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1.0 INTRODUCTION

Snubbers are widely used in the nuclear industry to protect components and piping systems against seismic, vibratory or impact loads. Concerns exist regarding the reliability of snubbers and their ability to remain operable during their intended service life.

Experience from operating nuclear plants demonstrates that snubber failures occur. The snubber failures compromise reactor safety by: (1) loss of intended function and (2) introduction of loads not considered in plant design.

A snubber failure may be defined as a condition whereby operability is impaired or degraded to the point that the component cannot perform its intended function. Although obvious structural failures of the snubber are easily identified, degradation of operating characteristics due to less obvious failure modes are less easily identifiable.

Operability assurance can be provided only if certain "controls" are exercised by the regulatory agencies, utilities and snubber manufacturers. These "controls" or criteria provide for the implementation of requirements and systematic procedures to provide safe operating facilities. Criteria are directives or guidelines for the utilization, testing, or assessment of snubbers or snubber-supported systems.

Snubber criteria are separated into five functional categories in this study.

These categories and their purposes are defined as follows:

- Design Criteria - Establish environmental requirements and define functional limits.
- Application Criteria - Provide guidance for snubber selection, placement, and installation.
- Analysis Criteria - Establish methods for linear and nonlinear analyses of snubber-supported systems and mathematical modeling of snubbers.
- Test Criteria - Provide guidance for qualification, acceptance, and inservice testing of snubbers and related hardware.
- Inspection Criteria - Identify manufacturing, preinstallation, and inservice inspection schedules and provide guidance for identifying failed or unacceptable snubbers.

Development of snubber criteria has accelerated due to:

- 1) Emphasis on seismic safety
- 2) The identification of inoperable snubbers
- 3) Knowledge gained from research studies
- 4) NRC emphasis on snubber reliability.

Snubber criteria are established by regulatory agencies, utilities, and snubber manufacturers. There are numerous documents that give directives (criteria) regarding snubber design, analyses, application, testing, and inspection.

The objectives of this study are to: (1) identify major snubber criteria documents, (2) review criteria, and (3) provide justification through test, and/or analysis and establish NRC positions regarding criteria.

Relative to these objectives:

- 1) The major snubber criteria documents are grouped for the purpose of discussion as follows:

Group I - Criteria originated or endorsed by NRC

Group II - Criteria originated by national or limited consensus organizations or those with wide applicability.

Group III - Limited application documents.

- 2) The criteria review examines the major criteria documents to identify inconsistencies, contradictions, and omissions. This task also includes a limited review of existing snubber research to provide data supporting criteria credibility.
- 3) Justification of criteria includes identification of specific research required to verify credibility of criteria having signifi-

cant impact on snubber usage. Priority is given to NRC-originated or endorsed criteria requiring supportive research.

The snubber program is an on-going research study initiated in FY 1980. The first phase of the program (FY 1980 - FY 1981) consists of identifying snubber criteria and necessary supportive research. The second phase (FY 1982 - FY 1983) provides justification and description of tests and analytical studies to support criteria and the final phase (FY 1984) consists of performing the required studies to support NRC positions.

2.0 SUMMARY

Snubber criteria are established by regulatory agencies, utilities, and snubber manufacturers. There are numerous documents that give directives regarding snubber design, analysis, application, testing, and inspection.

Identification and review of major criteria documents are presented in this report. The objective of this review is to identify inconsistencies, contradictions, and omissions in these documents. This information will be used to formulate supportive criteria research.

The major criteria documents reviewed in this study are listed in chronologic order in Section 2.1. These documents were selected because of their current or anticipated impact on snubber usage. A review of many other documents not listed indicates that nearly all existing criteria can be identified in these few major documents.

A review of the major criteria documents indicates inconsistencies with stated values of:

- 1) Activation level
- 2) Release rate
- 3) Permissible drag load
- 4) Lost motion
- 5) Stiffness.

Inconsistencies usually exist for criteria stating specific allowable values or ranges of values. Installation tolerances and fatigue life requirements also vary among the major documents.

Omissions of criteria regarding snubber usage have not been identified at this time. The general nature of many criteria statements permits critical areas of design, analysis, application, testing, and inspection to be addressed.

Several major studies are proposed based on identified inconsistencies and apparent lack of supportive data regarding critical criteria. Those studies include:

- 1) Snubber Malfunction Study - The object of this study is to verify if the NRC Standard Technical Specification - Snubber Surveillance Requirements can identify all snubber failures.
- 2) Snubber Drag Load Study - The object of this study is to provide supportive data for allowable drag load limits.
- 3) Snubber Sensitivity Study - The object of this study is to update previous sensitivity studies to include new snubber designs and to provide supportive data regarding allowable values and range of activation level and release rate.

- 4) Multiple Locations for Snubbers Used as Axial Restraint - The object of this study is to determine if two or more axial supports on a long pipe run require simultaneous activation.

- 5) Evaluation of Qualification Requirements - The object of this study is to determine if qualification procedures of NRC RG SC-708-4 are adequate to provide snubber reliability and to determine if current accelerated aging procedures, test requirements, and environmental testing procedures are sufficiently understood to assure reliability of safety related snubbers.

- 6) Identification and Evaluation of Existing Test Data - The object of this study is to use existing test and analytical data to justify snubber criteria.

- 7) Review of Application of Non-Snubber-Specific Criteria to Snubbers - The object of this study is to evaluate potential problems associated with adopting existing non-snubber specific criteria (e.g., manufacturing, painting, cleaning, etc.) for snubbers.

Program plans for these programs are summarized in Appendix D.

Table 2.1. Major Snubber Documents

Title	Report Number	Originator	Revision Date
RDT Standard: Pipe Hangers, Supports & Snubbers for Liquid Metal Service	E 7-6T	RDT/AEC	5/72
Design/Purchase Specification: Pipe Suspension	21A3502	GE	12/29/76
Draft Document: Snubber Criteria	NF-3*	ANSI/ASME	9/11/79
Draft Standard: Examination & Performance Testing of Nuclear Power Plant Dynamic Restraints (Snubbers) Standard	O&M-4	ANSI/ASME	10/20/80
NRC Draft Standard Technical Specifications: Revision on Snubber Surveillance Requirements	-	NRC	11/20/80
Draft Regulatory Guide: Qualification and Acceptance Tests for Snubbers Used in Systems Important to Safety	SC-708-4	NRC	2/81
Standard Review Plan	NUREG-0800	NRC	7/81
Draft Limited Consensus Standard Covering Mechanical and Hydraulic Snubbers	LCS NE E 7-9T	DOE	2/28/83

*Subsequently published as "Criteria for Nuclear Safety Related Piping and Component Support Snubbers" in ASME Publication PVP-47, "Critical Issues in Material and Mechanical Engineering," 1981

3.0 DISCUSSION

3.1 Snubber Criteria Identification

The program success is related directly to the success in identifying existing snubber criteria. The major national consensus documents such as American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PVC), Section III and Section XI and regulatory agency documents from the NRC and The Department of Energy (DOE) are obvious sources for snubber criteria. Other documents which do not have high visibility or wide applicability are also identified. These documents with limited applicability were identified through discussions, surveys, and literature research.

The following paragraphs describe the procedures used to identify criteria documents.

3.1.1 Snubber Survey

A survey questionnaire was prepared to identify: (1) snubber criteria documents, (2) snubber malfunctions or failures, (3) items to be included in snubber criteria, and (4) strengths and weaknesses of snubber designs. The questionnaire was sent to snubber manufacturers, utilities, Architect/Engineers (A/E's), consultants, reactor manufacturers, and other suppliers of nuclear components. The survey was performed in June 1980. Fifteen questions asked of the survey recipients were:

- 1) Name of person filling out questionnaire
- 2) Name of company
- 3) Association with snubbers
- 4) Types of snubbers used
- 5) Types of snubber malfunctions or failures which have occurred during the last three years
- 6) Snubber criteria documents used
- 7) Existing snubber criteria to be modified or eliminated
- 8) Items to be addressed under application criteria
- 9) Items to be addressed under design criteria
- 10) Items to be addressed under analysis criteria
- 11) Items to be addressed under testing criteria
- 12) Items to be addressed under inspection criteria
- 13) Strong points of snubber design
- 14) Weak points of snubber design
- 15) Other comments.

Out of a total of 61 questionnaires sent, 24 responses were received. The list of respondents and survey results are summarized in Appendix A.

The survey did not identify many documents. A list of criteria documents identified by the survey is indicated below.

- 1) ASME B&PVC, Section III, Subsection NF: Component Supports
- 2) ASME B&PVC, Section XI: Rules for Inservice Inspection of Nuclear Power Plant Components

- 3) American National Standards Institute (ANSI)/ASME B31.1: Power Piping
- 4) Manufacturers Standardization Society (MSS) Standard SP-58: Pipe Hangers and Supports - Materials, Design, and Manufacture
- 5) MSS Standard SP-69: Pipe Hangers and Supports - Selection and Application
- 6) ASME Draft Standard O&M-3: Inspection of Nuclear Power Plant Dynamic Restraints (Snubbers)
- 7) ASME Draft Standard O&M-4: Examination and Performance Testing of Nuclear Power Plant Dynamic Restraints (Snubbers)
- 8) Manufacturers Technical Manuals and Bulletins
- 9) Customer Procurement Specifications
- 10) Plant Technical Specifications
- 11) NRC Technical Specifications

3.1.2 Literature Survey

Discussions with snubber manufacturers, test engineers, and hanger/support cognizant engineers were instrumental in identifying criteria documents with limited applications. Unlike the national and limited consensus snubber criteria, these documents may be limited to a single facility or possibly have no current application in industry.

3.1.3 Foreign Documents

Discussions with French and German engineers regarding design, research, and

test of seismic restraints and licensing of nuclear plants are summarized in Appendix B. No foreign documents were obtained during these discussions.

3.2 Snubber Criteria Documents

Snubber criteria documents are separated for the purpose of discussion into three groupings. Group I criteria are those originated or endorsed by the NRC. These documents include:

- 1) NRC Draft Standard Technical Specifications: Revision on Snubber Surveillance Requirements
- 2) NRC Draft Regulatory Guide SC-708-4: Qualification and Acceptance Tests for Snubbers Used in Systems Important to Safety
- 3) NRC Standard Review Plan NUREG-0800 Section 3.9.3: ASME Code Class 1,2, & 3 Components, Component Supports, and Core Support Structures
- 4) ASME Draft Standard OM&M-4: Examination and Performance Testing for Nuclear Power Plant Restraints (Snubber)

Group II criteria are those originated by national consensus organizations, industry, or other regulatory agencies that have (or are intended to have) wide application. These documents include:

- 1) DOE Draft Limited Consensus Standard Covering Mechanical and Hydraulic Snubbers, NE E 7-9T
- 2) ASME B&PVC Draft Document NF-3: Snubber Criteria
- 3) ASME B&PVC Sections III and XI

- 4) General Electric (GE) Purchase Specification 21A3502: Pipe Suspension, Rev. 2, Dec. 29, 1976
- 5) C F Braun & Co. Specification 400-20: Design Certification, Pipe Snubbers & Struts, Rev. 3, October 12, 1977
- 6) ITT Grinnell Product Specification PHD-7556-7S: Figure 670 Hydraulic Shock Suppressor, Rev. 2, August 5, 1980

Group III criteria are those documents with limited application or criteria derived from Groups I or II documents. The criteria include as a partial list:

- 1) RDT/AEC (Division of Reactor Development & Technology/Atomic Energy Commission) Standard - Pipe Hangers, Supports and Snubbers for Liquid Metal Service
- 2) Manufacturers qualification specifications
- 3) Utility inservice inspection procedures (Based on NRC Standard Technical Specification)
- 4) Snubber analytical and testing research

The following sections briefly describe the major criteria documents of Table 2.1 on snubber usage.

