leader and one or more Team Members. Walkdown engineers shall meet the applicable qualifications listed below.

Walkdown Team Leader - The Team Leader shall meet the education and experience requirements of either a or b, below.

- a. BS in engineering and at least five years of experience in structural or mechanical engineering, including at least two years of seismic evaluation by walkdown and analysis applicable to nuclear facilities. Certified by DOE for completing the Training Course on SQUG/EPRI Walkdown Screening and Seismic Evaluation.
- b. MS or PhD in engineering and at least three years of experience in structural or mechanical engineering, including at least two years of seismic evaluation by walkdown and analysis applicable to nuclear facilities. Certified by DOE for completing the Training Course on SQUG/EPRI Walkdown Screening and Seismic Evaluation.

Walkdown Team Member - The Team Member(s) shall meet the education and experience requirements of either a or b, below.

- a. BS in engineering and at least three years of experience in structural or mechanical engineering, including at least one year of engineering mechanics.
- b. MS or PhD in engineering and at least one year of experience in engineering mechanics.

Reviewer - The Reviewer shall meet the qualification requirements of Walkdown Team Leader.

7.2 WALKDOWN TRAINING

The Team Leader may conduct the walkdown training. Team Members shall be trained in the implementation of this procedure if not already familiar in conducting a seismic walkdown. The training may be waived for a Team Member if the particular Team Member has previous seismic walkdown experience and has been verified by the Team Leader. The training may consist of reading assignments, one-on-one discussions, field training and/or walkdown observations. The material covered during training shall include the following:

- Walkdown Procedure and associated criteria
- PFP facility procedures applicable to Buildings 2736-Z & -ZB. Since the rooms to be walked down have entry restrictions, anybody that will be involved shall have been cleared for entry and therefore is familiar with the applicable entry requirements procedures.
- Walkdown safety

8.0 DATA DISPOSITION

Evaluation and disposition of candidate commodities will be performed using the methods delineated in the Evaluation Guidelines, and are not included in the scope of this procedure. The evaluations will be documented by calculation, report, and/or correspondence. Upon final determination of seismic adequacy for all SC 3 and non-SC 4 commodities in the scope of the walkdown, the Team Leader shall release the final walkdown documentation packages through Document Control as a Supporting Document.

9.0 REFERENCES

- 9.1 Ocoma, E. C., Westinghouse Hanford Company, "Generic Acceptance Criteria for Seismic Category III/I Resolutions in PFP RMC Line," Document Number SD-CP-SA-004, August 1988.
- 9.2 EQE Engineering, Inc., "Summary of the Seismic Adequacy of Twenty Classes of Equipment Required for Safe Shutdown of Nuclear Plants," EPRI Report NP-7149, March 1991.
- 9.3 EQE Engineering, Inc., "Procedure for the Seismic Evaluation of Metal HVAC Ducts at SRS Facilities," 52137-R-005, Rev. 0. September 1993.
- 9.4 EQE Engineering, Inc., "Piping Seismic Adequacy Criteria Recommendations Based on Performance During and After Earthquakes, Volume 2: Reference Document," EPRI Research Project Number RP-2635-1, Volume 2.
- 9.5 EQE Engineering Inc., "The Performance of Raceway Systems in Strong-Motion Earthquakes," EPRI NP-7150, San Francisco, CA.
- 9.6 Ocoma, E. C., WHC-SD-GN-DGS-30006, "Guidelines for Assessing the Seismic Adequacy of Safety Class 3 and Non-Safety Class 4 Equipment at the Hanford Site", 1992.
- 9.7 "Standard Arch-Civil Design Criteria - Design Loads for Facilities", Hanford Plant Standard SDC-4.1, Rev. 12.
- 9.8 Ocoma, E. C., WHC-SD-GN-DGS-30005, "Generic Walkdown Procedure for SC 3 & Non-SC 4 Commodities in Hanford Non-reactor Facilities", March 1992.
- 9.9 National Fire Protection Association, 1983, National Electric Code, NFPA 70-1984, Quincy, MA.
- 9.10 SQUG, "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment", SQUG/GIP, Rev. 2, February 1992.
- 9.11 EQE Engineering Inc., "Seismic Evaluation of Rod Hanger Supports for Electrical Raceway Systems," EPRI Report NP-7152-D, March 1991.
- 9.12 Ocoma, E. C., WHC-SD-CP-SA-026, "Seismic Re-analysis of Equipment in 2736-Z Complex from Safety Class 3 to Safety Class 1 Criteria," Rev. 0-A, April 1995.

ZONE OF INFLUENCE FOR INTERACTION
Maximum Influence for Specific Areas

Figure 1: Falling Object Zone of Influence

ATTACHMENT A
EVALUATION FORMS

	<u>Page</u>
1. Area Summary Sheet	A-2
2. Piping and Tubing	A-3
3. Raceways	A-4
4. HVAC	A-5
5. Equipment and Miscellaneous Commodities	A-6
6. Anchorage and Miscellaneous Attributes	A-7
7. Candidate Identification Sheet	A-8
8. Continuation Sheet	A-9
9. Instructions for Completion of Evaluation Forms	A-10

1. AREA SUMMARY SHEET

A	Facility _____ Building _____ Area _____ Floor Elevation _____ ft. Seismic Input at Floor (horizontal, 5% damping): Peak _____ g, ZPA _____ g Seismic Input at Floor (vertical, 5% damping): Peak _____ g, ZPA _____ g Area Summary Sheet 1 of _____ Total Number of Sheets in Area Walkdown Package _____ Walkdown Start Date _____												
B	<table border="0"> <tr> <td>Commodity Review Walkdown Sheets Attached:</td> <td>Number of Sheets</td> </tr> <tr> <td>▪ Piping and Tubing</td> <td>_____</td> </tr> <tr> <td>▪ Raceways</td> <td>_____</td> </tr> <tr> <td>▪ HVAC</td> <td>_____</td> </tr> <tr> <td>▪ Equipment and Miscellaneous Commodities</td> <td>_____</td> </tr> </table>			Commodity Review Walkdown Sheets Attached:	Number of Sheets	▪ Piping and Tubing	_____	▪ Raceways	_____	▪ HVAC	_____	▪ Equipment and Miscellaneous Commodities	_____
Commodity Review Walkdown Sheets Attached:	Number of Sheets												
▪ Piping and Tubing	_____												
▪ Raceways	_____												
▪ HVAC	_____												
▪ Equipment and Miscellaneous Commodities	_____												
C	Explain N/A's Entered Above, if Any:												
D	Total Number of Candidates Identified in Area: _____												
E	<table border="0"> <tr> <td>Commodity</td> <td>Number of Candidates</td> </tr> <tr> <td>▪ Piping and Tubing</td> <td>_____</td> </tr> <tr> <td>▪ Raceways</td> <td>_____</td> </tr> <tr> <td>▪ HVAC</td> <td>_____</td> </tr> <tr> <td>▪ Equipment and Miscellaneous Commodities</td> <td>_____</td> </tr> </table>			Commodity	Number of Candidates	▪ Piping and Tubing	_____	▪ Raceways	_____	▪ HVAC	_____	▪ Equipment and Miscellaneous Commodities	_____
Commodity	Number of Candidates												
▪ Piping and Tubing	_____												
▪ Raceways	_____												
▪ HVAC	_____												
▪ Equipment and Miscellaneous Commodities	_____												
F	Description of Revision:												
G	Revision _____ Team Leader _____ Print _____ Date _____ Team Member _____ Print _____ Date _____ Team Member _____ Print _____ Date _____ Team Member _____ Print _____ Date _____												
H	Area Walkdown Performed by Reviewer? Yes _____, No _____ Reviewer _____ Print _____ Date _____												

