

IEEE Standard for Qualification of Safety-Related Valve Actuators

Sponsor

**Nuclear Power Engineering Committee of the
IEEE Power Engineering Society**

© Copyright 1980 by

The Institute of Electrical and Electronics Engineers, Inc

*No part of this publication may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.*

Approved September 27, 1979

IEEE Standards Board

Joseph L. Koepfinger, *Chairman*

Irvin N. Howell, Jr, *Vice Chairman*

Ivan G. Easton, *Secretary*

G. Y. R. Allen
William E. Andrus
C. N. Berglund
Edward Chellotti
Edward J. Cohen
Warren H. Cook
R. O. Duncan
Jay Forster

Harold S. Goldberg
Richard J. Gowen
H. Mark Grove
Loering M. Johnson
Irving Kolodny
W. R. Kruesi
Leon Levy

J. E. May
Donald T. Michael*
R. L. Pritchard
F. Rosa
Ralph M. Showers
J. W. Skooglund
W. E. Vannah
B. W. Whittington

*Member emeritus



Documents
Document Sharing Hub

Foreword

(This Foreword is not a part of IEEE Std 382-1980, IEEE Standard for Qualification of Safety-Related Valve Actuators.)

Applicants applying for a construction permit or operating license for a nuclear generating station are required to provide assurance that systems, components, and structures are adequate for their service conditions to comply with the Code of Federal Regulations 10CFR50, Appendix B *Quality Assurance Criteria*, Criterion III *Design Control*. Each applicant has the responsibility to assure that this or any other standard, if used, is pertinent to the application and that the integrated performance of the station is acceptable. Implementation of this standard requires the applicant to produce documentary evidence to assure that the valve actuator can perform its intended function.

This standard has been developed to establish a method to accomplish this qualification. It is a combined effort of members of the American Society of Mechanical Engineers and the Institute of Electrical and Electronics Engineers.

Typical design basis event conditions for principal reactor types are presented as one source of parameters for generic type tests. If the actual parameters of a specific application differ, it will be the obligation of the user to specify these actual conditions. A new standard (ANSI N691) addressing DBE parameters is in preparation. When it is completed, this standard will be revised accordingly.

The user is reminded that it is his responsibility to assure the acceptability of the methods, procedures, and specifications for the specific applications.

The numerical values presented in this standard represent current industry design practices with respect to radiation types and levels, seismic levels, temperature, pressure, humidity levels, post accident periods of operability, spray initiation and duration, and composition of environment which can change in the future. The user is therefore cautioned to verify the suitability of these values for his application.

This standard was prepared by a joint ASME-IEEE Committee, organized at a meeting of IEEE and ASME representatives on August 14, 1974. Their task was to combine existing ANSI/IEEE Std 382-1972 and draft 2 of ANSI 278.2 Part 1 dated May 18, 1974, prepared by ANSI B16 Subcommittee H Task Force No 1 sponsored by ASME. The Joint Committee had the following membership:

W. J. Denkowski, *Chairman*

M. A. Moler, *Vice Chairman*

D. P. Allison
G. R. Brown
N. M. Burstein
S. P. Carfagno
H. E. Eminger
J. Flippo

W. J. Foley
R. J. Matthews
C. T. Nieh
G. D. Shipway
E. L. Solem
R. W. Tartaglia

This standard was ballotted simultaneously by ANSI Committee B16 SC-H, IEEE/NPEC SC-2, and Nuclear Power Engineering Committee, and reviewed and approved by the IEEE Standards Board.