3.2.1 RDT/AEC Standard RDT E 7-6T

The RDT/AEC standard RDT E 7-6T defines the requirements for the design, fabrication, quality assurance, inspection, testing, certification and

delivery of pipe hangers, supports and snubbers for liquid metal service. The requirements are not snubber specific; instead, the standard states that "Damper/snubber" requirements are to be specified in the Ordering Data.

3.2.2 General Electric Purchase Specification 21A3502

This specification defines the engineering requirements for ASME Code Section III Class 1 piping component supports for use in boiling water reactor piping systems. Piping component supports covered by this specification include constant support spring hangers, variable support spring hangers, struts, and snubbers.

The original document was released in 1975 and contained detailed requirements for mechanical and hydraulic snubbers. It was one of the first documents to define functional and design requirements of snubbers. Functional requirements address lost motion, stiffness, drag loads, activation levels, and release rates. Design requirements address misalignment, clamps, orientation, installation, and adjustment. Environmental requirements are also established in the specification.

The comprehensive list of snubber requirements in this document has prompted the adoption of these requirements in subsequent purchase and design specifications and by other organizations.

3.2.3 ASME Draft Document NF-3

This document was developed by the Working Group on snubbers but was not released by the ASME as a national consensus document. It was, however, published as a technical paper in PVP-47 during 1981. The snubber criteria document addresses functional design and loading requirements, application and installation requirements, startup and testing procedures, and inservice inspection.

The document represents a series of summary criteria statements being developed within ANSI/ASME, and the NRC. The NF-3 document contains criteria that appear in the following documents:

- o ASME B&PVC, Section III, Summer 1978
- o ASME Draft Standard O&M-4
- o NRC Draft Regulatory Guide SC-708-4
- o NRC Standard Review Plan NUREG-0800, Section 3.9.3
- o DOE Draft Limited Consensus Standard Covering Mechanical and Hydraulic Snubbers LCS NE E 7-9T

3.2.4 ASME Draft Standard O&M-4

This standard is one of a series of nuclear power plant equipment standards developed as a guide for inservice examination and performance testing under the sponsorship of the ASME.

This standard provides general requirements for examination and performance testing of nuclear power plant equipment restraints included in the users equipment restraint (snubber) inservice inspection program. Requirements are also established for sample size and composition, frequency and acceptance criteria, evaluation, and documentation of examination and performance test results.

3.2.5 NRC Draft Standard Technical Specifications

The standard specifies inservice surveillance requirements for snubbers under the Standard Technical Specification. The surveillance and testing requirements are specified for mechanical and hydraulic snubbers.

Theoretically, all operating plants are to adopt these inspection requirements. The standard is, however, often adopted in a modified form; therefore, numerous variations of this criteria document are being used.

The current version of the Technical Specifications was recently amended to include mechanical snubbers in the surveillance requirements.

3.2.6 NRC Draft Regulatory Guide SC-708-4

This draft regulatory guide provides one phase of a program intended to ensure proper performance of hydraulic and mechanical snubbers used for the restraint of fluid systems and components important to safety. The draft proposes construction and test methods which would be acceptable to the NRC staff for

design qualification and acceptance testing of snubbers. The proposed methods are intended to satisfy the requirement of 10 CFR Part 50, Appendix A, General Design Criteria 1 and 2.

The draft document contains the following three appendices:

Appendix A: Contents of a Functional Specification for Snubbers used in
Systems Important to Safety

Appendix B: Qualification of Functional Parameters for Snubbers used in
Systems Important to Safety

Appendix C: Acceptance Testing Criteria for Snubbers used in Systems
Important to Safety

The functional specification defines parameters and general performance requirements that provide the basis for qualification and acceptance tests. In particular, application, design, and operational requirements; functional parameters; special material, installation, maintenance and inspection requirements; and other requirements are addressed.

The qualification testing requirements are intended to demonstrate the capacity of particular snubber designs to satisfy all specified functional requirements except the ultimate load capability for which an analysis may be used instead of testing. As a minimum, the qualification plan required by the document should contain information regarding: snubber descriptions and

specifications; snubber sampling, material data, mounting, aging simulation, and service condition simulation requirements; functional parameters and environmental variables to be measured; test and monitoring equipment requirements; test sequence; special tests; limits or failure definition for the test and ultimate load capacity.

Acceptance testing requirements are intended to provide guidance for demonstrating the adequacy of fabrication in light of functional requirements for the acceptance of snubbers from the production line. The required production acceptance plan should contain information regarding: snubber descriptions and specifications, manufacturing data, test mounting requirements, functional parameters to be measured, test and monitoring equipment requirements, test sequence and limits or failure definition for the test.

3.2.7 NRC Standard Review Plan NUREG-0800

Section 3.9.3 of the SRP defines the scope of the SAR reviews necessary to confirm compliance with the requirements of the ASME B&PVC Section III, Division 1 and General Design Criteria 1, 2, 4, 14, and 15 of 10 CFR 50, Appendix A. The section states that "Although classified as component standard supports, snubbers require special consideration due to their unique function."

Requirements for snubber operability assurance are defined in Section 3.9.3.II, Acceptance Criteria. Specific requirements relate to structural analysis and systems evaluation, characterization of mechanical properties,

design specifications, installation and operability verification, use of additional snubbers, installation and testing, and classification and identification.

Additional requirements to assure operability in addition to those specified by the ASME B&PVC for structural integrity are defined in Section 2.2 of Appendix A of Section 3.9.3. Specifically, where mechanical and hydraulic snubbers are to be installed on safety-related systems, their need shall be clearly established and their design criteria presented for NRC staff review.

3.2.8 DOE Draft Limited Consensus Standard LCS NE E 7-9T

This draft standard covers the material, design, analysis, application, fabrication, testing, examination, quality assurance, certification, delivery, installation and in-service inspection of safety-related hydraulic and mechanical snubbers.

Extensive requirements for the design and analysis, fabrication, quality assurance, installation and pre-service and in-service inspection are included in the standard. Additionally, design specification requirements and design and analysis guidelines are addressed in two appendices.

This draft standard is extremely comprehensive and is similar in scope to that of the ASME Draft Document NF-3. Indeed, more than half of the contributors to this draft standard also contributed inputs to ASME NF-3.

3.3 Evaluation of Existing Snubber Criteria

A review of criteria statements in NRC originated or endorsed documents and other documents originating outside the NRC was performed to assess inconsistencies and omissions. Criteria statements in the latter category of documents are tabulated in Appendix C, Table of Industrial Snubber Criteria (ISC). Review comments are provided in the following categories:

Acceptance Tests - The ITT Grinnell spec. is the only ISC Document which states that drag loads should be part of the acceptance tests. The GE and NF-3 documents do not require drag loads to be measured during acceptance testing. The NRC position (Regulatory Guide SC-708-4) is that drag loads should be measured during acceptance testing.

Mandatory drag load tests provide additional assurance of snubber operability. A recent shipment of United States-built mechanical snubbers delivered to West Germany were defective yet satisfied activation requirements during acceptance tests. A drag load measurement would have identified these failures.

The need to measure activation level and release rate during acceptance testing is universally accepted.

Activation Level - There are inconsistencies in activation limits for hydraulic snubbers. Limits vary from 6 to 40 inches/minute. The activation limits for acceleration activated mechanical snubbers are less variable and

are generally set at 0.02 g. Activation level is accepted universally as an important functional parameter. Test and analysis substantiate this position.

Codes and Standards - Adoption of existing codes and standards for snubbers is common practice. Codes and standards are well researched for certain applications; however, most of these applications were not intended for snubbers. A study should be initiated to determine the impact of adopting existing codes and standards for snubber usage.

The ISC Documents reference codes and standards such as ASME, ANSI, and MIL-Spec requirements. The relevance of these selections is beyond the scope of this report.

Cleaning and Painting - The procedures defined in the ISC documents reference existing documents. Additional research beyond the scope of this report is required to evaluate the cleaning and painting specifications adopted by these references.

Drag Loads - The drag load criteria are important because they define a failed or inoperable snubber. Inconsistencies in existing requirements for restricted orifice hydraulic designs, acceleration activated mechanical and poppet valve hydraulic snubber designs are evident in the ISC documents.

Since drag is an important functional parameter, research should be performed to identify acceptance values to be used for (1) defining inoperable or failed snubbers, and (2) defining allowable values for thermal expansion stresses in piping.

The ISC documents list allowable values which range from 1% of rated load (or 5 pounds) to 2% of rated load (or 100 pounds).

End Connections - It is difficult to assess these requirements without regard to a specific application. Requirements reflect good design practice and should enhance snubber operability and provide a more reliable design.

Environment - It is difficult to evaluate specific environmental requirements since many of them are plant specific. The general criteria pertaining to abnormal transients and fatigue requirements cover a wide range of environmental conditions.

The need to identify environmental conditions that affect snubber operability or cause degradation is well established. Environmental conditions affecting snubbers in both passive and active modes should be considered.

Fabrication - The ISC documents contain a list of criteria related to snubber and snubber assembly fabrication. These criteria represent good design practices. Major inconsistencies or contradictions were not identified among these criteria.

Inspection and Examination - These criteria include a wide range of requirements. Criteria address both quality control inspection and inservice inspection requirements.

The influence of the NRC Technical Specification and the GE Purchase Specification on criteria listed in the ISC documents are addressed in the NRC Technical Specification and O&M-4 documents, the requirements will be discussed in Section 3.4.1.

Installation/Placement - The installation requirements contained in the ISC documents are based on common sense. When specific directives are given, differences or discrepancies often exist. For example, the ORNL Standard states that clamp location shall be ± 3 inches or one pipe diameter and the GE Purchase Specification states ± 6 inches or one diameter for clamp location. Justification for specific linear or angular dimensions should be provided.

Life/Fatigue - The criteria referenced in the ISC documents identify the importance of providing cyclic requirements for snubbers. The referenced documents vary in the number of required cycles (1,000 to 10,000 cycles). A larger variation is encountered if the NRC Regulatory Guide SC-708-4 is considered.

It is possible that the references are plant specific. Experience suggests that the required number of cycles are best guesses and justification cannot be provided.

Guidelines for specifying fatigue requirements should be provided in criteria documents. Reconciliation of differences on fatigue requirements should be made for qualification of snubbers when the snubbers are to have wide application.

Loads - The referenced criteria identify the loadings and load combinations to be considered for snubber design/selection. The ASME structural requirements are referenced in most cases. Loads resulting from normal and upset conditions are considered.

The functional properties of the snubber should also be considered such as load absorbing properties and activation characteristics. Additional consideration should be given to this section in the future.

Lost Motion - The allowable values identified in the ISC documents vary from ± 0.15 to ± 0.25 inches. Other documents not contained in the ISC documents list values up to ± 0.30 inches. Additional research is necessary to justify allowable values since lost motion has a significant effect on system response and impact loads.

Materials - Many criteria statements are identified in the ISC documents. ASME requirements are often cited for material guidance. Most criteria define common sense directives and conflicts between criteria documents do not exist. Research should be performed to assure existing requirements (documents) listed in the ISC documents do not create undesirable situations and perform their intended functions.

The requirements specified for hydraulic fluids (materials) are plant specific. Comments regarding hydraulic fluid requirements should be discussed in detail in criteria documents.

Performance Requirements - See Acceptance Tests

Placement - See Installation

Qualification Tests - Snubber qualification requirements listed in ISC documents state that activation level, release rate, drag loads, stiffness, and lost motion shall be considered. The documents listed have similar test requirements. The procedures for performing the tests often differ. For example, in one document, drag loads are to be measured at 3 inches/minute and in another they are to be measured at 5 inches/minute.