2. PIPING AND TUBING

I	Facility _____ Building _____ Area _____ Floor Elevation _____ ft. Piping and Tubing Evaluation Sheet 1 of _____			
J	Piping and Tubing Attribute Review (Guidelines provided in Attachment C):			Attribute Reviewed
	a. Unanchored, unrestrained or inadequately anchored commodities attached (anchor point displacement)			_____
	b. Stiff branch lines attached to flexible headers			_____
	c. In-line mass and/or eccentricity			_____
	d. Fittings (bellows, expansion joints, etc.) which may be susceptible to seismic induced displacement			_____
	e. Brittle mechanical joints (threaded, bell-and-spigot, victaulic, etc.)			_____
	f. Substantial visible corrosion			_____
	g. Non-ductile piping or fitting materials (cast-iron, PVC, etc.)			_____
	h. Non-standard fittings, branch connections, or attachments			_____
	i. Span Lengths			_____
	j. Heavily loaded supports			_____
	k. Multiple friction beam clamps in series			_____
	l. One-way supports lacking guides			_____
	m. Short fixed-end rod hangers			_____
	n. Damaged, missing or loose hardware			_____
	o. Support details with alterations such as coping out of members			_____
	p. Customized parts which appear inadequate			_____
	p. Other concerns			_____
K	Number of Piping and Tubing Candidates Identified in Area: _____			
	Candidate Number	No. Sheets	Candidate Number	No. Sheets
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
L	Comments:			
M	Team Leader/Date _____ / _____ Team Member/Date _____ / _____ Team Member/Date _____ / _____			

3. RACEWAYS

I	Facility _____ Building _____ Area _____ Floor Elevation _____ ft. Raceway Evaluation Sheet 1 of _____																			
J	Raceways Attribute Review (Guidelines are provided in Attachment D): <u>Conduit Specific Attributes</u> a. Undersized anchor bolts for one-hole finger clamps _____ b. Large junction boxes _____ <u>Cable Tray Specific Attributes</u> c. Customized parts _____ d. Cable restraint _____ e. Tray connector hardware _____ <u>General Raceway Attributes</u> f. Span lengths _____ g. Raceways member tie-downs _____ h. Channel nuts _____ i. Rigid boot connections _____ j. Beam or friction clamps _____ k. Atypical or unique support configuration _____ l. Substantial visible corrosion _____ m. Sagging _____ n. Damaged, missing or loose hardware _____ o. Stiff support along flexible run _____ p. Short fixed-end rod hangers _____ q. Heavily loaded supports _____ r. Other concern _____			Attribute Reviewed																
K	Number of Raceways Candidates Identified in Area: _____ <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Candidate Number</th> <th style="width: 12.5%;">No. Sheets</th> <th style="width: 25%;">Candidate Number</th> <th style="width: 12.5%;">No. Sheets</th> </tr> </thead> <tbody> <tr> <td>_____</td> <td>_____</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>_____</td> <td>_____</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>_____</td> <td>_____</td> <td>_____</td> <td>_____</td> </tr> </tbody> </table>				Candidate Number	No. Sheets	Candidate Number	No. Sheets	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
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L	Comments:																			
M	Team Leader/Date _____/ Team Member/Date _____/ Team Member/Date _____/																			

4. HVAC

I	Facility _____ Building _____ Area _____ Floor Elevation _____ ft. HVAC Evaluation Sheet 1 of _____			
J	HVAC Attribute Review (Guidelines are provided in Attachment E):			Attribute Reviewed
	a. Span lengths			_____
	b. Heavily loaded supports			_____
	c. Attachment of ducting to supports			_____
	d. Damaged, missing or loose hardware			_____
	e. Substantial visible corrosion			_____
	f. Beam or friction clamps			_____
	g. Short fixed-end rod hangers			_____
	h. Loose or incomplete duct joints			_____
	i. Long cantilevered duct segments			_____
	j. Appurtenances positively attached to duct			_____
	k. Any visible construction quality deviation			_____
	l. Heavy in-line mounted equipment (e.g. fans, coolers, dryers, blowers, etc.) independently supported and provided with adequate flexible joint			_____
	m. HVAC related equipment			_____
	n. Other concerns			_____
K	Number of HVAC Candidates Identified in Area: _____			
	Candidate Number	No. Sheets	Candidate Number	No. Sheets
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
L	Comments:			
M	Team Leader/Date _____ / _____ Team Member/Date _____ / _____ Team Member/Date _____ / _____			

5. EQUIPMENT AND MISCELLANEOUS COMMODITIES

I	Facility _____ Building _____ Area _____ Floor Elevation _____ ft. Equipment and Miscellaneous Commodities Evaluation Sheet 1 of _____			
J	Equipment and Miscellaneous Commodities Attribute Review:			Attribute Reviewed
	a. Electrical equipment reviewed per Attachments F			_____
	b. Miscellaneous commodities, structural items and architectural features reviewed per Attachment G.			_____
	c. Other Concerns.			_____
K	Number of Equipment and Miscellaneous Commodities Candidates Identified in Area: _____			
	Candidate Number	No. Sheets	Candidate Number	No. Sheets
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
L	Comments:			
M	Team Leader/Date _____/_____ Team Member/Date _____/_____ Team Member/Date _____/_____			

6.0 ANCHORAGE AND MISCELLANEOUS ATTRIBUTES

I	Facility _____ Building _____ Equip. ID _____ Floor Elev. _____ ft.	
	Anchorage and Miscellaneous Attributes Evaluation Sheet 1 of _____	
J	<p>Anchorage Attribute Review (Guidelines provided in Attach G)</p> <p><u>Expansion Anchor Review</u></p> <p>a. Spacing, edge distance and concrete cracks reviewed. _____</p> <p>b. Embedment and nuts bottomed out reviewed. _____</p> <p>c. Verify expansion anchors are not used to anchor rotating equipment _____</p> <p><u>Welded Anchorage Review</u></p> <p>e. Welded anchorage reviewed. _____</p> <p><u>Unistrut Anchorage Review</u></p> <p>f. Channel nuts spot checked for alignment of nut grooves with channel? _____</p> <p><u>Richmond Inserts</u></p> <p>g. Non-Seismic commodities anchored with Richmond Inserts identified? _____</p> <p><u>General Anchorage Attributes</u></p> <p>h. Gaps between attachments and concrete surface generally $\leq \frac{1}{4}$ inch. _____</p> <p>i. Bolts reviewed for full thread engagement or substantial thread engagement for light for lightly loaded anchors. _____</p> <p>j. Anchorage reviewed for substantial rust or corrosion. _____</p> <p>k. Anchorage reviewed for small washers on thin sheet metal. _____</p> <p>l. Anchorage reviewed for extremely thin equipment base framing. _____</p> <p>m. Anchorage reviewed for missing nuts, bolts or washers. _____</p> <p>n. Anchorage reviewed for non-positive anchorage configurations. _____</p> <p>o. Based on engineering judgement, anchorage appears adequate. _____</p> <p>p. Other concerns. _____</p> <p><u>Concrete strength and Bolt Type</u></p> <p>q. Concrete strength _____ psi per drawing _____</p> <p>r. Anchor bolt type _____ per []inspection []drawing no. _____</p>	Attribute Reviewed
	Candidates identified because of anchorage and miscellaneous attributes shall be included in the appropriate commodity review evaluation.	
	Comments:	
M	<p>Team Leader/Date _____ / _____</p> <p>Team Member/Date _____ / _____</p> <p>Team Member/Date _____ / _____</p>	

8. CONTINUATION SHEET

S	Facility _____ Building _____ Area _____ Floor Elevation _____ ft.
	Continuation of: _____ Sheet _____ of _____
T	

9. INSTRUCTIONS FOR COMPLETION OF EVALUATION FORMS

General

The numbered blocks on the Seismic Adequacy Evaluation forms are included for the following instructions only.