The membership of Subcommittee 2 on Qualification which recommended approval of this standard were:

J. T. Bauer, *Chairman*

M. Pai, *Vice Chairman*

L. D. Test, *Vice Chairman*

N. S. Porter, *Secretary*

A. E. Butt
J. F. Bates
A. E. Blanchard
N. M. Burstein
D. G. Cain
S. P. Carfagno
D. J. Castro
F. W. Chandler
C. E. Corley
J. L. Crenshaw
R. P. Daigle

W. J. Denkowski
G. T. Dowd
C. V. Fields
J. B. Gardner
A. Garshick
R. F. Gilton
D. Green
G. K. Henry
J. T. Keiper
J. Kroll

T. H. Ling
E. E. McIlveen
D. J. Meraner
C. F. Miller
J. A. Naber
E. W. Rhoads
R. M. Scates
R. R. Schemmel
C. F. Seyer
A. P. Stakutis
J. C. Wright

At the time it approved this standard, the Nuclear Power Engineering Committee had the following membership:

A. J. Simmons, *Chairman*[†]

J. T. Boettger, *Vice Chairman*

R. E. Allen, *Secretary*

J. F. Bates
J. T. Bauer
F. D. Baxter
J. T. Beard
R. G. Benham
D. F. Brosnan
W. J. Brynda
F. W. Chandler
C. M. Chiappetta
E. Corte
R. P. Daigle
N. C. Farr
J. Ferencsik

J. M. Gallagher
J. B. Gardner
R. I. Hayford
T. A. Ippolito
I. M. Jacobs
R. F. Karlicek
A. Laird
T. J. Martin
T. J. McGrath
G. M. McHugh
W. C. McKay
W. P. Nowicki
W. E. O'Neal

M. Pai
E. S. Patterson
J. R. Penland
H. V. Redgate
B. M. Rice
W. F. Sailer
J. H. Smith
A. J. Spurgin
L. Stanley
J. K. Stolt
D. F. Sullivan
P. Szabados
L. D. Test

[†] Deceased

Contents

SECTION	PAGE
1. Scope and Purpose	7
2. Definitions	7
3. References.	9
4. Introduction	9
4.1 General	9
4.2 Requirements	9
5. Qualification of Generic Actuator Group	9
5.1 Generic Actuator Group Identification	9
5.2 Selection of Actuator Units for Type Testing	9
5.3 Type Test Parameter Values	11
5.4 Type Test Specification.	19
5.5 Type Test Procedure	19
5.6 Generic Actuator Group Design Modifications	22
6. Qualification for Specific Actuator Application	22
6.1 General	22
6.2 Specification	22
6.3 Relationship to Generic Actuator Group.	23
6.4 Relationship to Specification	23
7. Documentation	23
7.1 General	23
7.2 Documentation for Qualification of Generic Actuator Group.	23
7.3 Documentation for Qualification for a Specific Actuator Application	23
FIGURES	
Fig 1 Flow Chart for Valve Actuator Qualification	10
Fig 2 Seismic Qualification, Required Input Motion (RIM)	12
Fig 3 Seismic Qualification, Required Response Spectrum (RRS)	13
Fig 4 Qualification Type Test Parameters, Inside BWR Drywell and Steam Tunnel, Case I	14
Fig 5 Qualification Type Test Parameters Inside Containment, Outside BWR Drywell and Steam Tunnel, Case II	15
Fig 6 Qualification Type Test Parameters LOCA Inside (PWR) Containment, Case III . .	16
Fig 7 Qualification Type Test Parameters MSLB Inside (PWR) Containment, Case IV . .	17
Fig 8 Qualification Type Test Parameters Outside Containment (BWR and PWR), Case V	18
APPENDIXES	
Appendix A: Method for Selection of Representative Actuator or Actuators for Type Testing	25
A1 Introduction	25
A2 Example	25

SECTION	PAGE
Appendix B: Representative Normal and Design Basis Event Environmental Conditions . .	29
B1 General	29
B2 Normal Service Conditions	29
B3 Design Basis Event Conditions	32
Appendix C: Rationale for Normal Thermal Aging	35
Appendix D: Rationale for Vibration and Seismic Test Methods	37
D1 Vibration Aging	37
D2 Seismic Aging	37
Appendix E: Performance Verification Test	39
E1 Electric, Pneumatic-Motor, or Hydraulic-Motor Actuators	39
E2 Pneumatic, Electrohydraulic, and Hydraulic Actuators (Cylinders, Rams, Rotary Vanes, and Diaphragm Double-Acting or Spring Return)	39
E3 Integral Valve — Solenoid Type Actuators	39
APPENDIX FIGURES	
Fig B1 Reference Service Conditions, DBE Parameters Inside Containment (BWR)	30
Fig B2 Reference Service Conditions, LOCA Environmental Parameters Inside Containment (PWR)	30
Fig B3 Reference Service Conditions, MSLB Environmental Parameters Inside Containment (PWR)	31
Fig B4 Reference Service Conditions, Line Break Parameters Outside Containment (BWR and PWR)	32
Fig B5 Gamma Dose Rate and Integrated Dose Within Containment (BWR or PWR)	33
APPENDIX TABLES	
Table A1 Significant Parameter Values	26
Table A2 Identification of Eligible Models	27
Table A3 Selection of Test Models	27