Obvious inconsistencies are noted in statements in the ISC documents on Qualification Tests. Some procedures are defined in more detail than others. Questions relating to qualification procedures will be addressed in the review of the NRC Regulatory Guide on Qualification and Acceptance Testing (SC-708-4).

Release Rate - Specific requirements for bleed rate should be verified. Bleed rate (release rate) requirements vary among listed criteria documents.

Stiffness - Stiffness requirements are plant specific. The reasons for existing differences in stiffness values cannot be explained with available information. Methods for evaluating dynamic stiffness values should be verified.

3.4 Criteria Justification

Future research to provide validation for existing snubber criteria is based upon needs identified in this report. Research requirements are established based upon the ability to (1) provide technical support for NRC originated criteria, (2) support O&M-4 endorsement, or (3) provide credibility for criteria having a significant impact on snubber usage.

The four NRC originated and endorsed documents specifically addressed in this report are identified in Section 3.2. Section 3.4.1 discusses research requirements to support the four documents.

Snubber research based on needs identified from criteria documents originating outside of the NRC, i.e. industry, will be discussed in Section 3.4.2. The required research is based on an overview of these snubber criteria and lack of justification for criteria having a significant impact on snubber usage.

3.4.1 NRC-Originated and Endorsed Criteria

Research requirements for providing credibility to NRC-originated or endorsed criteria are discussed in this section.

3.4.1.1 Snubber Malfunction Study

This task was identified to evaluate the adequacy of NRC Snubber Surveillance Requirements. A test program is proposed to 1) identify potential failure

modes of various snubber designs and 2) evaluate the adequacy of NRC Snubber Surveillance Requirements for identifying inoperative snubbers.

Snubbers are required to be operable to ensure the structural integrity of safety related systems. To provide assurance of snubber functional reliability, the NRC has issued Inspection and Surveillance (I/S) requirements in Inspection and Enforcement (IE) Bulletins and Technical Specifications to identify inoperable snubbers and provide a confidence level of approximately 95% that 90% to 100% of the snubbers in the plant will be operable within acceptable limits. The objectives of this test program are:

- 1) Ensure that current I/S procedures are sufficient to identify inoperable snubbers.
- 2) Identify inspection procedures for new snubber designs currently undergoing manufacturer qualification.
- 3) Provide recommended changes to current I/S requirements to ensure the adequacy of these procedures.

Current I/S requirements have evolved over a period of several years. Licensee Event Reports (LER's) have historically provided justification for changes or modifications to I/S requirements; consequently, the current procedures are generically biased toward acceleration activated mechanical snubbers and velocity activated poppet-valve type hydraulic snubbers. Manufacturer qualification of new snubber designs (restricted orifice hydraulic snubber and velocity activated mechanical snubber) and their availability in the near future have created concerns regarding the adequacy of current I/S

requirements to identify inoperable snubbers of the new designs. Plant safety will be compromised if I/S requirements are left to evolve when new snubber designs become available for use in new and existing facilities.

Concerns regarding the adequacy of current I/S requirements to identify inoperable snubbers of acceleration activated mechanical and velocity activated hydraulic designs are identified below. Current visual inspection requirements include 1) that there are no visual indications of damage, 2) attachments are secure, and 3) the snubber is not frozen up. Function test requirements include 1) verification of activation level, 2) verification of release rate, and 3) measurement of the force that initiates free movement. The I/S visual and functional requirements enable many snubber malfunctions and failures to be identified; however, they do not assure that all known failure modes will be detected.

Visual inspection requirements will not detect, for example, snubber malfunctions or failures such as:

- 1) Broken capstan spring.
- 2) Broken capstan spring tang.
- 3) Broken poppet-spring.
- 4) Air in system.

Visual inspection requirements may not detect:

- 1) A frozen poppet valve.

2) Loss of lubricant (mechanical snubber).

Functional test requirements as currently defined in NRC Technical Specifications may not detect:

- 1) Broken capstan spring.
- 2) Broken capstan spring tang.
- 3) Broken poppet-spring.

The adequacy of current I/S requirements to detect all possible failure modes is questionable; the utilization of new snubber designs will raise additional questions regarding the adequacy of these procedures. Therefore, it is essential that this test program be performed to identify potential failure modes not detectable under current I/S procedures.

3.4.1.2 Evaluation of Qualification Requirements

The object of this study is to determine if qualification procedures of NRC RG SC-708-4 are adequate to provide snubber reliability and to determine if current accelerated aging procedures, test requirements, and environmental testing procedures are sufficiently understood to assure reliability of safety related snubbers.

A test program is proposed to assess the effects of test sequence and aging times on snubber qualification parameters. Details of the program are discussed in Section D5 of Appendix D.

3.4.2 Industrial Snubber Criteria

A review of criteria statements in Appendix B indicated inconsistencies and questionable practices regarding snubber usage. The results of the review are discussed in this section.

3.4.2.1 Codes, Standards, and Specifications

The adoption of existing specifications and standards (cleaning/painting, materials, etc.) not specifically developed for snubbers is a questionable practice. A detailed review of these documents is required to evaluate omissions or potential problems arising from their use.

3.4.2.2 Activation Level

The large variation in acceptance values of activation level for hydraulic snubber (poppet valve design) should be investigated. Present values range from 6 to 40 inches/minute. Potential problems due to very low or very high values should be identified and assessed.

3.4.2.3 Drag Loads

Inconsistencies in allowable drag loads and methods for determining drag loads should be reviewed. The allowable drag load value is an important parameter because it is used to define an inoperable or failed snubber, the implications of which are far reaching.

The definition of drag for restricted (fixed) orifice hydraulic snubbers requires clarification with supportive data.

3.4.2.4 Environment

Inconsistencies in criteria statements regarding identification of environmental factors affecting snubber operability suggests research is needed in this area. Research is needed to (1) identify environmental factors affecting snubber degradation, and (2) establish the sequence for environmental testing and qualification.

3.4.2.5 Lost Motion

The limits for lost motion identified in the CSD* have a significant range of variability. Research is required to establish allowable values for lost motion and evaluate the influence of this parameter on snubber operability, i.e., impact loads and response.

3.4.2.6 Release Rate

Variations in allowable release rate values for hydraulic snubbers should be evaluated. Research should be performed to evaluate/establish acceptable limits for this parameter.

*Criteria Support Document

3.4.2.7 Installation/Application

Variations in application and installation practice are observed in the identified criteria. Displacement and angular tolerances differ among criteria documents. The significance of these differences should be evaluated.

A P P E N D I X A
S U R V E Y R E S U L T S

Energy Technology Engineering Center
Energy Systems Group
P.O. Box 1449
Canoga Park, CA 91304
(213) 341-1000

Operated for U.S. Department of Energy

Rockwell
International

Subject: Survey for Nuclear Regulatory Commission Program
on Application and Testing of Snubbers

Your aid is solicited in helping the Nuclear Regulatory Commission (NRC) develop a support document for a Regulatory Guide on the "Application and Testing of Snubbers." The Energy Technology Engineering Center (ETEC) is currently under contract with the NRC to assist with this task.

Aid can be provided by making available to ETEC your expertise in the design, qualification, analysis, application or testing of snubbers.

A brief description (Enclosure 1) of the ETEC program is enclosed. It would be appreciated if you would complete and return the enclosed survey questionnaire (Enclosure 2). Comments on items not covered in the questionnaire are welcomed. Your input or comments are considered essential to the success of this survey. The raw data will be used to identify generic issues. NRC will be provided only with summary data identifying these issues.

Your response to this request would be appreciated by June 25, 1980. Questions regarding this request should be addressed to Mr. A. T. Onesto, [(213) 341-1000, Ext. 6624] of ETEC.

Sincerely yours,

J. O. Bates, Program Manager
Energy Programs Office
Energy Technology Engineering Center

Enclosures
As noted

Enclosure 1 to Letter

Page 1

SNUBBER APPLICATION AND TEST REQUIREMENTS

ETEC is currently under contract to the Nuclear Regulatory Commission (NRC) to produce a background support document for a proposed NRC Regulatory Guide on "Assumptions and Criteria for Design, Application and Test Requirements of Snubber Applications."

The support document shall be based on: 1) a literature search to identify and collect various independently formulated snubber criteria in existence at this time; 2) screening of current design and test criteria to identify a preliminary consistent set of criteria; 3) validation of the preliminary criteria of 2) by test and/or analysis; and 4) modification of the criteria to provide a basis for the background document.

Comments are being solicited from interested individuals and organizations so the needs of both industry and the NRC will be addressed. Specific help is requested to:

- 1) identify existing criteria documentation,
- 2) identify criteria,
- 3) identify inconsistencies in existing criteria,
- 4) identify new criteria, and
- 5) identify unique problems associated with snubber testing, operation and/or inspection.

A brief explanation of these five items is provided.

Item 1 - Snubber criteria can be found in limited and national consensus Snubber Standards such as ASME (NF-3, OM-3), ANSI, RDT, etc., in Qualification Procedures used by snubber manufacturers; in nuclear facility design documents; and in other documents pertaining to the use of snubbers.

Your assistance is solicited in compiling, as complete as possible, the various sources of snubber criteria which are currently being used for qualification, testing, application or inspection of snubbers. Item 2 describes specific items that may be considered when identifying criteria documents.

Enclosure 1 to Letter

Page 2

Item 2 - Current snubber criteria can generally be categorized under one of the following titles:

- a) Snubber Application Criteria
- b) Snubber Design Criteria
- c) Snubber Analysis Criteria
- d) Snubber Inservice Inspection Criteria
- e) Snubber Qualification Criteria

Specific criteria to be addressed for each category may include the following as a minimum.

I. SNUBBER APPLICATION CRITERIA

- A. Snubber Support Backup Stiffness
- B. Support-Structure Interactions
- C. Snubber Redundancy
- D. Multiple Snubber Usage
- E. Size Limitations
- F. Snubber Placement Design Guide
- G. Orientation

II. SNUBBER DESIGN CRITERIA

- A. Response Parameter Limits (Single or Multiple Snubbers)
- B. Failure Mode Requirements
- C. End Fitting Flexibility and Clearances
- D. Proposed Parameter Limits

III. SNUBBER ANALYSIS CRITERIA

- A. Simplified Analysis Assumptions and Requirements
- B. Detail Analysis Assumptions and Procedures Including Definition of Parameters Used and Needed
- C. Structural Modeling Techniques and Requirements
 - 1) Linear
 - 2) Nonlinear
- D. Faulted Analysis Requirements (Inelastic Analysis)
- E. Boundary Definition for Analysis

Enclosure 1 to Letter

Page 3

IV. SNUBBER IN-SERVICE CRITERIA, INSPECTION AND TESTING

- A. Inspection Requirements
- B. Identification of the parameters that measure or provide an index of Snubber Degradation with respect to safe service life
 - 1) Establish basis for bounding values of parameters
 - 2) Define acceptance range for in-service inspection and testing parameters
- C. In-Service Inspection Requirements
- D. Field Verification Inspection Requirements and Tests

V. SNUBBER QUALIFICATION CRITERIA

- A. Background Information for Regulatory Guide

Item 3 - Conflicts and inconsistencies among various existing criteria are to be identified and their resolution attempted as part of this program.

Item 4 - Your aid is requested in identifying criteria which you consider necessary but are not addressed in current literature. Identification of new criteria and providing the justification are essential elements of this program.

Item 5 - Additional criteria or modifications of current criteria are to be identified. Such criteria or modifications may be modified by examining unusual occurrence reports associated with snubber applications or tests.