An entry shall be provided for each block. If a block is not applicable, N/A should be entered.

Block A

Facility identification (Non-Reactor).

Building Number.

Area number from Reference 10.2.

Area floor elevation (may be rounded to nearest foot).

Peak spectral acceleration at 5 % damping for the nearest floor elevation. Accelerations shall be expressed as ratio to gravity (g) for DBE from Reference 9.7. The seismic input is for comparison only.

Zero Period Acceleration (ZPA) for the nearest floor elevation expressed as ratio to gravity (g) for DBE from Reference 9.7. ZPA is the acceleration corresponding to 33 hz. The seismic input is for comparison only.

Record the date the walkdown is initiated.

Block B

Record the number of sheets included in each of the commodity review packages. If no Safety Class 3 and Non-Safety Class 4 commodities in a specific category (i.e., piping and tubing) are identified in the area, enter N/A under Number of Sheets and explain below.

Block C

Explain any N/A's entered in Block B, such as "All HVAC in area is Safety Class 1 and 2.

Block D

Record the total number of candidates identified in the area.

Block E

Record the number of candidates for each commodity. If none, enter none.

Block F

Leave blank for Revision 0. Enter a clear and concise description for subsequent revisions, including sheets affected. Use continuation sheets for additional space, as needed.

Block G

Team Leader signature, name (printed or stamped) and date.

Team Member signature, name (printed or stamped) and date. A Continuation Sheet may be used if additional space is required.

Block H

State if an area walkdown was performed by the Reviewer. Reviewer signature, name (printed or stamped) and date.

Block I

Facility identification (Non-Reactor).

Building Number.

Area number from Reference 10.2.

Area floor elevation (may be rounded to nearest foot).

Sheet number

Block J

Check off after review of the attribute is complete. A number for reference to a note in the comments may be entered in lieu of a check mark.

Block K

Record the total number of candidates identified in the area for the commodity under review.

Record the candidate number using the format defined in Section 5.3 and number of sheets for each candidate.

Block L

Enter any comments or walkdown notes pertinent to the commodity or attribute review. Also include reference to any drawings or other facility documents used in the evaluation. If none, enter none or N/A.

Block M

Team Leader signature and date.

Team Member signature and date. Block L or a Continuation Sheet may be used if additional space is required.

Block N

Facility identification (Non-Reactor).

Building Number.

Area number from Reference 10.2.

Area floor elevation (may be rounded to nearest foot).

Candidate number.

Sheet number.

Block O

Physical description of the candidate, including sufficient information to compare the candidate to other candidates within the same general category of commodities (e.g. small bore piping, cable tray, horizontal pumps). Sketches and continuation sheets are recommended.

Block P

Physical location of the candidate such as column lines, elevations, termination points, etc.

Block Q

Reason(s) for selecting the candidate.

Block R

Enter any comments pertinent to the candidate. If none, enter none or N/A.
Enter photo identification number.

Block S

Facility identification (Non-Reactor).

Building Number.

Area number from Reference 10.2.

Area floor elevation (may be rounded to nearest foot).

Name of form that is continued.

Sheet number.

Block T

Continuation of appropriate block(s).

ATTACHMENT B

GUIDELINES FOR IDENTIFYING SAFETY RELATED COMMODITIES

	<u>Page</u>
Piping	B-2
Conduits	B-2
Cable Trays	B-2
Instrument Tubing	B-3
HVAC	B-3
Special Situations	B-3

SAFETY RELATED COMMODITIES

Safety Class 1 and 2 commodities may be identified in the field as follows:

Piping

Safety Class 1 and 2 piping may be identified by any of the following:

- N-Stamp tags on piping.
- Red-line P & ID
- Safety equipment lists
- N-Stamps on components within the piping system (e.g. valves)
- As built ID tags which identify the function of the line.

Conduits

Safety Class 1 and 2 conduits may be identified by:

- Color bands: All colors except black indicate Safety Class 1 and 2 conduit.
- Conduit ID number: Electrical conduits have a unique numbering system. All conduit numbers are prefixed by a letter "C" to indicate conduit. The second digit of the number is a "0", "1", or "2" indicating building number. The third digit is a "1" through "6" indicating a system function. The fourth field is a letter "O", "G", "R", "W", "B", "Y", or "K". They represent the colors orange, green, red, white, blue and yellow, respectively. "K" is not associated with a color. "K" represents Safety Class 3 and Non-Safety Class 4 conduit.

Cable Trays

Safety Class 1 and 2 cable trays may be identified by:

- Colored cables in the tray: All colors except black indicate Safety Related. Note: Cables with color bands every 5 feet indicate a change in the safety class.
- Colored markers on trays: Cable trays are marked with 2" to 3" colored markers. All colors except black indicate that the cable trays are Safety Related.
- Cable tray ID number: same as that for conduit except that "T", which stands for Cable Tray, is used in lieu of "C."

Instrument Tubing

Safety Class 1 and 2 instrument tubing may be identified by:

- Color banding per applicable PFP facility procedure. Note: Safety Class 3 and Non-Safety Class 4 tubing is not color coded.
- If process end of tubing is connected to Safety Class 1 and 2 piping or equipment.

HVAC

Safety Class 1 and 2 HVAC ducts cannot be readily identified in the field. Document reviews or questions to facility operators are recommended.

Special Situations

The walkdown team should be aware of special situations associated with Safety Class 1 and 2 fluid systems. It is possible, for example, that a Safety Class 3 and Non-Safety Class 4 instrument and its associated tubing are treated as Safety Class 1 and 2. This is because the instrument, although not performing a safety function, forms part of the pressure boundary for the Safety Class 1 and 2 fluid system. When it is not clear if commodities are Safety Class 1 and 2, the walkdown team should be conservative and consider them as a potential source during the area evaluation.

ATTACHMENT C

PIPING AND TUBING SCREENING GUIDELINES

	<u>Page</u>
Seismic Anchor Motion	C-2
Corrosion	C-2
Non-Welded Joints	C-2
Piping Support Failure	C-3
Excessive Eccentric Masses	C-3
Other Potential Vulnerabilities	C-3

PIPING AND TUBING SYSTEMS

Earthquake experience has identified the types of conditions that have resulted in breakage or leakage (spray) in piping and tubing systems. These conditions can be categorized as:

- 1) Seismic Anchor Motion
- 2) Corrosion
- 3) Non Welded Joints
- 4) Piping Support Failure
- 5) Excessively Eccentric masses
- 6) Other Potential Vulnerabilities

Note that piping collapse due to inertia loading has not been demonstrated as a cause of failure. Thus, the conditions that have resulted in piping failures can usually be identified by field walkdown as opposed to detailed seismic analysis.

Seismic Anchor Motion

Excess motion of pipe or tubing anchor or support points relative to other support points may result in breakage. This excess anchor motion may be caused by:

- 1) Failure of the anchorage of tanks, pumps, heat exchangers, compressors, etc. resulting in excess displacement of the piping or tubing anchor point.
- 2) Differential displacement of structures to which the piping or tubing is attached.
- 3) Large displacement of headers with restraint of smaller diameter branch lines (Figure C-1).