IEEE Standard for Qualification of Safety-Related Valve Actuators

1. Scope and Purpose

This standard describes the qualification of all types of power-driven valve actuators, including damper actuators, for safety-related functions in nuclear power generating stations. This standard may also be used to separately qualify actuator components.

This standard establishes the minimum requirements for, and guidance regarding, the methods and procedures for qualification of all safety-related functions of power-driven valve actuators.

2. Definitions

actuator performance verification test. A test conducted as outlined in a manufacturer's specification to demonstrate compliance with a buyer's actuator specification.

air equivalent radiation dose. The energy that would be absorbed per unit mass of air at the geometric center of the volume occupied by the specimen if it were replaced with air and a uniform flux were incident at the boundary of the volume, directed toward the center.

aging. The cumulative effect of operating cycles and environmental and system conditions imposed on the actuator during a period of time.

analysis. A process of mathematical or other logical reasoning that leads from stated premises to the conclusion concerning specific ca-

pabilities of equipment and its adequacy for a particular application.

auditable data. Technical information which is documented and organized in a readily understandable and traceable manner that permits independent auditing of the inferences or conclusions based on the information.

Class 1E. The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment.

containment. That portion of the engineered safety features designed to act as the principal barrier, after the reactor system pressure boundary, to prevent the release, even under conditions of a reactor accident, of unacceptable quantities of radioactive material beyond a controlled zone.

design basis events (DBE). Postulated events used in plant design to establish the performance requirements of the structures, systems, and components.

design life. The time during which satisfactory performance can be expected for a specific set of service conditions.

generic actuator group. An actuator or family of actuators within a range of sizes with similar design principles, materials, manufacturing processes, limiting stresses, operating principles, and design margins.

installed life. The interval, from installation to removal, during which the equipment or component thereof may be subject to service conditions and system demands.

margin. The difference between the most severe specified service conditions of the plant and the conditions used in type testing.

motive power. The electric, fluid, or mechanical energy required to operate the actuator.

operating basis earthquake (OBE). The earthquake which could reasonably be expected to affect the plant site during the operating life of the plant. It is that earthquake which produces the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.

qualified life. The period of time for which satisfactory performance has been demonstrated for a specific set of service conditions.

NOTE: The qualified life of a particular equipment item may be changed during its installed life when justified.

ratio set. A set of performance parameter values described by a range of numerical values whose boundaries have been established by doubling and halving the numerical mean value of a selected physical performance parameter.

required input motion (RIM). The input motion in terms of acceleration, velocity, and displacement expressed as a function of frequency that an actuator being tested shall withstand and still perform its intended function.

required response spectrum (RRS). The response spectrum issued by the user or his designee as part of his specifications for proof testing, or artificially created to cover future applications. The RRS represents a requirement to be met.

response spectrum. A plot of the maximum response of single-degree-of-freedom bodies, at a damping value expressed as a percent of critical damping of different natural frequencies, when these bodies are rigidly mounted on the surface of interest (that is, on the

ground for the ground response spectrum or on the floor for the floor response spectrum) when that surface is subjected to a given earthquake's motion as modified by any intervening structures.

safe shutdown earthquake (SSE). That earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to ensure: (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in safe shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents which could result in potential off-site exposures greater than the guideline exposures CFR10, Part 100 (Dec 5, 1973.)