Examples of snubber criteria which have been identified in existing snubber documents (standards, design specifications, etc.) include:

- 1) ... drag loads shall be limited to less than 2% of their rated capacity ...
- 2) ... if two or more snubbers are used at the same location (and same direction), means for simultaneous activation shall be provided ...
- 3) ... the snubber shall be modeled as a linear spring ...
- 4) ... snubber backup support stiffness shall be greater than 20,000 lb/inch ...
- 5) ... snubber lost motion shall be less than .06 inch for frequencies between 3 and 33 Hz ...

Enclosure 1 to Letter

Page 4

- 6) ... during qualification a snubber shall be subjected to 5,000,000 cycles of activation at 10% of the rated snubber load ...

Documents that contain requirements as indicated above should be listed as snubber criteria documents. These requirements as well as others identified will be studied to determine their validity. Data relating to the validation of the criteria will become part of the background support document.

In order to assist with this survey your cooperation in answering the enclosed questionnaire (Enclosure 2) will be appreciated. The return address is provided at the end of the survey.

SAMPLE

Enclosure 2 to Letter

Page 1

SURVEY FOR NRC PROGRAM ON
"APPLICATION AND TESTING OF SNUBBERS"

1. NAME OF PERSON FILLING OUT QUESTIONNAIRE: _____

2. COMPANY: _____

3. ASSOCIATION WITH SNUBBERS:

☐ SNUBBER MANUFACTURER/DESIGNER☐ TESTING/QUALIFICATION☐ FACILITY DESIGN (APPLICATIONS)☐ ANALYSIS☐ INSERVICE TEST/INSPECTION

4. TYPES OF SNUBBERS USED:

TYPE (MECH., HYD.) MANUFACTURER MODEL NUMBERS

5. LIST THE TYPES OF SNUBBER MALFUNCTIONS OR FAILURES WITH WHICH YOU ARE FAMILIAR AND WHICH HAVE OCCURRED DURING THE LAST THREE YEARS.

Enclosure 2 to Letter

Page 2

6. IDENTIFY SNUBBER CRITERIA USED IN SNUBBER APPLICATION, INSPECTION AND QUALIFICATION (STANDARDS, DESIGN SPECS., ASME/ANSI CODES, OTHER).

7. IDENTIFY EXISTING SNUBBER CRITERIA THAT SHOULD BE MODIFIED OR ELIMINATED.

SEE ITEM 2 OF PROGRAM DISCUSSION FOR GUIDANCE ON QUESTIONS 8 THROUGH 12.

8. ITEMS YOU WOULD LIKE TO SEE ADDRESSED UNDER APPLICATIONS CRITERIA (E.G., SIZE LIMITATIONS, PLACEMENT, ORIENTATION, ETC.)

9. ITEMS YOU WOULD LIKE TO SEE ADDRESSED UNDER DESIGN CRITERIA (E.G., ALLOWABLE CLEARANCE, HARDWARE FLEXIBILITY, ACTIVATION LEVEL LIMITS, ETC.)

Enclosure 2 to Letter

Page 3

10. ITEMS YOU WOULD LIKE TO SEE ADDRESSED UNDER ANALYSIS CRITERIA (E.G., STIFFNESS REQUIREMENTS, LINEAR MODELS, BOUNDARY DEFINITIONS, ETC.)

Handwritten scribble consisting of several intersecting lines.

11. ITEMS YOU WOULD LIKE TO SEE ADDRESSED UNDER ACCEPTANCE/QUALIFICATION CRITERIA (E.G., TEST SEQUENCE, QUALIFICATION PARAMETER RANGES, ETC.)

Handwritten scribble consisting of several intersecting lines.

12. ITEMS YOU WOULD LIKE TO SEE ADDRESSED UNDER INSERVICE TEST/INSPECTION CRITERIA (E.G., INSPECTION REQUIREMENTS, MALFUNCTION REQUIREMENTS, ETC.)

Handwritten scribble consisting of several intersecting lines.

13. LIST STRONG POINTS OF SNUBBER DESIGNS WITH WHICH YOU ARE FAMILIAR. LIST MODEL, TYPE AND MANUFACTURER (E.G., VELOCITY ACTIVATED, MECHANICAL, XXYY CO. ... DOES NOT HAVE FLUID OR SEAL LEAKAGE PROBLEMS)

Handwritten scribble consisting of several intersecting lines.

Enclosure 2 to Letter

Page 4

14. LIST WEAK POINTS OF SNUBBER DESIGNS WITH WHICH YOU ARE FAMILIAR. LIST MODEL, TYPE, AND MANUFACTURER (E.G., VELOCITY ACTIVATED, MECHANICAL, XXYY CO. ... HAS COMPLEX INTERNAL MECHANISM WHICH IS SUSCEPTIBLE TO FAILURE)

15. USE THIS SPACE FOR ADDITIONAL COMMENTS:

SEND SURVEY REPLY TO:

ENERGY TECHNOLOGY ENGINEERING CENTER
P. O. Box 1449
Canoga Park, California 91304
Attn.: Armand T. Onesto (720/211 T211)

Internal Letter

Rockwell International

Date: . August 1, 1980

No: . 80-211-19-193

TO: (Name, Organization, Internal Address)

. A. T. Onesto
 . ETEC
 . 720-211 T211

FROM: (Name, Organization, Internal Address, Phone)

. D. A. Larson
 . ETEC
 . 720-211 T211
 . 6682

Subject: . Results of the Survey for NRC Program on Application and Testing of Snubbers

Reference: 80ETEC-DFF-1800, Bates to Brunet, "Survey for Nuclear Regulatory Commission Program on Application and Testing of Snubbers, "dated May 1, 1980

Attached are the results of the survey for the NRC program on the application and testing of snubbers. These results are based on the responses to the questionnaire enclosed in the referenced letter which was sent to various snubber manufacturers, nuclear power generating stations, laboratories, A/E's, reactor manufacturers and other suppliers of nuclear components. A total of 61 questionnaires were sent out in two different mailings with a response of 44% for the first mailing, 33% for the second mailing and 39% for the combined mailing.

The results of this survey indicate that numerous problems still exist in the design, application and testing of snubbers and re-emphasizes the need for a guide on "Application and Testing of Snubbers" which would be useful to create uniformity throughout the nuclear power industry. Much of the data collected in this survey may be useful in establishing the requirements for this guide.

D. A. Larson

D. A. Larson
 Process Engineer

/me

cc: W/O attachments

L. J. Auge
 J. O. Bates
 W. P. Chen
 B. B. Gillies B.B.G./JOC

Attachment to: 80-211-19-193

1. and 2. NAME OF PERSON AND COMPANY FILLING OUT QUESTIONNAIRE:

- 1) Harold R. Erikson
Bergen-Paterson Pipesupport Corporation
- 2) Frank L. Bernhard
E-Systems, Inc., Montek Division
- 3) D. P. Brown
ITT Grinnell Corp., Pipe Hanger Division
- 4) John E. Kirby
Arizona Public Service Co.
- 5) G. G. Whitney
Boston Edison Co. (Pilgrim)
- 6) John R. Davis
Carolina Power & Light Co. (Brunswick)
- 7) Raymond Smith
Jersey Central Power & Light Co. (Oyster Creek)
- 8) David Ross
Maine Yankee Atomic Power Co.
- 9) Lynn F. Dunton and C. R. Noyes
Nebraska Public Power District (Cooper)
- 10) Ray Palmieri
Northeast Nuclear Energy Co.
- 11) Oliver N. Iverson
Northern States Power Co. (Montecello)
- 12) T. E. Amundson
Northern States Power Co. (Prairie Island)
- 13) Rodger J. Wehage and Jay C. Perry
Portland General Electric Co. (Trojan)
- 14) David C. Hofley
Tennessee Valley Authority
- 15) C. W. Fay
Wisconsin Electric Power Co.
- 16) A. J. Stevens
Babcock & Wilcox, Nuclear Power Generation Division
- 17) D. A. Peck
Combustion Engineering, Inc., C-E Power Systems
- 18) R. T. Hope and J. M. Triompo
EDS Nuclear, Inc.

1. and 2. NAME OF PERSON AND COMPANY FILLING OUT QUESTIONNAIRE: (continued)

- 19) Michael D. Potter
General Electric Co., Nuclear Energy Group
- 20) Frederick W. Gettler
Gibbs & Hill, Inc.
- 21) L. P. Pollono
Westinghouse Electric Corp., Advanced Nuclear Systems Divisions
- 22) C. Roderick
Westinghouse Electric Corp., Advanced Nuclear Systems Divisions
- 23) E. J. Renkey, Jr.
Westinghouse Electric Corp., Hanford Engineering Development Laboratory
- 24) L. K. Severud and M. J. Anderson
Westinghouse Electric Corp., Hanford Engineering Development Laboratory

3. ASSOCIATION WITH SNUBBERS:

- 3 PERSONS WERE ASSOCIATED WITH SNUBBER MANUFACTURER/DESIGNER
- 10 PERSONS WERE ASSOCIATED WITH TESTING/QUALIFICATION
- 11 PERSONS WERE ASSOCIATED WITH FACILITY DESIGN (APPLICATIONS)
- 7 PERSONS WERE ASSOCIATED WITH ANALYSIS
- 17 PERSONS WERE ASSOCIATED WITH INSERVICE TEST/INSPECTION

4. TYPES OF SNUBBERS USED

<u>Type</u>	<u>Manufacturer</u>	<u>Model Number</u>
Hydraulic	Basic Engineers	BE410 & BE411
Hydraulic	Bergen-Paterson	HSSA-3 thru 50 2500 Series Special Design to 2000 Kips HSMR Series 251 & 252 Series
Hydraulic	ITT- Grinnell	Fig. C200 & C201 Special Design Bore 10" thru 20"
Hydraulic	Anchor-Holth	6 Kips to 90 Kips
Hydraulic	McDowell-Wellman Eng. Co.	900 Kips
Hydraulic	Paul-Munroe	PMH-2200 & 2300
Hydraulic	E-Systems	SSA-0015 (1.5 Kips) thru SSA-100 (100 Kips)
Mechanical	Pacific Scientific	PSA 1/4 thru PSA 100
Mechanical	International Nuclear Safeguards	MSVA 1 thru 5
Mechanical	Bergen-Paterson	2700 & 2540 series

5. TYPES OF SNUBBER MALFUNCTIONS OR FAILURES WHICH HAVE OCCURRED DURING THE LAST THREE YEARS

A. Hydraulic Snubber Malfunctions or Failures

- 1) Oil leakage caused by:
 - a) Degradation of molythane, polyurethane and viton seals. (Replace with ethylene-propylene seals has solved this problem).
 - b) Improper seal installation
 - c) Seals being damaged by paint splatter
 - d) Loose fittings
 - e) Scoring and pitting on piston rod and inner surface of cylinder.
 - f) Damage to piston rod by improper handling
 - g) Broken plastic reservoirs
- 2) Actuation and release rates out of acceptance range
- 3) Jammed and distorted parts
- 4) Foreign matter in snubber fluid
- 5) Structural failure due to clamp rotation
- 6) Corrosion of accumulator spring
- 7) Grease being pumped thru the alemite fitting
- 8) Spring wrapping around poppet valve causing it not to close

B. Mechanical Snubber Malfunctions or Failures

- 1) Lock-up caused by:
 - a) Corrosion
 - b) Low amplitude vibration wear
 - c) Installation damage (Rods twisted & weld damage)
 - d) Overload
 - e) Lubricant breakdown
 - f) Misassembled capstan spring
- 2) Structural (Torque transfer drum cracked)