Corrosion

Evidence of substantial external corrosion should be noted for further evaluation.

Non-Welded Joints

Threaded and other brittle mechanical joints (i.e., victaulic type couplings, bell and spigot joints) have been observed to be more vulnerable to seismic events than welded piping joints. Piping that is not well supported and contains brittle mechanical joints is a strong candidate for further evaluation. Bolted flange connections have not been observed to be vulnerable in seismic events, thus do not fall into the "brittle" joint category.

Piping Support Failure

Support failure usually does not result in piping failure unless multiple

supports fail. Supports most susceptible to failure are:

- 1) Short threaded rods that are fixed against rotation (Figure C-2). These may fail in low cycle fatigue. Rod fatigue evaluation screening charts are presented in Figures D-1 to D-5.
- 2) Under-supports that could allow pipe to slide off and fall.
- 3) Poorly installed beam clamps used as hangers.
- 4) Cast stanchions.
- 5) Axial supports that restrain motion of long runs of pipe.
- 6) Customized, damaged, corroded or altered parts resulting in non-ductile failure or significant weakness in the load path.

Rod hangers that act as pinned members and welded structural steel pipe supports have not been observed in seismic events to be particularly vulnerable unless there are major design or construction flaws in their attachment to the supporting structure.

Excessively Eccentric Masses

Screening guidelines for air-operated diaphragm valves, spring-operated pressure relief valves and piston-operated valves of light-weight construction are provided in Figure C-3 (Reference 9.2). Screening guidelines for motor-operated valves and substantial piston-operated valves are provided in Figure C-4 (Reference 9.2). Piping or tubing less than 1 inch in diameter with in-line eccentric masses such as motor or air operated valves should be supported near the valve or the valve should be supported. Supports should not be placed on the valve operator without supports on the valve body or piping adjacent to the valve body. The valve body and operator should be supported by a common structure to prevent differential displacement.

Other Potential Vulnerabilities

Piping and tubing may also be susceptible to seismic damage if the following conditions exist.

- 1) Piping with expansion joints lacking lateral support in close proximity to the expansion joints.

- 2) Piping with dead weight support spacing greatly in excess of ANSI/ASME B31.1 suggested spans (Table C-1). If exceeded, use Reference 9.1 criteria. Tubing with support spans greatly in excess of 8'-0" and 12'-0" for 3/8" O.D. and 1/2" O.D., respectively.
- 3) Heavy in-line masses (e.g., accumulators, filters, strainers)
- 4) Piping constructed of non-ductile materials such as cast iron or PVC
- 5) Non-standard fittings, such as mitered elbows or unreinforced branch connections, or unusual attachments that could cause excessive localized stresses.

Table C-1

NOMINAL SUGGESTED SPANS PER ANSI B31.1

Nominal Pipe Size (in.)	Outside Pipe Diameter (in.)	Nominal Suggested Maximum Span (ft.)	
		Water Service	Steam, Gas, or Air Service
1	1.315	7	9
2	2.375	10	13
3	3.500	12	15
4	4.500	14	17
6	6.625	17	21
8	8.625	19	24
10	10.75	21	26
12	12.75	23	30
16	16.00	27	35
20	20.00	30	39
24	24.00	32	42

Note: Does not apply where there are concentrated loads between supports such as flanges, valves, etc.

Figure C-1: Example seismic anchor movement hazards to branch lines of large flexible header lines.

Figure C-2: Deflected shapes of "fixed-fixed" and "fixed-free" rod hanger piping supports showing seismically vulnerable locations.

ATTACHMENT D
RACEWAYS SCREENING GUIDELINES

	<u>Page</u>
Large Junction Boxes	D-2
Customized Parts	D-2
Cable Restraint	D-3
Tray Connector Hardware	D-3
Span Lengths	D-3
Raceway Member Tie-Downs	D-4
Channel Nuts	D-4
Rigid Boot Connections	D-4
Beam or Friction Clamps	D-4
Atypical or Unique Support Configuration	D-5
Cast-Iron Anchor Embedment	D-5
Substantial Visible Corrosion	D-5
Sagging	D-5
Damaged, Missing or Loose Hardware	D-5
Stiff Support Along Flexible Run	D-6
Short Fixed-End Rod Hangers	D-6
Heavily Loaded Supports	D-6
Anchorage	D-6

RACEWAYS

Cable tray and conduit systems have consistently preformed well at conventional power and industrial facilities subjected to past strong-motion earthquakes, even though the systems are typically not designed for earthquakes. A number of shake table tests on portions of raceways systems confirm these observations.

The few cases of collapse of conduit or cable tray support systems in earthquakes or on shake tables have been related to the presence of non-ductile type connections. The walkdown procedure provides guidelines to screen out the types of connections which have led or may lead to poor seismic performance.

Undersized Anchor Bolts for 1-Hole Finger Clamps

The size of anchor bolts for 1-hole finger clamps should not be less than the following table:

<u>Clamp Size (Inches)</u>	<u>Minimum Diameter of Concrete Anchor Bolt (Inches)</u>
3/4	1/4
1	1/4
1-1/2	3/8
2	3/8

Large Junction Boxes

The anchorage of large junction boxes should be reviewed. If the junction boxes are mounted in-line to the conduit and are not independently supported, the adjacent conduit support should be reviewed to ensure they can accommodate the additional mass.

Customized Parts

Customized cable tray hardware (i.e. plant specific, non-standard, non-off-the-shelf cable tray hardware) may exhibit non-ductile behavior under seismic loads and should be reviewed in detail.

Cable Restraint

Any cables above the top of the side rail should be restrained to keep them in the tray in an earthquake. Isolated cables in the center of the tray do not have to be restrained. When cable trays have vertical drops of more than about 20 feet and flapping of the cables during an earthquake might cause pinching or cutting of the cables that may lead to impact with proximate fragile equipment. Under such conditions, the cables should be reviewed to determine if restraint is needed to keep them in the tray.

Tray Connector Hardware

Review tray connector hardware such as vendor supplied splice plates and riser connectors.

Span Lengths

Cable Tray Span

The length of unsupported cable tray between adjacent supports should not exceed about 10 feet. The length of an unsupported cable tray that cantilevers out from a support should not exceed about 5 feet. These spans are selected because they are supported by earthquake experience data (Reference 9.2).

Conduit Span

The length of unsupported conduit between adjacent supports, or the length of unsupported conduit that cantilevers out from a support, should not exceed that in the following table. These spans are selected because they are supported by earthquake experience data (Reference 9.2) and are consistent with the National Electrical Code (Reference 9.9).

<u>Conduit Size (inches)</u>	<u>Approximate Distance Between Adjacent Supports (feet)</u>	<u>Approximate Maximum Cantilever Overhang (feet)</u>
1/2 and 3/4	10	5
1	12	6
1-1/4 and 1-1/2	14	7
2 and 2-1/2	16	8
3 and larger	20	10

Raceway Member Tie-Downs

For cantilever bracket-supported systems, cable trays and conduits should be secured to their supports so the trays or conduits cannot slide and fall off the supports. Normal industrial friction type hardware such as the "z-clip" commonly used for cable trays (Figure D-1, Ref. 9.8) is a sufficient means of attachment.

Systems do not have to be secured to every support, unless the supports are at the maximum spacing described above. For example, consider a 60-foot length of cable tray. If the supports are at the maximum span of 10 feet, then there would be seven supports in the 60-foot run. Trays need to be secured to only seven supports in any 60-foot run, regardless of how many supports there actually are in the run.