sample valve actuator. A representative unit manufactured in accordance with the manufacturer's quality control system and specifications for production units.

service conditions. Environmental, loading, power, and signal conditions expected as a result of normal operating requirements, expected extremes (abnormal) in operating requirements, and postulated conditions appropriate for the design-basis events of the station.

test response spectrum (TRS). The response spectrum that is constructed using analysis or derived using spectrum analysis equipment based on the actual input test table motion to the actuator.

type test. Tests made on one or more sample actuators to verify adequacy of the design and the manufacturing processes.

valve actuator. An electric, pneumatic, hydraulic, or electrohydraulic power-driven mechanism for positioning two-position or modulating valves and dampers. Included are those components required to control valve action and to provide valve position output signals, as defined in the actuator specification.

valve actuator specification. A document to be provided to the valve actuator manufacturer which contains technical requirements for a specific application.

zero period acceleration (ZPA). The acceleration that appears as a constant portion of a response spectrum in the highest frequency range. It is the maximum acceleration in the time history from which that response spectrum was developed.

3. References

ANSI/IEEE Std 344-1975, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

IEEE Std 323-1974, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

4. Introduction

4.1 General. Safety-system equipment in nuclear power stations shall be capable of performing satisfactorily under defined conditions, including postulated design basis events (DBE). It is necessary to provide assurance that such equipment meets its performance requirements throughout its installed life. This is accomplished through a disciplined program of design, qualification, production quality control, installation, maintenance, and surveillance testing.

This standard applies only to the qualification portion of the above-mentioned program.

Most actuators are designed and manufactured in generic design groups (families) which, although varying considerably in size, are made of similar materials and have similar design and manufacturing principles. Individual actuators from these design groups can be adopted to a wide range of applications. An independent qualification of each possible variation of design within each generic group is not practical. When a specific purchase request does exist, qualification must be demonstrated with regard to that specific application.

Specific qualification requires demonstration that each actuator is a member of a qualified generic family and further that it will, when manufactured to meet an actuator specification, function as required for a particular

application. If a particular actuator for which qualification is required cannot be related to a qualified generic actuator group, the qualification test procedure shall be performed on a sample of that particular actuator.

This standard divides the qualification process for actuators into the following two sequential steps:

- (1) Qualification of generic actuator group
- (2) Qualification for specific actuator

4.2 Requirements. Methods used for qualification include type testing, operating experience, and analysis. This standard requires that: (1) qualification of a generic actuator group shall be accomplished by type testing, supplemented as needed by analysis; (2) specific qualification for each application shall be accomplished by analysis utilizing generic group qualification data, operating experience, and additional testing when necessary.

In type testing, sample actuators shall be subjected to environmental and operating conditions that simulate the intended normal service and DBE environmental conditions and safety-related functions for which they are to be qualified.

Documentation shall be provided as described in this standard.

Fig 1 describes the qualification process as defined in this standard.