6. SNUBBER CRITERIA USED IN SNUBBER APPLICATION, INSPECTION AND QUALIFICATION

- 1) ASME B&PV Code, Section III, Subsection NF - Component Supports
- 2) ASME B&PV Code, Section XI - Rules for Inservice Inspection of Nuclear Power Plant Components
- 3) ANSI B31.1 - Power Piping
- 4) MSS Standard SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture
- 5) MSS Standard SP-69 - Pipe Hangers and Supports - Selection and Application
- 6) ASME O&M Working Group on Mechanical Equipment Restraints (OM-3)
- 7) ASME O&M Working Group on Examination and Performance Testing of Nuclear Power Plant Dynamic Restraints (Snubbers) (OM-4) Draft
- 8) Manufactures Technical Manuals and Bulletins
- 9) Customer Procurement Specifications
- 10) Plant Technical Specifications
- 11) NRC Model Tech. Specifications

7. EXISTING SNUBBER CRITERIA THAT SHOULD BE MODIFIED OR ELIMINATED.

- 1) A better definition for lock-up and bleed rate vs temperature (hydraulic snubbers)
- 2) Load ratings should be more clearly defined
- 3) Loading criteria time-frequency
- 4) A better definition for acceptable snubber performance (lock-up rate, bleed rate, and spring constant)
- 5) Existing standards are sufficiently comprehensive regarding snubber requirements
- 6) Qualification should include low level vibration testing over an extended time period
- 7) The drag force acceptance level should be established as the maximum of 2% rated load or 10 pounds
- 8) Support backup stiffness should not be included in snubber criteria
- 9) Need a national standard which is acceptable to both industry and the NRC which provides the requirements similar to those of a Customer Procurement Specification
- 10) Modify ASME Section III, Subsection NF to:
 - a) Provide inspection requirements
 - b) Provide stiffness requirements for snubber assemblies
 - c) Provide snubber-piping interaction criteria
- 11) The ASME PVP snubber criteria document PVP-45 should be modified to present more realistic and stringent criteria or be eliminated
- 12) Change inspection interval for hydraulic snubber to once a year instead of a decreasing interval based on failures
- 13) Consider using snubbers in pairs and of different lengths
- 14) Load rating reduction if snubbers do not align (larger than allowed angle) with directed thermal movement and loading.
- 15) Snubber manufacturer's production functional testing acceptance criteria should not be used as installed operability acceptance limits. Requirement to shut down the plant when a snubber is inoperable without regard to requirements for the operability of the system on which the snubber is installed should be eliminated. Requirements for inspection should be based on statistical basis rather than on quantities which have no relationship to the number of snubbers involved.

8. ITEMS THAT SHOULD BE ADDRESSED UNDER APPLICATIONS CRITERIA

1. General rule that the number of snubbers should be minimized (use rigid struts whenever possible)
2. Snubber sizing should consider pipe size regardless of predicted seismic load (e.g. small snubbers not to be used on large pipe)
3. Multiple snubber usage
4. Snubber redundancy
5. Treatment of snubbers, extensions, pipe clamps, and attachments as a complete system that has overall performance characteristics reflected in the procurement specification and the supported component analysis.
6. Criteria for snubber orientation-acceptable orientation deviation from the direction assumed in the piping analysis should be provided. Tolerance on location of attachments and on incidence angle
7. Address logical rigid strut and snubber placement review covering need for actuation displacement, applying restraints at effective mass points rather than at locations where they may act as fulcum points with increased loading effects on terminal connections.
8. Material combinations acceptability for various metals, gaskets, o-rings, and hydraulic fluids
9. A detailed discussion on pipe clamps should address thermal effects due to pipe clamp contact, loading snubbers clamps in a direction greater than the angle allowed, and loading the clamp somewhere other than the load bolt.
10. Placement, thermal movement, thermal movement rate, environment dynamic application (i.e. oscillatory or uni-directional loading), location.
11. Question use of snubbers on small (<3") pipe where the snubber friction load may be greater than the piping load. Also consider more effective means of securing snubber to pipes.
12. Alignment of snubber vs load capacity (due to field installation). Position snubber such that it is in mid-stroke in hot condition. The effect of extension struts on load capacity and stiffness. Sizing of a snubber for a known load. Overload capability.
13. It is important that some one organization, or group within the parent organization retain overall system design responsibility to assure that the total or net spring rate assumed in the analysis is actually provided by the design of the constituent pieces. Specify snubber stiffness in terms of $\pm$ load versus maximum total deflection to define the minimum effective spring rate used in seismic analyses. This results in a higher actual spring rate of the snubber after all clearances and deadband are traversed.

9. ITEMS THAT SHOULD BE ADDRESSED UNDER DESIGN CRITERIA

1. Lateral load capacity of the complete assembly, including extension, with simultaneous application of compressive loads.
2. Fatigue requirements to withstand normal pipe vibrations and vibrations induced during transient plant operation such as associated with load changes.
3. Establish the acceptable range for activation and bleed rates for normal application condition. (Make it as large as possible).
4. Snubber lost motion should include clearances in pin fit-up at pipe end and structural attachments in addition to internal lost motion.
5. Stiffness should be identical in both tension and compression.
6. Definitive statement of lost motion and faulted load as applied to snubbers.
7. Environment, dynamic application, activation level load rating corrosion resistance, orientation sensitivity, rotation of end attachments, stroke length, number of thermal cycles, size range, temperature (min/max continuous and brief transients), lateral load capability, stiffness, pin to pin length, code compliance, drag force limits and free motion.
8. Design for in-place verification of functionability.
9. Spring rates with tolerance specified.
10. Snubber support back-up stiffness criteria should be provided. Support steel for snubbers must be designed with consideration for side loads from unexpected events such as water hammer.
11. Specify failure mode requirements.
12. Clearly visible fluid level indication.
13. Allowable clearance after installation.
14. Gages, scales or other direct indicating means provided for establishing snubber extension amount for cold position determination.
15. Damping, freeplay and spring rates, both static and dynamic values are important considerations. Note that freeplay, damping and spring rates are frequency dependent.
16. Response characteristics (allowable load vs frequency).
17. Specify the desired performance in terms of cyclic loading at the natural frequency of the supported component. Snubber must allow thermal movement within a short time (such as 1-2 minutes) after cessation of the vibratory loading.

9. ITEMS THAT SHOULD BE ADDRESSED UNDER DESIGN CRITERIA (continued)

18. Stiffness values at various positions of the snubber at OBE and SSE loads (Taken from actual test conditions)

10. ITEMS THAT SHOULD BE ADDRESSED UNDER ANALYSIS CRITERIA

1. Requirement that the system analysis snubber model be realistic. Snubbers should not be assumed to be activated until the imposed velocity or acceleration at each snubber reaches the maximum allowed activation level. The maximum allowed dead band and the total system spring rate, variable with frequency if appropriate, should be simulated.
2. The characteristics of the complete pipe support system must be included in the seismic analysis. This includes clamps, snubbers, clevis assemblies, and civil support structure. For both linear and non-linear analyses, parametric studies may be required to envelop all known variables.
3. At locations where snubbers are required, the stiffness of the snubber assembly should be input data for the pipe stress analysis. Also included should be lost movement, friction, lockup rate and creep rate, etc.
4. Structural attachment stiffness requirements and guidelines for the relationship to system frequency.
5. Effective damping of snubbers
6. Snubber size selection is normally based on the maximum accumulation of a number of shock loading conditions. The actual loading the snubber would normally be subjected to is about 1/3 that of rated load. This point should be considered in establishing the method for determination of snubber spring constant.
7. Guideline should be given for snubber stiffness, and suspension boundary definitions. Unless this program is prepared to give methods of modeling snubbers that are proven by testing of piping and comparisons with predicted analytical results, modeling technique should not be required.
8. Simple linear model that correlates well with testing.
9. Simplified analysis requirements (lower bounds), modeling rules linear/non-linear. Faulted performance requirements.
10. The use of real loads and not hypothetical ones with many accumulated conservatisms.
11. Code definition of boundaries (building/support boundary) should be better defined.
12. The linear approximations currently used for snubbers in seismic analyses are reasonable and consistent with the conservative definition of the seismic event required for plant design.

11. ITEMS THAT SHOULD BE ADDRESSED UNDER ACCEPTANCE/QUALIFICATION CRITERIA

1. Snubbers should be tested statically and dynamically by external loading only with no modification to the snubbers allowed such as pre-activation.
2. Requirement that stiffness be met at each specified test frequency instead of averaging the results of two frequencies.
3. Fatigue testing should be part of qualification testing.
4. Snubbers should be qualified to withstand the normal vibration environment to which they will be subjected over the plant operating lifetime such as low amplitude vibration usually induced by pumps or other mechanical devices and flow induced vibrations.
5. Qualification program should demonstrate that the snubber proposed for the application is capable of withstanding the maximum tensile and compressive loads without permanent damage, and will subsequently allow normal thermal expansion/contraction motion.
6. Testing in horizontal mode to evaluate 1 G side load affect. Testing to cover minimum pin to pin and maximum pin to pin. Sequence (1) ambient for drag, activation, displacement vs time at rated load. (2) Operating temperature for drag, activation, displacement vs time. (3) Local environment with functional test for operability only.
7. At least one complete snubber assembly should be tested dynamically at the specified cyclic frequency to demonstrate the required effective spring rate in terms of total deflection under load reversal. This need not be performed at rated load, since this is a performance test, not a proof test.
8. For hydraulic snubbers with adjustable valves, each and every valve should be tested to the equivalent of the cyclic loading case, and also tested for nonclosure at the equivalent of the slow thermal expansion rate.
9. The design criteria should be tested under this subsection. The test sequences should be left to the individual.
10. Development of a statistical data base verifying snubber operability which in turn would relax field testing of snubbers.
11. Acceptance test should verify that each snubber meets specification requirements.

12. Qualification Testing

Dynamic performance
Load carrying ability
Activation level
Bleed Rate (if applicable)
Drag Force
Abnormal environment

Acceptance Testing

Load testing
Activation level
Bleed rate (if applicable)

11. ITEMS THAT SHOULD BE ADDRESSED UNDER ACCEPTANCE/QUALIFICATION
CRITERIA (continued)

13. Limiting acceleration verified in such a manner that the actual value for each individual snubber can be determined.
14. Test parameters for acceptance max/min for (A) in-situ (B) shop testing in field.
15. Definition of input motions, time duration, etc. of testing conditions. Load-controlled and/or displacement-controlled testing. Testing of snubber itself or include typical clamp, pipe and support structure.

12. ITEMS THAT SHOULD BE ADDRESSED UNDER INSERVICE TEST/INSPECTION CRITERIA

1. This entire subject needs to be expanded upon and clarified in the ASME Code, Section XI. Presently, the Code seems totally inadequate on this matter.
2. The requirements of the ASME Operation and Maintenance Committee Working Group on Mechanical Equipment Restraints (Snubbers) Inspection of Nuclear Power Plant Dynamic Restraints Standard, OM-3, should be used for Inservice Testing/Inspection Criteria.
3. All important parameters such as dead band, friction, activation level, and release rate should be inservice tested 100% on all snubbers regardless of manufacturer's claims. A reduction or elimination of inservice testing of any single parameter should only be allowed after repeated successful testing of that parameter on each model.
4. Functional parameters test on a sample basis. Recommendation that a formal log be established and maintained which would record all functional and setting data for the as installed condition for all units and same data recorded each time a particular unit is subjected to inspection.
5. The variable inspection frequency for visual inspection should be changed to once a refueling cycle. The variable frequency is linked to problems with the millable polyurethane seals and these seals, for the most part, have been replaced in the industry.
6.