Channel Nuts

For use of these evaluation guidelines, channel nuts used with light metal framing systems need to have teeth or ridges stamped into the nut where it bears on the lip of the channel (Figure D-2, Ref. 9.8). Test experience has shown that channel nuts lacking the teeth or ridges have capacities (slip resistance) significantly less than channel nuts with the teeth or ridges.

Rigid Boot Connections

Strut systems supported by "boots" or similar rigid devices, especially plant-specific designs, need to be evaluated on a case-by-case basis. Shake table tests have shown that a rigid boot overhead connection detail, as shown in Figure D-3, (Reference 9.8), has a significantly reduced vertical load-carrying capacity in seismic motion. Any gap between the vertical support member and the boot prevents the development of high clamping forces in the connection and thus causes a significantly reduced load-carrying capacity. Cable tray test specimens with this detail have collapsed in shake table tests. The customized rigid boot detail is not included in the earthquake experience data base.

Beam or Friction Clamps

Beam or friction clamps should be restrained to prevent them from loosening and slipping off during an earthquake (see Figure D-4, Ref. 9.8). The earthquake experience data base includes several instances of failure of supports with unrestrained beam clamps. However, the earthquake experience data base includes many examples of beam clamps with restraining straps as shown in Figure D-5 (Ref. 9.8) which have performed successfully.

Atypical or Unique Support Configuration

A major portion of the walkdown should be conducted from the floor level. The walkdown team members should familiarize themselves with the design and construction details of typical support configurations. When any suspect condition is observed, a closer examination should be carried out to review all relevant details such as anchorage and raceway to support attachments. Unique supports are those that cannot be bounded by other support configurations. Examples of such supports are described below:

- Raceway spanning between separate buildings. Such raceway systems should have sufficient flexibility to accommodate relative differential building deformations.
- Supports attached to block walls or sheet rock walls.
- Supports that possess complex geometry, with multiple raceway runs and having a low degree of redundancy versus supported weight.

Cast-Iron Anchor Embedment

The earthquake experience data base includes examples where heavily loaded rod hangers threaded into cast-iron inserts failed (see Reference 9.5, 1987 Whittier, California, Earthquake). The use of this type of anchor in various areas at the PFP facility should be reviewed with applicable cognizant engineer.

Substantial Visible Corrosion

Excessive corrosion of cable trays, conduit, or supports should be evaluated for its effect on structural integrity. Evaluations should consider the alternative of estimating the strength reduction due to corrosion if appropriate.

Sagging

There should not be a noticeable sag of the conduit or cable tray. As a general guideline, noticeable sags are about 1 inch of deflection in 10 feet. If a noticeable sag is found, its cause should be determined before selecting it as a candidate. For example, the sag may have occurred during construction, have no relation to structural integrity, and therefore would not be considered a candidate.

Damaged, Missing or Loose Hardware

Damaged, missing or loose cable tray and conduit components should be identified. Particular attention should be given to loosely installed unions on conduits.

Stiff Support Along Flexible Run

Occasional stiff supports in long flexible runs of cable trays or conduit should be evaluated to determine if the longitudinal movement of the run could cause the stiff support to fail. Cable tray or conduit systems may contain a long run of supports that are relatively flexible in the longitudinal direction, and then a support that is relatively stiff (Figures D-6 and D-7, Ref. 9.8). The stiff support may thus be subjected to considerable load during earthquake-induced longitudinal movement and might fail. Where the stiff support is located around the bend from the long run, the flexibility and ductility of the bend in the tray or conduit will typically prevent failure of the stiff support from being a credible hazard. The walkdown team should note instances of occasional short, fixed-end rod hangers (stiff supports) in raceway runs with predominantly longer, more flexible supports. These instances should be selected as candidates to be evaluated for possible failure due to fatigue. Eccentrically-braced rod hanger trapeze support systems should also be selected as candidates.

Short Fixed-End Rod Hangers

Shake table tests have shown that the seismic capacity of rod hung supports with short threaded rods that are fixed against rotation (Figure D-7, Ref. 9.8, configuration applies to raceways as well as to piping), is limited by the fatigue life of the rods. Rod fatigue evaluation screening charts are presented in Figures D-1 to D-5. Rod hangers with pinned connections have been observed not to be particularly vulnerable in past earthquakes and shake table tests unless there are major design or construction flaws in their attachment to the supporting structure.

Heavily Loaded Supports

The walkdown team members should seek out heavily loaded raceway supports with respect to their capacity. Long spans, multiple tier systems, top supports at vertical runs, are examples of indicators of heavy load. Of particular concern are raceway support systems that appear to have possibly more load than originally designed for. These can be identified by the presence of other plant components attached to the raceway support, such as pipe supports, HVAC duct supports, etc.

Anchorage

The walkdown team should pay close attention to the review of anchorages for raceway supports. Refer to Attachment P for a complete discussion on anchorage attributes.

The team should pay particular attention to system anchorages for heavily loaded supports. When the type of anchorage detail cannot be determined by visual inspection, other methods of determining the anchorage detail may be used, providing the review team is convinced they understand the actual details. For example, the plant design drawings, construction records, or procurement specifications may provide the unknown details. If attachment welds are not visible because they are covered by fire retardant, or for other reasons, similar supports with visible welds can be inspected or as-installed plant documentation reviewed to gain understanding of the weld adequacy. Anchorage adequacy for lightly loaded conduit supports rigidly attached to a wall, with less than 100 pounds dead load, may be verified by giving the conduit a tug (equal to two times deadweight) by hand.

Visible large cracks, significantly spalled concrete, serious honeycomb, or other gross defects in the concrete to which the cable tray or conduit supports are attached should be evaluated for their potential effects on structural integrity during an earthquake.

1/4" THREADED RODS

EOB
ONE

Figure D-1. Fatigue evaluation screening chart for manufactured 1/4-inch diameter all-thread rods. Weight corresponds to the total supported load (i.e., on both rods). Length corresponds to clear length above top tier. (Reference 9.11)

3/8" THREADED RODS

Figure D-2. Fatigue evaluation screening chart for manufactured 3/8-inch diameter all-thread rods. Weight corresponds to the total supported load (i.e., on both rods). Length corresponds to clear length above top tier. (Reference 9.11)

1/2" THREADED RODS

Figure D-3. Fatigue evaluation screening chart for manufactured 1/2-inch diameter all-thread rods. Weight corresponds to the total supported load (i.e., on both rods). Length corresponds to clear length above top tier. (Reference 9.11)

5/8" THREADED RODS

Figure D-4. Fatigue evaluation screening chart for manufactured 5/8-inch diameter all-thread rods. Weight corresponds to the total supported load (i.e., on both rods). Length corresponds to clear length above top tier. (Reference 9.11)

3/4" THREADED RODS

Figure D-5. Fatigue evaluation screening chart for manufactured 3/4-inch diameter all-thread rods. Weight corresponds to the total supported load (i.e., on both rods). Length corresponds to clear length above top tier. (Reference 9.11)

Figure D-6. Bounding rod fatigue spectra anchored to 0.33g, 0.50g, and 0.75g, at 5% damping. (Reference 9.11)

ATTACHMENT E
HVAC SCREENING GUIDELINES

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HVAC SYSTEMS

The seismic experience data base includes many examples of ducts that have performed well in actual earthquakes. The large number of duct systems that have survived earthquakes indicates the inherent ruggedness of these systems. The limited, smaller set of HVAC ducts and related equipment that have been found to have performed poorly in seismic events points out key characteristics of HVAC installations that may contribute to seismic damage. Numerous shake table tests of portions of HVAC systems confirm these observations.