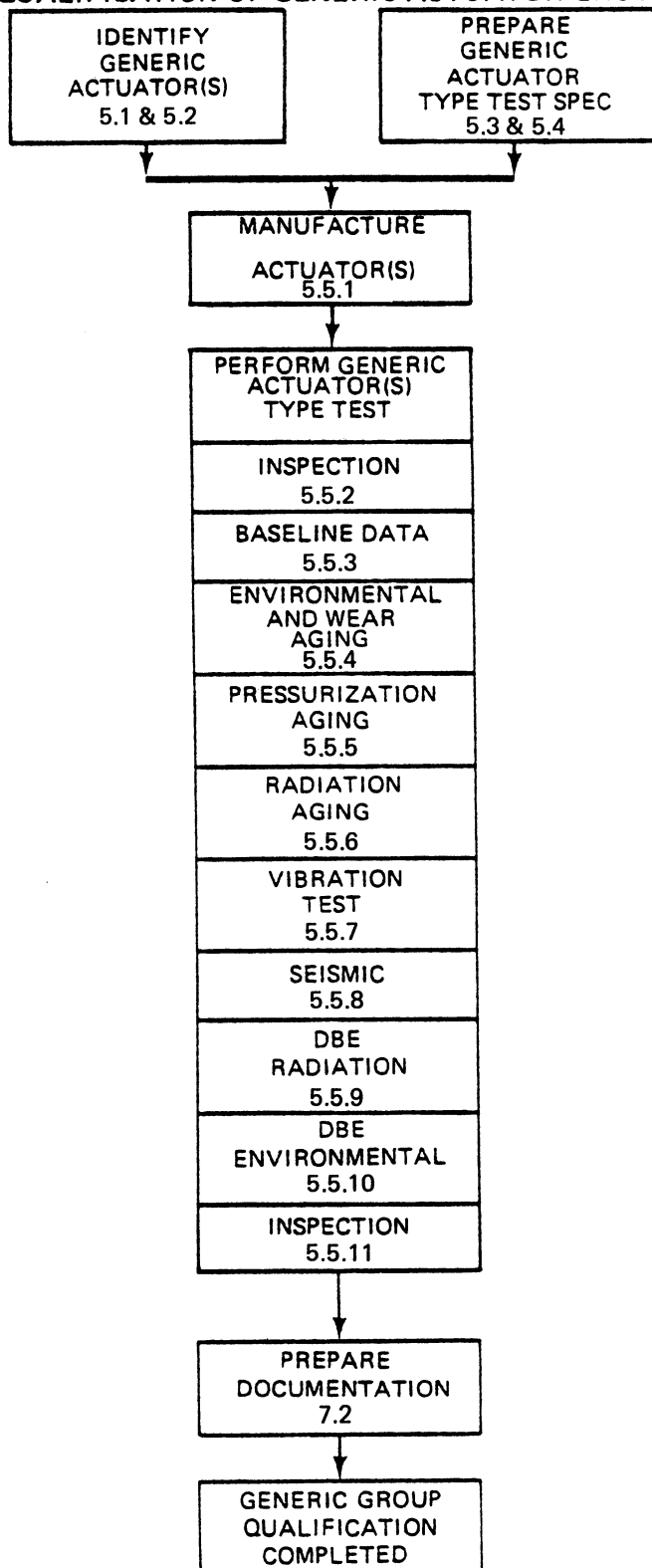
5. Qualification of Generic Actuator Group

5.1 Generic Actuator Group Identification. A generic actuator group from which sample actuators will be selected for type tests shall be established and identified. Consideration shall be given to design principles, materials, manufacturing processes, limiting stresses, deformations, deflections, operating principles, design margin, etc.

5.2 Selection of Actuator Units for Type Testing. Due to the variation in types, sizes, and configurations of valve actuators, it is not practical for this standard to establish a fixed number of actuators to be tested in order to establish qualification. It is also impractical to require that all actuators be tested.