<u>Examination</u>	<u>Testing</u>
Hands on check of fitting tightness	Activation Level
Reservoir fluid level and leakage	Load Carrying Ability
Check for structural damage	Bleed Rate (if applicable)
Check for correlation with applications	
Drawing	
Check for position settings	
Check for visible signs of impaired operability	
7. A definition of "Operability" for both mechanical and hydraulic snubbers. Requirements for the condition of the snubber that are to be tested.
8. Failure analysis permitted to determine extension of testing. Categorization of snubbers into inspection groups based on design features. Reduced inspection lot sizes based on satisfactory results. Inoperable snubber require system on which it is installed to be declared inoperable and operating restrictions be based on the inoperable systems.

12. ITEMS THAT SHOULD BE ADDRESSED UNDER INSERVICE TEST/INSPECTION
 CRITERIA (continued)

9. A simple inexpensive SISI procedure is needed to verify operability of snubbers. This should be a simple in situ test such as using a "fish scale" to verify that drag force has not excessively deteriorated. Inaccessible snubbers should be prequalified or checked with displacement transducers. Hydraulic snubbers will continue to need visual check on leakage.
10. Monitoring of snubber position in both cold and hot conditions. Periodic stroking of snubber through full range of travel.
11. Not applicable other than a comprehensive testing and inspection program which would provide a high degree of reliance in the snubber functioning properly.
12. Some consideration should be given to the type of snubber failure. For example, a lockup is more likely in a mechanical snubber and is likely to have detrimental stress implications. A well-trained utility maintenance force greatly reduces leakage, etc.
13. Some simple easy go/no go type of test.
14. Less frequent inspection just because of 1 or 2 failures. Once a year is enough.
15. Not necessary. The simple tests for functioning of bleed rate and lockup are adequate.

13. STRONG POINTS OF SNUBBER DESIGNS

A. Hydraulic Snubbers

1. Few moving parts for higher reliability
2. Less susceptible to installation damage
3. Less susceptible to corrosion
4. Less susceptible to vibration damage
5. Does not require lubrication
6. High load margin between rated load and actual failure load
7. Provisions for in-service in-place inspection
8. Fail safe (no lockup)
9. Velocity actuated
10. Adjustable lock-up and bleed rate
11. Some snubbers are not orientation limited
12. Some snubbers have a double ended piston rod which eliminates binding due to high side loads
13. Probably helps to damp out vibration better than mechanical snubbers
14. Maintains lock-up and bleed rate settings
15. Some snubbers have the same valve block used on all sizes.
(Ease of maintenance)
16. Will carry static as well as vibration loads
17. Some snubbers have fluid reservoir incorporated in the snubber body
18. Failure mode is loose of fluid which usually can be detected by visual observation.

B. Mechanical Snubbers

1. No fluid leakage problems
2. Rapid response
3. Low friction resistance developed during thermal displacement of piping
4. Less maintenance requirements (high reliability)

13. STRONG POINTS OF SNUBBER DESIGNS (continued)

5. Appear easy to test for functionability
6. Insensitive to radiation damage at levels of radiation of a CRBRP
7. Do not exhibit untoward ratchet characteristics
8. The breaking mechanism is relatively simple
9. Acceleration activated (there is a velocity activated mechanical snubber being tested by its developer)
10. Less bulky to install
11. Velocity limiting snubber provide restraining action throughout full cycle thereby increasing damping factor
12. Less susceptible to temperature effects and can operate at high temperature
13. Tamper proof activation level
14. No lock up (if not abused)
15. Direct reading extension scale

14. WEAK POINTS OF SHUBBER DESIGNS

A. Hydraulic

1. Subject to leakage in elevated temperature and high vibration application
2. Generally require periodic seal replacement
3. Some manufacturers use spherical bushings which require periodic relubrication
4. Seals wear out, fluid leaks, radiation effects to the fluid
5. Some snubbers are orientation sensitive
6. Some snubbers have plastic reservoirs which are susceptible to damage
7. Some snubbers have one common valve block for all sizes which results in varying performance (high lock-up velocity for smaller size snubbers and low lock-up velocity for larger size snubbers)
8. Some snubbers have adjustable tapered bleed orifices susceptible to temperature variations, external protrusions or plumbing susceptible to handling damage, face mounted control valves, open reservoirs, piston rods attached in close proximity to high temperature pipe dams resulting in excessive rod seal and fluid temperature.
9. On some snubbers the valve block assembly-poppet and spring are not interchangeable and the spring will jam against the poppet and will cause failure to lockup.
10. Difficulty in purging snubbers after rebuilding.
11. Low or no fatigue capacity
12. Improve ability to determine that adequate hydraulic fluid is present in the snubber

B. Mechanical

1. Most likely to fail in the locked up mode
2. Possible lack of capability in withstanding loads perpendicular to the axis of the snubber (slight binding of the unit may occur if a workman stands on it)
3. Very high gain mechanisms susceptible to jamming or mechanical tolerances
4. Small load capacity mechanical snubbers are easily damaged during installation due to improper handling

14. WEAK POINTS OF SNUBBER DESIGNS (continued)

5. Subject to fatigue failure
6. Appear to be somewhat sensitive to wear if subject to uncontrolled low amplitude vibration.
7. Generally have complex internal mechanisms which may be susceptible to failure due to the number of moving internals.
8. Provides very little if any component damping when activated and usually raises the natural frequency of the supported system.
9. Allows the supported system to displace more than hydraulic snubbers at lower frequencies, inversely proportional to frequency.
10. Low or no fatigue capacity
11. Poor L/D support for ball screw especially in the extended position.
12. May be difficult to test due to weight

15. ADDITIONAL COMMENTS:

1. ASME is developing a standard on snubber testing and surveillance. This standard should be issued and given a chance before additional or conflicting regulatory requirements are imposed.
2. Very little is done in the design stage to minimize the number of snubbers. Snubbers should be used only when no other type or types of restrains will meet the design requirements.
3. More attention should be given to reducing maintenance requirements and making the required maintenance easy to perform and as nearly mistake-proof as possible
4. Snubbers shall have large legible serial numbers on two or more sides.
5. Cylinder, rod and rings should be made of a harder material to reduce wear.
6. The seismic analysis of a piping system must address the dynamic characteristics of all supporting elements of which the snubber is only one part. Linear response spectra analyses still appear to be a reasonable cost effective conservative approach to the analysis problem. Non-linear time history analysis techniques can be utilized to remove conservatism but is generally not recommended particularly for small bore (<6-in. diameter) pipe because of cost and computer core size limits. Present data indicated normal static total freeplay up to 60 mils peak-to-peak is not particularly harmful. Large freeplay should be avoided.
7. Development of hydraulic fluids and seals resistant to radiation. Improve structural design of mechanical snubbers. Develop snubbers to accommodate long term low amplitude vibration when the amplitude is less than the snubber freeplay.

A P P E N D I X B

F O R E I G N T R I P R E P O R T

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Operated for U.S. Department
of Energy

Rockwell
International

October 19, 1981

81ETEC-DRF-4249

Mr. Dan Guzy
Mechanical/Structural Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Foreign Travel Trip Report of A. T. Onesto, August 1981

Reference: Snubber Application and Test Requirements - FIN #B3035

Dear Mr. Guzy:

The subject report on a trip to France and Germany in support of the referenced Snubber Program is enclosed.

Questions regarding this report may be addressed to me at (213) 700-5524.

Sincerely yours,

Armand T. Onesto
Senior Staff Engineer
Energy Programs
Energy Technology Engineering Center

Enclosure: as noted

cc w/encl: W. F. Anderson, NRC
D. D. Reiff, NRC
J. E. Richardson, NRC
J. K. Hartman, ETEC PO

FOREIGN TRAVEL TRIP REPORT OF A. T. ONESTO - AUGUST 1981

Energy Technology Engineering Center

INTRODUCTION

This trip report summarizes the activities, discussions and observations during visits in France and West Germany to a nuclear component test facility, two architectural engineering (A&E) companies and a licensing agency. Specific activities addressed in this report include:

- 1) Meeting at FRAMATOME (Paris, France)
- 2) Meeting at INTERATOM (Bergish-Gladbach, West Germany)
- 3) Meeting at KRAFTWERK UNION (Erlangen, West Germany)
- 4) Meeting at TUV* (München, West Germany)
- 5) Attendance at SMiRT Conference (Paris, France)

The trip was in support of snubber research performed by Mr. Onesto under contract to the Nuclear Regulatory Commission (NRC). Specific goals were:

- 1) Present a technical paper at the Structural Mechanics in Reactor Technology (SMiRT) Conference titled "Snubber Application and Test Research". Mr. D. Reiff of the NRC co-authored the paper with Onesto.
- 2) Publicize NRC snubber research programs with the intent of fostering information exchange programs with foreign agencies or companies.
- 3) Establish contacts with foreign nationals to discuss research that may benefit NRC programs.
- 4) Fulfill programmatic needs by providing a comprehensive snubber research program.

SUMMARY

During August, 1981, Armand T. Onesto of Energy Technology Engineering Center traveled to France and Germany to 1) present a technical paper at the SMiRT Conference and 2) discuss snubber research, testing and licensing requirements. The purpose of the trip was to support snubber research under contract to the NRC. Specific objectives were 1) publicize NRC snubber research programs with the intent of fostering information exchange programs, 2) establish contacts with foreign nationals to discuss research that may benefit NRC programs, and 3) fulfill programmatic needs by providing a comprehensive research program.

*Technischer Überwachungs - Verein Bayern e.V.

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Discussions were held at Framatome, Interatom, Kraftwerk Union and TUV. United States (US) research programs discussed during meetings with foreign nationals included:

NRC sponsored programs

- 1) Snubber Sensitivity Study
- 2) Single Versus Dual Snubber Installation
- 3) Snubber Application and Test

Department of Energy (DOE) sponsored programs

- 4) One Inch Protoypic Line Seismic Tests
- 5) Limited Concensus Standard (LCS) on Snubbers.

Discussions were limited to program objectives, application of results and future research. Results and data were not discussed nor were any materials, data or reports exchanged.

The results of discussions between the foreign nationals and Onesto are summarized herein. Details of individual visits, observations and evaluations are presented in the DISCUSSION. A list of names, addresses and organizations of individuals contacted are listed in APPENDIX A. The briefing charts for the SMiRT Conference presentation are contained in APPENDIX B. A list of reports discussed during visits with foreign nationals are presented in APPENDIX C.

Publicizing US research for the purpose of fostering information exchange was partially successful. The three German agencies were interested in obtaining the referenced US reports. Since information guidelines were not established for this trip, names of appropriate individuals in the NRC and DOE will be sent to KWU, Interatom and TUV to enable pursuit of these reports through official channels. Due to limited analytical and test experience, the Germans could not contribute significantly in the area of snubber research. Kraftwerk Union (KWU) has dynamic pipe test experience which may be of interest to other NRC research programs.

The Germans may have difficulty entering into new information exchange programs because of a joint venture with the French Government requiring three-party contractual agreements. The reluctance of the French to participate in exchange programs may preclude new exchange programs with the Germans.

The DOE does have, however, an existing exchange agreement with the Germans which may permit transfer of information. Exchange may be possible as a result of "Working Group III, Plant Systems and Components, Agreement of October 13, 1978", between the US, Germans and French (DOE/BMFT/CEA) which has an open item on

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information exchange dated 1 April 1979.

US structural and snubber design requirements are used in both France and Germany. American Society of Mechanical Engineers (ASME) and American National Standards Institute (ANSI) structural requirements are used extensively in Western Europe. {

Snubber design requirements have not been established by either the French nor the Germans. The French have adopted a modified version of the General Electric Purchase Specification 21A3502 for snubber design requirements.