Observed seismic damage to HVAC systems can be characterized as follows:

- Broken and fallen cantilevered sections;
- Opened and sheared seams;
- Duct fallen off support;
- Excessive movement of flexibly mounted in-line equipment;
- Interaction with adjacent components.

The walkdown procedure provides guidelines to screen out the types of configurations which have led or may lead to poor seismic performance.

Span Length

The walkdown team members should seek out HVAC runs with long spans for selection of potential candidates. As a generic guideline, a 10 foot span may be used, but in this facility specific application, the values in Table E-1 shall be used.

Heavily Loaded Supports

The walkdown team members should seek out the most heavily loaded HVAC support in relation to its capacity for each configuration. Long spans, multiple tier systems, top supports at vertical runs, and insulation coating are indicators of heavy load. Of particular concern are support systems that appear to have more load than originally designed for. These can be identified by the presence of other plant components attached to the HVAC support, such as pipe supports, conduit supports, etc.

Attachment of Ducting to Supports

Ducts should be secured to their supports to preclude the possibility of sliding off during a seismic event. Seismic experience data indicate that HVAC duct falling off its support is a common seismic failure mode.

Broken, Damaged, Missing, or Loose HVAC Ducting Hardware

Broken, damaged, missing, or loose HVAC ducting hardware should be evaluated for their potential effects on structural integrity during a seismic event.

Excessive Corrosion

Similarly, excessive corrosion of HVAC ducts, supports, or related equipment should be evaluated for its potential effects on structural integrity during a seismic event.

Beam or Friction Clamps

Beam or friction clamps should be restrained to prevent them from loosening and slipping off during an earthquake (see Figure D-4, Ref. 9.8). The earthquake experience database includes several instances of failure of supports with unrestrained beam clamps. However, the earthquake experience database includes many examples of beam clamps with restraining straps as shown in Figure D-5 (Reference 9.8) which have performed successfully.

Short, Fixed-End Rod Hung Supports

Shake table tests have shown that the seismic capacity of rod hung supports with short threaded rods that are fixed against rotation (Figure C-2), is limited by the fatigue life of the rods. Rod fatigue evaluation screening charts are presented in Figures D-1 to D-5. Rod hangers with pinned connections have not been observed to be particularly vulnerable in past earthquakes and shake table tests unless there are major design or construction flaws in their attachment to the supporting structure.

Loose or Incomplete Duct Joints

HVAC joints (including connected tees and elbows) that are observed to be loose, incomplete, or otherwise suspect (such as those repaired with duct tape or fiberglass) should be reviewed in detail. Seismic experience data have shown that such joints are often the point of failure of HVAC systems in an earthquake.

Long Cantilevered Duct Segments

Long cantilevered sections of duct and duct diffusers should be reviewed to ensure connections to the main duct run are seismically rugged. The seismic experience database includes instances of duct sections breaking at relatively weak joints.

Appurtenances Positively Attached to Duct

Equipment attached to the HVAC ducts (e.g. dampers, louvers, air diffusers, intake and discharge screens and vanes, etc.) should be adequately attached to the duct to avoid falling during a seismic event. Equipment protruding from the duct should be reviewed to ensure connections are seismically adequate. Excessive large openings in ducts (e.g. at air diffusers) without reinforcement around the opening may weaken the bending resistance of the duct and should be reviewed.

Construction Quality of the Supports

Any visible deviation from proper construction practices are to be noted. Attributes include weld quality and dimensional adequacy of welds in support member connections and between duct and support.

Flexibly Mounted In-Line Heavy Equipment

HVAC systems often have heavy pieces of equipment mounted in-line with the ducts. Examples include but are not limited to fans, coolers, dryers, and blowers. Seismic experience data have shown that large pieces of equipment mounted in-line on flexible supports can damage the duct by swinging and banging into it during an earthquake. Adequate flexible joints connecting the equipment to the duct should be provided to accommodate any expected swinging of the equipment.

Heavy equipment along HVAC runs is also commonly floor mounted on isolation pads. Instances of damage have been caused by floor mounted equipment falling off their isolation pads and damaging attached ducts in the process.

HVAC Related Equipment

General screening guidelines from Reference 9.2 for structural integrity are summarized below.

1. Fans
 - a. Drive motor and fan mounted on common base
 - b. Long shafts should be supported at fan and motor
 - c. No excessive duct distortion causing binding or misalignment of fan
 - d. Base vibration isolation checked
 - e. Sufficient slack and flexibility of attached lines
 - f. Adequate anchorage

2. Air Handlers

- a. Anchorage of internal component
- b. Doors secured
- c. Base vibration isolation checked
- d. Sufficient slack and flexibility of attached lines
- e. Adequate anchorage

3. Chillers

- a. No reliance on weak-way bending of steel plate or structural steel shapes
- b. Vibration isolation systems checked
- c. Adequate anchorage

TABLE E - 1
HANGER SPACING TABLE

Max Hanger Load = 540 lbs.

Duct Size	Duct Wt. per foot	Duct Wt. only	Duct Wt. w/vanes	3 x Duct Wt. only	3 x Duct Wt. w/vanes
10 x 10	7 lbs./ft.	77'	74'	25'	22'
10 x 12	8 lbs./ft.	67'	65'	22'	20'
12 x 12	9 lbs./ft.	60'	57'	20'	17'
12 x 14	9 lbs./ft.	60'	57'	20'	17'
14 x 14	10 lbs/ft.	54'	52'	18'	16'
14 x 16	10 lbs/ft.	54'	52'	18'	16'
16 x 16	12 lbs/ft.	45'	43'	15'	13'
16 x 18	12 lbs/ft.	45'	43'	15'	13'
18 x 18	13 lbs/ft.	41'	40'	13'	12'
18 x 20	13 lbs/ft.	41'	40'	13'	12'
18 x 30	20 lbs/ft.	27'	26'	9'	8'

Assumes (2 sets of vanes = 20 lbs.)

ATTACHMENT F
CONTROL AND ELECTRICAL PANELS ANCHORAGE
SCREENING GUIDELINES

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CONTROL AND ELECTRICAL PANELS ANCHORAGE

Applicability

Typically, wall mounted electrical panels are small and lightweight. Based on the typical size and construction of the panels installed at the 2736-Z and -ZB buildings, it is reasonable to assume that the panels are rigid. The SQUG/GIP, Reference 9.9, allows tug tests to be used for lightweight equipment. The weight limitation are presented in Reference 9.6, Table 2.6.

Table 2.6

MAXIMUM WEIGHTS (POUNDS) OF SCE'S THAT CAN BE EVALUATED
WITHOUT SPECIFIC ESTIMATES OF SEISMIC DEMAND
(Reference 9.6)

	SC3/4 Structure	SC2 Structure		SC1 Structure	
		Areas 100 & 200	Areas 300 & 400	Areas 100 & 200	Areas 300 & 400
Rigid at Grade	200	120	170	90	140
Rigid above Grade		30	40	20	30
Flexible at Grade	150	60	80	40	70
Flexible above Grade		15	20	10	15

ATTACHMENT G

MISCELLANEOUS COMMODITIES, STRUCTURAL
ITEMS AND ARCHITECTURAL FEATURES SCREENING GUIDELINES

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Architectural Features	G-2

Miscellaneous Commodities

Miscellaneous commodities not specifically addressed in Attachments C through F should be reviewed to select candidates for further evaluation. Miscellaneous commodities may include Safety Class 3 and 4 tanks, radiation monitoring equipment, and other items which are unique or present in limited quantities.