All actuators within a generic group will be

QUALIFICATION OF GENERIC ACTUATOR GROUP



STEP 2 QUALIFICATION FOR SPECIFIC ACTUATOR

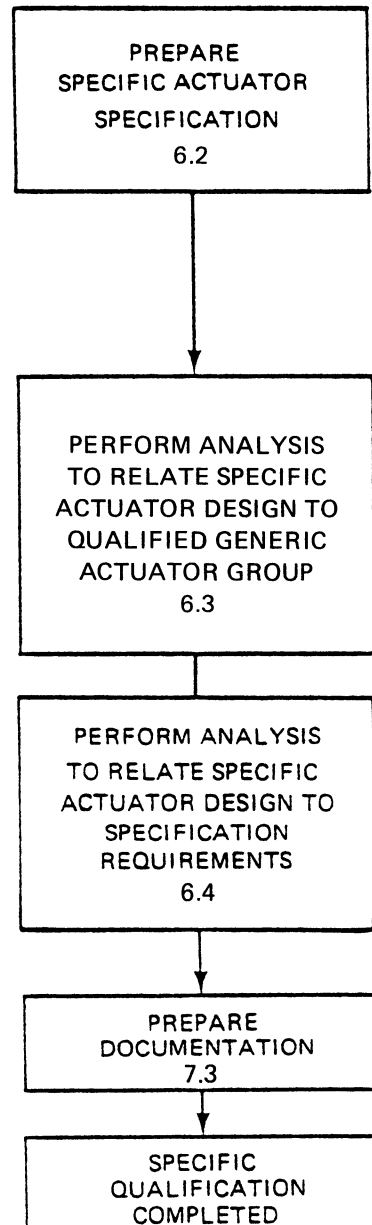


Fig 1
Flow Chart for Valve Actuator Qualification

considered qualified provided an appropriate number of units are type tested. The number of units to be tested shall be based on an evaluation of the variations in physical and performance parameters that exist within the generic group, such as thrust, torque, power, speed, materials, pressure, weight, dimension, inertia, and seismic moment.

Appendix A describes a suggested procedure for the selection of test units.

5.3 Type Test Parameter Values

5.3.1 Test Parameter Values. Parameter values to be used in the qualification of a generic actuator group shall be obtained from one of the three sources described in 5.3.1.1 and 5.3.1.2.

The environmental parameters and duration used to establish qualification of a generic actuator group vary depending on the level of qualification sought. The elements contributing to these variations are location in the plant and required function.

5.3.1.1 Standard Source. The standard qualification cases are defined in 5.3.2. The test parameter values for these cases are shown in Figs 2–8, which include environmental margins as suggested in IEEE Std 323-1974, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations. The values for Figs 4–8 are based on composite service conditions, shown in Appendix B, which are a compilation of data obtained from the nuclear community at the time this standard was written. The thermal aging values are based on the rationale described in Appendix C. The vibration testing and seismic simulation values are based on the rationale described in Appendix D.

5.3.1.2 Other Source. Test parameters other than those in, but in a form comparable to, Figs 2–8 may be developed. Margins, as required by IEEE Std 323-1974, shall be applied to environmental service conditions to obtain test parameter values.

5.3.2 Standard Qualification Cases. The cases and the environmental test parameters for qualification which apply if the standard source method is selected, are described below.

Seismic qualification parameters are shown in Figs 2 and 3 and apply to all cases.

5.3.2.1 Multiple Operations

(1) *Case I.* Locations inside the drywell and steam tunnel of plants using a boiling water reactor (BWR) and intended to operate

following the start of the DBE and on demand for an extended period.

Fig 4 describes the qualification parameter values and time profile for actuators that are to be qualified for Case I.

(2) *Case II.* Locations inside the containment (outside the drywell and steam tunnel) of plants using a BWR and intended to operate following the start of the DBE and on demand for an extended period.

Fig 5 describes the qualification parameter values and time profile for actuators that are to be qualified for Case II.

(3) *Case III.* Locations inside the containment of plants using a pressurized water reactor (PWR) and intended to operate following the start of a loss of coolant accident (LOCA) and on demand for an extended period.

Fig 6 describes the qualification parameter values and time profile for actuators that are to be qualified for Case III.

(4) *Case IV.* Locations inside the containment of plants using a PWR and intended to operate following the start of MSLB event and on demand of an extended period.

Fig 7 describes the qualification parameter values and time profile for actuators that are to be qualified for Case IV.

(5) *Case V.* Locations outside the PWR and BWR containments subject to steam exposure and intended to operate following the start of the DBE and on demand for an extended period.

Fig 8 describes the qualification parameter values and time profile for actuators that are to be qualified for Case V.

(6) *Case VI.* Locations outside the PWR and BWR containments not subject to steam exposure and intended to operate following the start of the DBE and on demand for an extended period. No DBE radiation or steam/temperature simulation test is required. Normal service aging qualification may be accomplished by either demonstration of prior use or analysis.