Surveillance and inspection (S/I) requirements do not exist at this time. Installed snubbers have no mandatory requirements for inservice inspection. The French have a draft document in preparation on S/I requirements and the Germans will undertake this task in the near future.

Since seismic loads for the design of nuclear plants in Western Europe are less stringent than US seismic requirements, lack of snubber research by France and Germany is understandable. Although aircraft impact loads have been included, neither country is expected to spend money rivaling that spent on US research.

DISCUSSION

FRAMATOME is the A&E in charge of the design of all Pressurized Water Reactors (PWR) in France. FRAMATOME is a Westinghouse subsidiary designing power plants for Electricite de France (EdF). NOVATOME is FRAMATOME's counterpart for the breeder reactor program. NOVATOME is under the direction of Commissariat a l'Energie Atomique (CEA) to build nuclear power stations for EdF.

On 25 August 1981 a meeting was held at the FRAMATOME offices in Paris 1a Defense with Mr. Bernard Monnier to discuss seismic restraints and snubber research. Monnier is Chief Project Engineer, Primary Systems, 900 MWe Plants. Onesto outlined US snubber research sponsored by the NRC and DOE which included:

- 1) Snubber Sensitivity Study
- 2) Single Versus Dual Snubber Installation Test
- 3) One-inch Prototypic Pipe Test
- 4) DOE LCS on Snubbers

Monnier indicated that FRAMATOME used CEA laboratories for qualification and research testing. The CEA laboratories are also utilized by NOVATOME and WESTINGHOUSE for research testing.

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Snubber research is not a critical or major issue in France; therefore studies similar to the NRC and DOE research have not been performed. The French use a modified version of the General Electric Purchase Specification 21A3502 for snubber qualification. A copy of this document could not be obtained during the visit, since Monnier was reluctant to provide it.

Monnier indicated that the French policy is to use as few snubbers as possible to satisfy seismic and aircraft impact load requirements. FRAMATOME purchases snubbers from Pacific Scientific Company (PSCo) for limited applications. French snubber manufacturers include Messier, Vibrachoc and Quiri.

Although Monnier was cordial and willing to discuss his personal experience with snubbers, he was reluctant to discuss research and test programs originating from CEA or other sources.

A visit to NOVATOME did not materialize as expected due to the unavailability of key personnel.

INTERATOM (Internationale Atomreaktorbau GMBH) is primarily an engineering company involved in the field of advanced systems engineering and power technology. It develops new systems from basic concept to the commercial application stage. Plant components are tested in large scale company facilities. INTERATOM has the responsibility for the development and construction of power systems which have not yet been introduced commercially.

On 27 August 1981 a meeting was held with Messrs. Adami (Manager System Planning), Schmitz (Manager Piping Analyses), Faust (Program Management), Meek and Damm (Test Facility Managers) at INTERATOM to discuss seismic restraint qualification and inspection requirements and nuclear test programs. Adami chaired the meeting and hosted Onesto during his stay at the facility.

Adami stated that the Germans would like to participate in information exchange programs but are not able to do so as a result of a joint venture with the French requiring three party agreements. The problem is the French reluctance to participate in such programs.

Onesto outlined snubber research efforts in the US sponsored by the NRC and the DOE. INTERATOM was very much interested in the results of these programs because of problems identified during construction of the Schnell-Brüter-Kernkraftwerksgesellschaft (SBK) nuclear power station in Kalkar. Two problems requiring immediate solution in this plant are:

- 1) How can snubber reaction loads be reduced to lower dynamic piping stresses?
- 2) How many overload cycles can a PSCo snubber take before failure occurs?

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Adami was informed that the results of US research could provide insights to the solution of the first problem, and that Mr. Glauser of PSCo could provide information regarding the second problem.

Since information exchange guidelines were not established for the visit, Onesto agreed to send names and addresses of cognizant individuals in appropriate organizations (NRC and DOE). Adami could then request this data through official procedures. Adami will contact Glauser directly since the SBK power station uses PSCo snubbers.

Snubber functional and design requirements have not been established for the SBK power station. The seismic restraints for piping and components provided by PSCo are employed on the assumption that if they are acceptable for US plants they will be acceptable for the SBK facility.

Seismic restraint structural requirements are provided by ASME and ANSI Codes. The Germans have not formulated their own requirements but have adopted US codes and standards.

The Germans do not have surveillance or inspection requirements for installed snubbers. The licensing agency TUV is formulating draft surveillance and inspection requirements which may become mandatory at a future date.

Analytical procedures utilized by the Germans are similar to US techniques. Many of the computer codes used in Germany are the same used in the US such as, SAP IV, PIPESD and ANSYS. Snubbers are modeled as linear springs for dynamic analysis and nonlinear properties are not considered for seismic restraint design.

A tour of the INTERATOM test facilities followed the morning discussion. The tour included a sodium pump test facility, small sodium component test loop, breeder reactor handling mechanism test facility and the materials research laboratory to witness dynamic testing.

Current test programs at INTERATOM include: flow induced vibration of core components, sodium thermal striation measurements, identification of in-vessel handling tolerances, gas cooled reactor testing, development of a device to eliminate trapped gas bubbles in sodium, sodium-water reaction research, and functional testing of sodium components.

Additional information regarding test programs and facility capabilities can be obtained from Onesto.

KRAFTWERK UNION (KWU) is a subsidiary of Siemens AG, and, is the largest manufacturer of power stations in Germany. KWU's primary function is the design and construction of conventional nuclear power stations, whereas INTERATOM, which

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is owned by KWU, supports design and construction of breeder plants.

On 31 August 1981 a meeting was held at KWU in Erlangen, West Germany, with Dr. Hans Buerhop to discuss seismic restraints and research testing. Buerhop is the responsible engineer for the piping design group.

Onesto outlined US snubber research efforts sponsored by the NRC and the DOE. Buerhop was interested, since KWU to date has performed only functional testing of snubbers. Since information exchange guidelines were not established for the visit a list of names of appropriate individuals in the NRC and DOE will be forwarded to Buerhop to request the desired data through official procedures.

KWU has extensive experience with nonlinear analysis of snubber-supported systems. However, testing experience is limited. ANSYS, PIPESD, MARC and KWU-PIPE (KWU developed) computer codes are used to analyze piping systems and components. Piping design and analysis methods are similar to US methods, and structural requirements (ASME and ANSI) are the same.

Buerhop indicated that KWU has received a large number of inoperative US-built mechanical snubbers, apparently a result of inadequate Quality Assurance procedures. KWU is upset with the additional costs required to correct the problem. The lack of S/I requirements suggests that there are installed inoperative snubbers yet to be identified. Although draft S/I requirements are in preparation mandatory requirements are not expected in the near future.

The Lisega hydraulic snubber presently is favored by KWU. However, until the design has been proven the snubber will have limited application.

After the morning discussion a tour of the engineering and design departments was made. The KWU facility at Erlangen is staffed with 25,000 employees and covers many acres. The engineering department has access to Control Data Corporation (CDC) computers owned by KWU and located on the premises. Batch and timesharing computing options and plotting facilities are used for piping design work.

TUV (TECHNISCHER ÜBERWACHUNGS-VEREIN BAYERN e.v.) is the licensing authority in Germany. The German nation is divided into 11 Lander (states), each having its own licensing agency (TUV). Each licensing agency is responsible for establishing minimum safety requirements for its own state. Consequently safety requirements vary throughout Germany.

TUV performs tests to verify minimum safety requirements and awards a seal of compliance when requirements are met. A seal of compliance is required by law. The agency is responsible for the safety of everything from automobiles

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to snubbers. TUV evaluates reactor safety and makes licensing recommendations to the Federal German authority.

On 2 September 1981 a meeting was held in the TUV office in München, West Germany. Alfred Nagel, manager of the technical safety division and components testing department, was there to discuss snubber tests and licensing requirements.

Nagel discussed test methodology and acceptance requirements for snubbers and hangers used in nuclear stations. TUV works closely with KRAFTWERK UNION, a major nuclear plant builder, in establishing the final safety requirements. Consequently the final requirements are generally acceptable to both parties.

Snubber acceptance is based primarily on:

- 1) the activation level exceeding rate of movement of piping,
- 2) activation occurring at 1 Hz input, and
- 3) fatigue requirements (1,500,000 cycles).

The only environmental acceptance requirement is compliance with items 1 and 2 above at elevated temperature (800°C and 1500°C).

The tests are performed to measure drag loads and activation levels. Activation level is measured by loading the snubber with a constant displacement and increasing frequency input. Velocity activation is measured by using specified velocity inputs and noting at which velocity activation occurs.

Nagel indicated that S/I requirements are to be formulated by TUV and the draft document is only in the planning stage. Following the discussion on US S/I requirements, Nagel requested a copy of the NRC Technical Specification on S/I of snubbers to use for guidance on their draft document.

Onesto outlined snubber research efforts sponsored by the NRC and DOE. Nagel was interested in the 1" Prototypic Pipe Test performed at ETEC for the DOE and requested a copy. Since information exchange guidelines were not established for the visit Onesto agreed to forward the request to the DOE.

A tour of the TUV test laboratory performing hanger and snubber tests followed the afternoon discussion. The laboratory was equipped with MTS (dynamic) and hydraulic static load machines. There was a notable absence of sophisticated test and recording equipment. Constant effort hanger tests to measure load tolerances were witnessed.

The Structural Mechanics in Reactor Technology (SMiRT) Conference was held in Paris at the Palais des Congre's during the week of 17 August 1981. The con-

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ference covered all aspects of engineering mechanics as applied to mechanical and structural components and the relevant systems in nuclear fission or fusion reactors.

The papers presented at the conference included theoretical developments of mechanics applicable to reactor technology and/or application of these theories. Discussions of load conditions, behavior of materials, interactions with fluid mechanics, accident sequences and calculation procedures were included in the agenda.

A paper titled "Snubber Application and Test Research" co-authored by D. Reiff of the NRC was presented by Onesto. APPENDIX B contains the presentation briefing charts.

APPENDIX AFRAMATOME

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APPENDIX A (continued)

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Manager Technical Safety Divisions and Component Test Department.