Attributes for consideration when selecting candidates for further evaluation include the following:

- Physical size and mass
- Anchorage (Attachment H)
- Support configuration
- Load path
- Flexibility
- Location within the structures (considering seismic input accelerations)

Anchorage screening guidance for Miscellaneous Commodities is provided by Figures G-1 through G-4. These figures provide conservative 4-bolt anchorage configurations for commodities mounted to concrete walls or floors with expansion anchor bolts.

Structural Items

The design of miscellaneous structural items such as platforms, ladders, monorails and stairs to maintain structural integrity during a SSE is addressed by the Structural Group. Anchorage and miscellaneous attributes listed in Attachment B Form 6 and the associated guidelines presented in Attachment H should be reviewed, for these items, as applicable, as well as the following:

- Gratings and/or checker plates are attached or restrained to ensure they will not fall.
- Building and secondary wall displacements per Attachment H.

Architectural Features

Guidelines for architectural features are listed below:

- Suspended Ceilings - Suspended ceilings are not anticipated in Non-Nuclear facility buildings. If they are found, they should be identified as candidates for further evaluation.
- Light Fixtures - Light fixtures that are judge to pose a falling

hazard during the DBE should be identified as an observation in the Comments section of Form 5. It is not necessary to identify each individual light which lacks sufficient restraints.

- Other - Other features such as water fountains, eyewash stations, storage cabinets/racks, office furniture, sinks, etc., should be reviewed to insure they are properly anchored. Judgement should be exercised in evaluating the item for structural integrity. Identify installations judged to be inadequate as candidates for further evaluation.

Figure G-1: Generic Floor Mounted Equipment Anchorage Screening chart 3/8" ϕ Expansion Anchor Bolts

Figure G-2: Generic Floor Mounted Equipment Anchorage Screening Chart 1/2" ϕ Expansion Anchor Bolts

Figure G-3: Generic Wall Mounted Equipment Anchorage Screening Chart 3/8" ϕ Expansion Anchor Bolts

Figure G-4: Generic Wall Mounted Equipment Anchorage Screening Chart 1/2" ϕ Expansion Anchor Bolts

ATTACHMENT H
ANCHORAGE SCREENING GUIDELINES

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ANCHORAGE

A thorough review of anchorage type, installation and load path should be performed for commodities such as independently supported mechanical and electrical equipment that do not have alternate load paths. Distributed systems such as piping, tubing, raceway and HVAC ducts generally have alternate load paths to compensate for potential weaknesses in individual supports. This is evident during past strong motion earthquakes where piping and raceway supports have failed with no, or minimal impact on the distributed systems (References 9.4 and 9.5). The walkdown team should review anchorage attributes on an area basis and focus on independently supported commodities and key distributed system supports such as those at changes in direction, short stiff supports (Figure D-7, Reference 9.8), and/or supports braced for longitudinal loads.

Expansion Anchors

Capacities of concrete expansion anchors are dependent on proper installation to achieve the allowable loads provided in Table H-1. The walkdown addresses embedment, spacing, edge distance, nuts bottomed out and concrete cracks.

Embedment

Inadequate embedment installations should be identified by reviewing installations for bolts with substantial projection above the concrete surface relative to other installations. Tall grout pads may be indicative of shallow embedment. Suspect installations should then be reviewed in detail by verifying the actual bolt length and determining the actual embedment.

Nuts Bottomed Out

Bolts with nuts bottomed out should be identified by reviewing installations for bolts with substantial projection above the equipment base plate surface relative to other installations. Suspect installations should then be reviewed in detail by verifying the actual thread length and determining if the nut may be bottomed out on the bolt thread rather than the structural surface.

Concrete Cracks

Significant structural cracks which penetrate the concrete mass and pass through the vicinity of the anchor could degrade the anchor capacity. It is not feasible to inspect each installation for the presence of structural concrete cracks in the vicinity of anchor bolts due to floor topping, paint, large baseplates and equipment bases. The walkdown team should look for cracks, where feasible, and review installations which may be affected considering reduced allowables based on Table H-4.

Spacing and Edge Distance

The walkdown team should look for installations with bolt spacing or edge distance significantly less than 10 bolt diameters. Installations with significantly less than 10 diameters of spacing or edge distance should be reviewed considering reduced allowables. A reduction factor should be considered for each nearby anchor. Reduction factors for bolt spacing less than 10 diameters are included in Table H-2. Reduction factors for bolt edge distance of less than 10 diameters are included in Table H-3. Judgement should be exercised in determining if installations with less than 10 diameters of spacing and edge distance should be identified as candidates.

Cast-In-Place Bolts

Cast-in-place bolt allowables listed in Table H-5 are for the review of existing Safety Class 3 and Non-Safety Class 4 commodities. The following conditions result in reduced capacity anchorage:

- Presence of significant structural cracks in the vicinity of anchors.
- Bolt spacing less than the minimum spacing listed in Table H-5.
- Edge distance less than the minimum edge distance listed in Table H-5.

Welded Anchorage

Allowable load capacities of typical welds made with E60 electrodes and an allowable weld shear stress of 30.6 ksi, are provided in Table H-6. Welds used for anchoring equipment to embedded or exposed steel should be reviewed to identify the following potentially unacceptable conditions:

- Presence of weld burn-through in cabinets
- Puddle welds (plug welds) that are of poor quality carrying high tension loads

- Welding only on the inside edge of cabinet base flanges
- Bridge welds built up across gaps subject to bending
- Welds of obvious poor quality based on visual review

Unistrut Anchorage

Unistrut Bolt allowables are listed in Table H-6. Channel nuts should have proper alignment of nut grooves with the channel in-turned edge. Installations which do not have an alternate load path and may be heavily loaded should be spot checked for channel nut alignment.

Richmond Inserts

Richmond Inserts have capacities comparable to cast-in-place bolts when properly installed. However, they may be susceptible to installation deficiencies which cannot be verified by visual inspection (such as engagement). Therefore, identify Richmond Inserts anchoring Safety Class 3 and Non-Safety Class 4 commodities subject to substantial loads for further evaluation.

Building and Secondary Wall Displacements

Building and secondary wall displacements shall be considered during the screening walkdowns and candidate selection. Displacements may result in Seismic Anchor Motion (SAM) for attached commodities or pounding for adjacent commodities without sufficient clearance. Judgement should be exercised to determine if the installation has sufficient flexibility for the postulated displacements. Configurations susceptible to structural displacements include the following.

- Distributed systems attached to multiple structures without sufficient flexibility for differential displacement
- Equipment and/or supports attached to multiple structures
- Rigid equipment, distributed systems and/or supports attached to a secondary wall and a structure.
- Commodities without sufficient clearance for postulated building and secondary wall displacements may be impacted.

Table H-1

NOMINAL ALLOWABLE CAPACITIES FOR EXPANSION ANCHORS
($f'_c \geq 4000$ psi for pullout and $f'_c \geq 3500$ psi for shear)¹, Reference 9.6

Bolt/Stud Diameter (D, in.)	Pullout Capacity P_{nom} , kip)	Shear Capacity (V_{nom} , kip)	Minimum Spacing ² (S_{min} , in.)	Min. Edge Distance ² (E_{min} , in.)
3/8	1.46	1.42	3.75	3.75
1/2	2.29	2.38	5.00	5.00
5/8	3.17	3.79	6.25	6.25
3/4	4.69	5.48	7.50	7.50
7/8	6.09	7.70	8.75	8.75
1	6.95	9.53	10.00	10.00

¹ The pullout and shear capacities shown here are for the expansion anchor types included in Table 8.2 (Ref. 9.6) installed in sound, uncracked concrete (i.e., no cracks passing through the anchor bolt installation) with a compressive strength (f'_c) of at least 4000 psi for pullout and 3500 psi for shear.