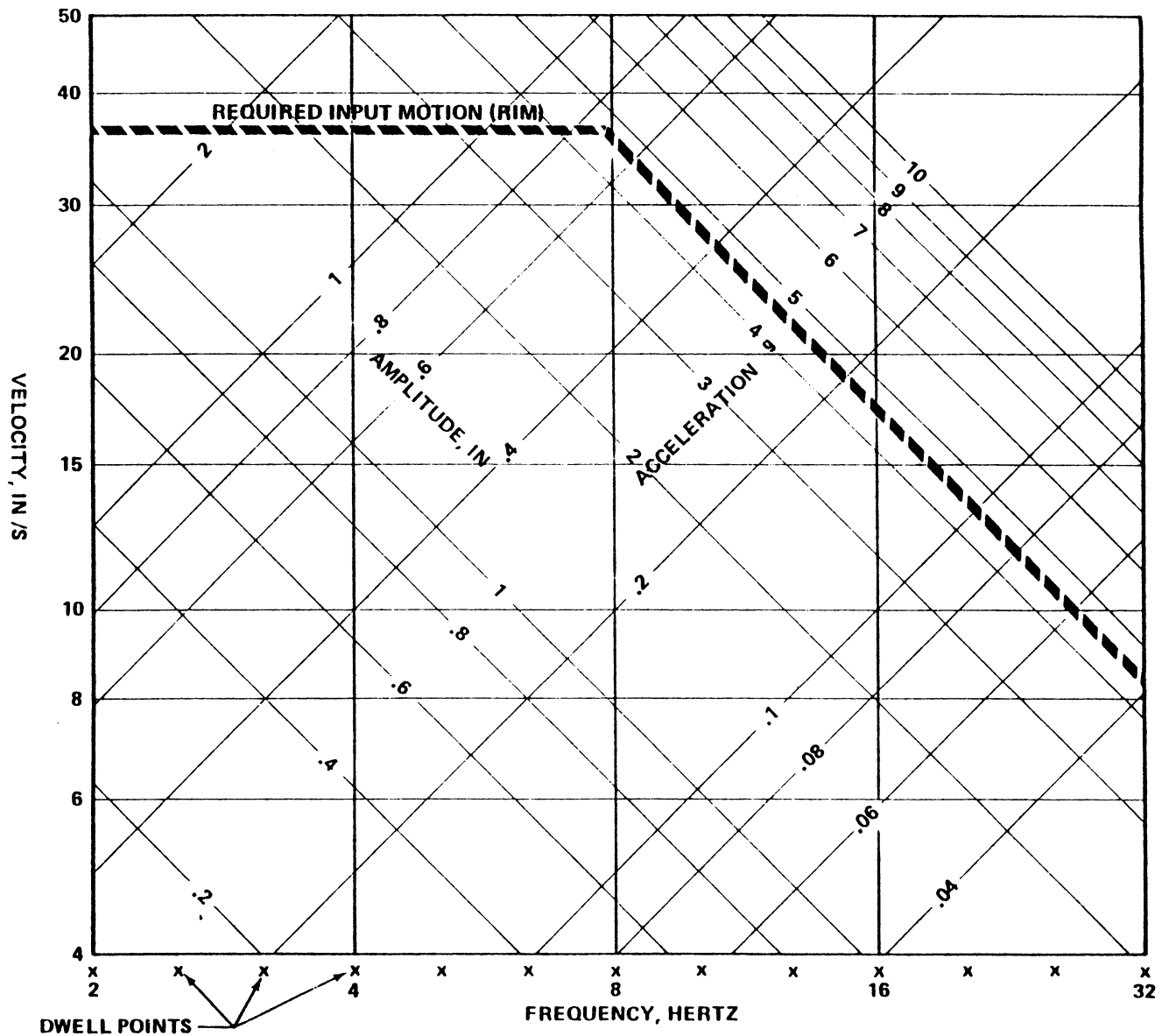
Actuators qualified for Case III are considered to be qualified for Cases I and II.

Actuators qualified for Case IV are qualified for Cases I, II, and III.

Actuators qualified for Cases I, II, III, or IV are qualified for Cases V and VI.

Actuators qualified for Case V are considered to be qualified for Case VI.

NOTE: The above are satisfactory for actuators not required to operate beyond 30 days.



VALUES ARE SUBJECT TO CHANGE,
USER SHOULD VERIFY ADQUACY.

Fig 2
Seismic Qualification
Required Input Motion (RIM)