² Minimum spacings and edge distances are measured from bolt center to bolt center or concrete edge. Smaller spacings and edge distances less than the minimums given here can be used with the reduction factors given in Tables H-2 and H-3.

Table H-2

EXPANSION ANCHOR BOLT MINIMUM
SPACING AND REDUCTION FACTORS

Allowables for concrete expansion anchor bolts provided in Table P-1 are based on greater than or equal to 10 bolt diameters(1) of spacing (measured from bolt center to bolt center) to the nearest anchor bolt(s). The pullout and shear reduction factors provided below for bolts with spacing of less than 10 bolt diameters.

Spacing pullout reduction factors $(RS_p)_{(2)}$:

RS_p	=	1.0	For $S \geq 10D$
	=	0.1 S/D (Note 3)	For $5D \leq S < 10D$
	=	0.50	For $2.5D \leq S < 5D$
	=	0	For $S < 2.5D$

Spacing shear reduction factors $(RS_s)^{(2)}$:

RS_s	=	1.0	For $S \geq 2D$
RS_s	=	0.5	For $S < 2D$

Notes:

1. Minimum spacing to obtain maximum working load
2. If an anchor is near 2 or more other anchors, a reduction factor is calculated and applied for each anchor.
3. where $S = 5D$ or $6D$ or $7D$, etc. (measured in nominal bolt diameters)

Table H-3

EXPANSION ANCHOR BOLT
MINIMUM EDGE DISTANCE AND REDUCTION FACTORS

Allowables for concrete expansion anchor bolts provided in Table H-1 are based on greater than or equal to 10 bolt diameters(1) of edge distance (E) measured from bolt center to the nearest free edge of concrete. The pullout and shear reduction factors are provided below for bolts with edge distance of less than 10 bolt diameters.

Edge distance pullout reduction factors (RE_p)⁽²⁾:

$$\begin{aligned} RE_p &= 1.0 && \text{For } E > 10D \\ RE_p &= 0.1 E/D \text{ (Note 3)} && \text{For } 4D < E < 10D \\ RE_p &= 0 && \text{For } E < 4D \end{aligned}$$

Edge distance shear reduction factors (RE_s)⁽²⁾:

$$\begin{aligned} RE_s &= 1.0 && \text{For } E > 10D \\ RE_s &= (0.1 E/D)1.5 && \text{For } 4D < E < 10D \\ RE_s &= 0 && \text{For } E < 4D \end{aligned}$$

Notes:

1. Minimum edge distance to obtain maximum working load allowables.
2. If an anchor is near two edges the reduction factor is calculated and applied for each edge.
3. Where E = 3D or 4D or 5D, etc. (measured in nominal bolt diameters).

Table H-4

PULLOUT CAPACITY REDUCTION FACTORS FOR
EXPANSION ANCHORS IN CRACKED CONCRETE⁽¹⁾⁽²⁾

Conditions	Reduction Factor for Pullout Capacity (RCP)
▪ No cracks	1.0
▪ Crack size (width) < 0.01 in. and the number of anchors securing the equipment that are affected by these cracks is:	
<50%	1.0
>50%	0.75(3)
▪ 0.01 in. < crack size < 0.02 in.	0.75(3)
▪ Crack size > 0.02 in.	Outlier

Notes:

1. The pullout capacity reduction factor applies only to significant structural cracks which penetrate the concrete mass and pass through the vicinity of the anchor installation. Concrete with surface (craze) cracks or shrinkage cracks which only affect the surface of the concrete should be considered un-cracked. It may be necessary to exercise judgement to establish whether cracks in the vicinity of an anchor actually pass through the installation. Inspections for crack width should be visual (i.e., detailed measurement of crack widths is not necessary).
2. The shear capacity of expansion anchors is not significantly affected by cracks in the concrete.
3. Capacity reduction factor applies to all anchors securing the item of equipment, not just anchors that are affected by the cracks.

Table H-5

NOMINAL ALLOWABLE CAPACITIES FOR
CAST-IN-PLACE BOLTS AND HEADED STUDS

Bolt/Stud Pullout Diameter Capacity (D, in.)(P _{nom} , kip) (2)	Shear Capacity (V _{nom} , kip) (2)	Minimum Embedment (L _{min} , in.)	Minimum Spacing (S _{min} , in.) (1)	Min. Edge Distance (E _{min} , in.) (1)
3/8	3.74	1.87	3-3/4	3-3/8
1/2	6.66	3.33	5	4-3/8
5/8	10.44	5.22	6-1/4	5-1/2
3/4	15.03	7.51	7-1/2	6-5/8
7/8	20.44	10.22	8-3/4	7-3/4
1	26.69	13.35	10	8-3/4
1-1/8	33.80	16.90	11-1/4	9-7/8
1-1/4	41.72	20.86	12-1/2	11
1-3/8	50.40	25.25	13-3/4	12-1/8

Notes:

1. Minimum spacings and edge distances are measured from bolt center to bolt center or concrete free edge. Smaller spacings and edge distances less than the minimums given here can be used with the reduction factors given in Reference 9.2.
2. The pullout and shear capacities shown here are for ASTM A-307 or equivalent-strength bolts installed in sound, un-cracked concrete (i.e., no cracks passing through the anchor bolt installation).

TABLE H-6

COMPARISON OF ALLOWABLE LOADS FOR VARIOUS FASTENERS

FASTENER SIZE (3) (INCHES)	EXPANSION ANCHORS		UNISTRUT BOLTS		THREADED FASTENERS		NELSON STUDS		CAST-IN-PLACE BOLTS		FILLET WELDS (2)		
	Pa	Sa	Pa	Sa	Pa	Sa	Pa	Sa	Pa	Sa	t	l	Fa
1/4	0.36	0.65	0.60	0.30	1.57	0.79	1.57	0.79	N/A	N/A	1/8	0.5	1.35
3/8	2.19	2.12	1.00	1.00	3.53	1.77	3.53	1.77	3.74	1.87	1/8	1	2.70
1/2	3.43	3.57	2.00	1.50	6.28	3.14	6.28	3.14	6.66	3.33	3/16	0.5	2.03
5/8	4.75	5.68	2.00	1.70	9.82	4.91	9.82	4.91	10.44	5.22	3/16	1	4.06
3/4	7.03	8.22	2.00	1.70	14.14	7.07	14.14	7.07	15.02	7.51	1/4	0.5	2.70
7/8	N/A	N/A	N/A	N/A	19.24	9.62	19.24	9.62	20.44	10.22	1/4	1	5.41
1	10.4	14.3	N/A	N/A	25.13	12.57	25.13	12.57	26.70	13.35	5/16	0.5	3.38
1-1/8	N/A	N/A	N/A	N/A	31.81	15.90	N/A	N/A	33.80	16.90	5/16	1	6.76
1-1/4	(1)	(1)	N/A	N/A	39.27	19.63	N/A	N/A	41.72	20.86	3/8	0.5	4.06
1-3/8	N/A	N/A	N/A	N/A	47.52	23.76	N/A	N/A	50.50	25.25	3/8	1	8.11

Definitions:

Pa = Pullout (or tensile) allowable capacity (kips)

Sa = Shear (or slip) allowable capacity (kips)

Fa = Allowable load for welds (kips)

t = Thickness of weld (inches)

l = Length of weld (inches)

Notes:

1. Use allowable loads for 1 inch anchors
2. Factor allowable loads linearly by length for larger (or smaller) welds
3. For larger sizes screen on the value for the largest listed size

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