APPENDIX B

SMiRT Conference Technical Presentation

SMIRT-6 TECHNICAL CONFERENCE
SNUBBER APPLICATION AND TEST RESEARCH

BY
ARMAND T. ONESTO

ENERGY TECHNOLOGY ENGINEERING CENTER
ROCKWELL INTERNATIONAL

AND

DAVID D. REIFF

OFFICE OF NUCLEAR REGULATORY RESEARCH
U.S. NUCLEAR REGULATORY COMMISSION

AUGUST 21, 1981

Rockwell International
Energy Systems Group

NO. ETEC-TDR-82-2 REV.
PAGE 80 OF 237
DATE May 2, 1983
REV. DATE

SMIRT-6 TECHNICAL CONFERENCE

- NRC SNUBBER RESEARCH PROGRAM
 - SNUBBER SENSITIVITY STUDY
 - MULTIPLE SNUBBER TEST
 - SNUBBER APPLICATION AND TEST
- RESEARCH RESULTS
 - ALLOWABLE PARAMETER RANGES
 - MISMATCH AND LOAD SHARING
 - VALIDATION OF CRITERIA
- APPLICATION
 - DESIGN TOOL
 - NRC LICENSING
 - UNIFORMITY DESIGN/ANALYSIS
- FUTURE RESEARCH

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81JY16-82-1

SMIRT-6 TECHNICAL CONFERENCE

- **SNUBBER SENSITIVITY STUDY**
 - IDENTIFY PERFORMANCE PARAMETERS
 - EVALUATE RESPONSE SENSITIVITY
 - DEVELOP SIMPLIFIED DESIGN/ANALYSIS GUIDELINES
- **PERFORMANCE PARAMETERS**
 - ACTIVATION LEVEL
 - RELEASE RATE
 - LOST MOTION
 - STIFFNESS
 - FRICTION
- **TYPICAL STUDIES**

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81-JY16-82-2

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SMIRT-6 TECHNICAL CONFERENCE TYPICAL STUDY (SENSITIVITY STUDY)

SMIRT-6 TECHNICAL CONFERENCE **TYPICAL STUDY (SENSITIVITY STUDY)**

Rockwell International
 Energy Systems Group

81-JY16-82-4

NO. ETEC-TDR-82-2 REV.
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SMIRT-6 TECHNICAL CONFERENCE

• ALLOWABLE AND DESIRABLE SNUBBER RESPONSE PARAMETER RANGES

PARAMETER	TYPE	ALLOWABLE RANGE	DESIRABLE RANGE
ACTIVATION LEVEL	H	<40 in./min IF $\dot{X}_B > 5$ in./min <50 in./min IF $\dot{X}_B < 5$ in./min	LOW AS POSSIBLE, BUT GREAT ENOUGH TO PRECLUDE LOCK-UP DURING THERMAL EXPANSION
	M	<0.02g	
RELEASE RATE ($\dot{X}_B$)	H	$<0.50 \times \left(\frac{\text{RATED LOAD}}{\text{COMPONENT WT}} \right)$ in./min	5 → 30 in./min
	M	SEE ACTIVATION LEVEL	SEE ACTIVATION LEVEL
CLEARANCE	B	<0.05 in.	0
FRICTION	B	<40% RATED LOAD	AS LARGE AS POSSIBLE BUT SMALL ENOUGH TO MAINTAIN THERMAL STRESSES WITHIN ACCEPTABLE LIMITS
STIFFNESS	B	$> \frac{20}{\alpha - 20\alpha_H}$	$\geq \frac{20}{\alpha - 20\alpha_H}$

NOTES:

H = HYDRAULIC (VELOCITY ACTIVATED, POPPET TYPE)

M = MECHANICAL (ACCELERATION ACTIVATED)

B = BOTH

 α = FLEXIBILITY OF PIPE AT SNUBBER LOCATION (in./lb) α_H = COMBINED FLEXIBILITY OF ALL HARDWARE BETWEEN THE CENTER OF THE COMPONENT AND "GROUND" (in./lb) Rockwell International
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SMIRT-6 TECHNICAL CONFERENCE

- MULTIPLE SNUBBER SUPPORTS (TEST)
 - LARGE SNUBBER REPLACED BY TWO SMALLER SNUBBERS
 - LOAD SHARING OF SNUBBER PAIR
 - ▲ ACTIVATION LEVEL
 - ▲ RELEASE RATE
 - ▲ END FITTING CLEARANCE
- TEST SETUP

Rockwell International
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SMIRT-6 TECHNICAL CONFERENCE

• TEST SETUP

ATTACHMENT LOCATION X: (X)

SMIRT-6 TECHNICAL CONFERENCE TEST RESULTS

SMIRT-6 TECHNICAL CONFERENCE

- SUMMARY

- UNIFORM LOAD SHARING

- ▲ END FITTING CLEARANCE DIFFERENTIAL < 0.01 in. (0.004 cm)
- ▲ ACTIVATION LEVEL BETWEEN 8 AND 25 in./min (20 AND 63 cm/min)
- ▲ RELEASE RATE BETWEEN 4 AND 15 in./min (10 AND 38 cm/min)

- LOAD SHARING SENSITIVITY

- ▲ END FITTING CLEARANCE
- ▲ RELEASE RATE
- ▲ ACTIVATION LEVEL
- ▲ 30 TO 70% WHEN ENDFITTING CLEARANCE IS 0.05 in. (0.02 cm)

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SMIRT-6 TECHNICAL CONFERENCE

- SNUBBER APPLICATION AND TEST PROGRAM
 - DEVELOP BACKGROUND SUPPORT DOCUMENT
- IDENTIFY CRITERIA
 - DESIGN
 - ANALYSIS
 - APPLICATION
 - TEST
 - INSPECTION
- VERIFY CRITERIA
 - ANALYSIS
 - TEST
- MODIFY/SUPPLEMENT/DELETE CRITERIA

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Energy Systems Group

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SMIRT-6 TECHNICAL CONFERENCE

- MAJOR STUDIES

- SNUBBER MALFUNCTION STUDY
- EFFECTS OF DRAG LOAD ON PIPING STRESSES
- SNUBBER SENSITIVITY STUDY
- EVALUATION OF QUALIFICATION TEST REQUIREMENTS
- MULTIPLE LOCATIONS FOR LONGITUDINAL/AXIAL RESTRAINTS
- EVALUATION OF RESPONSE PARAMETERS FOR PIPE WHIP RESTRAINTS

Rockwell International
Energy Systems Group

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SMIRT-6 TECHNICAL CONFERENCE

- APPLICATION
 - OPERABILITY ASSURANCE OF SNUBBERS
 - SUPPORT NRC LICENSING
 - ENCOURAGE UNIFORMITY IN DESIGN/ANALYSIS

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APPENDIX C

Reference Reports

- 1) ETEC-TDR-80-16, A. T. Onesto, "Snubber Sensitivity Study Final Report, FY1979", November 26, 1980.
- 2) ETEC-TDR-80-12, A. T. Onesto, "Single vs Dual Snubber Installations", July 31, 1980.
- 3) ETEC-TDR-79-10, J. D. Stearns, A. T. Onesto, R. G. Hunter, "Dynamic Testing of a Prototypical FFTF Piping Systems), September 28, 1979.

A P P E N D I X C

I N D U S T R I A L S N U B B E R C R I T E R I A

This appendix presents the vast amount of data available in documents used by industry to date in a manner which enables review to: 1) determine inconsistencies, 2) identify strengths or weaknesses and omissions, and 3) define required research to establish criterion credibility.

The format selected for the presentation of the criteria permits separation into categories and the incorporation of additional criteria identified in the future. Additionally, provisions are provided to furnish information regarding the relative significance of and reference document for each criterion.

Categories of Criteria Identified are:

Acceptance Tests

Activation Level

Analysis

Assembly

Codes & Standards

Cleaning & Painting

Drag Loads

End Connections

Environment

Fabrication

Inspection & Examination

Installation

Life

Loads

Lost Motion
Materials
Performance Requirements
Performance Tests
Placement
Qualification Tests
Release Rate
Stiffness
Snubber Design
Snubber Combinations
Storage & Handling

Levels defined are A, B, and C. Level A statements are very general and do not give specific directions regarding snubber usage. Level B statements are similar to Level A statements but contain directives that may impact snubber usage. Level C statements have direct impact on snubber usage and require validation.

References identified to date are:

G. E. Purchase Specification Number 21A3502, Pipe Suspension, Rev. 2,
Dec. 29, 1976

C. F. Braun Specification Number DC400-20, Design Certification, Pipe
Snubbers & Struts , October 22, 1977

ASME B&PVC Draft Document NF-3: Snubber Criteria, July 11, 1979

ITT Grinnell Product Specification PHD-7556-7S, ITT Grinnell Fig. 670,
Hydraulic Shock Suppressor, Rev. 2, August 5, 1980

DOE Draft Limited Consensus Standard Covering Mechanical and Hydraulic
Snubbers, NE E 7-9T, Feb. 28, 1983

If the paragraph notation is not part of the criterion statement, the
paragraph number is listed with the document reference.

TABLE OF INDUSTRIAL SNUBBER CRITERIA

1

Level	Document	Statement	Comments
CRITERION CATEGORY: ACCEPTANCE TESTS			
-	GE 21A3502 Rev. 2	5.2 <u>Performance Test for Equipment</u> 5.2.1 The Seller shall prepare and submit for Buyer's approval the procedure for the applicable test listed below:	
B	GE 21A3502 Rev. 2	5.2.1.1 <u>Hydraulic Snubbers</u> . Each hydraulic snubber purchased under this specification shall be tested for lockup rate and bleed rate in accordance with para. 4.3.4.4.2.c at room temperature.	
C	GE 21A3502 Rev. 2	5.2.1.2 <u>Mechanical Snubbers</u> . Each mechanical snubber purchased under this specification shall be tested for acceleration lockup rate in accordance with para. 4.3.4.4.3.a at room temperature.	
C	GE 21A3502 Rev. 2	5.2.1.3 <u>Hydraulic and Mechanical Snubbers</u> . Each snubber purchased under this specification shall be tested for friction in accordance with para. 4.3.4.4.1.f.	
B	ASME NF-3 Rev. 11	2.4.2 Performance testing shall be performed on each unit to verify the following: a) Full stroke and freedom of motion. b) Velocity or acceleration activation level, as applicable. c) Release rate based on design or operating condition load after activation, if applicable. d) Fluid pressure integrity, as applicable.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: ACCEPTANCE TESTS			
B	ITT Grinnell PHD-7556-7S Rev. 2	5.3 <u>Production Testing</u> (For details, see ITT Grinnell procedure PHD-7556-12.) a) Fully stroke units 10 times for wear-in. b) Measure breakaway and drag force. c) Measure control velocity. d) Fully load to ASME level D in both directions.	
B	NE E 7-9	2.7.2 <u>Acceptance Test</u> . Every snubber shall be subjected to a final functional test at the end of assembly. Acceptance tests are to be conducted at ambient conditions as the vendor's facility.	
B	NE E 7-9	Appendix C to Draft Regulatory Guide SC-708-4 shall be used as a guide for the development of the acceptance test and documentation required.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: ACTIVATION LEVEL			
C	GE 21A3502 Rev. 2	4.3.4.4.2 <u>Hydraulic Snubbers</u> . Hydraulic snubbers for resistance to dynamic loads shall include the following feature(s): a) The snubber valve unit shall remain open at a rod end velocity of 5 in./minute and smaller. The unit shall lock up at a rod end velocity between 6 and 20 in./minute. If the hydraulic snubber has a flow orifice instead of a poppet valve, then the unit shall resist motion with a force that is a function of the rod end velocity.	
B	GE 21A3502 Rev. 2 4.3.4.4.2	c) The lockup rate (lockup rate defined as the pipe velocity that causes the snubber to lock) shall be set and recorded for each snubber. The proper setting of adjustments screws shall be marked on valves, and means shall be provided to prevent tampering in the field. Lockup rate information for each snubber shall be provided to Buyer as part of the permanent records.	
C	GE 21A3502 Rev. 2	4.3.4.4.3 <u>Mechanical Snubbers</u> . Mechanical snubbers for resistance to dynamic loads shall include the following feature(s): a) The snubber shall limit acceleration of the pipe to a maximum of 0.02 g when subjected to any load up to the rated load. This requirement shall be met in both tension and compression.	
A	ASME NF-3 Rev. 11	2.3.4 <u>Activation Level</u> . The activation level as defined in 2.1.3 should be greater than thermal growth rate of the piping or component margin of safety and adequate to limit abnormal movement.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: ACTIVATION LEVEL			
C	ITT Grinnel PHD-7554-7S Rev. 2	4.4 Velocity limiting control valve: Lower Limit: 8 in./min at 70°F Upper Limit: 15 in./min at 70°F 20 in./min at 250°F from 25% to 100% of Level A design loads (see Figure C).	
C	NE E 7-9	3.2.1.b The activation level of an acceleration sensitive snubber shall not exceed 0.020 g.	
C	NE E 7-9	3.2.1.b The activation level of a velocity sensitive snubber shall not exceed 40 in./minute.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: ANALYSIS			
A	ASME NF-3 Rev. 11	4.2.4 <u>Other Considerations.</u> a) Whenever a snubber assembly is attached to a component, the additional load caused by the weight of the snubber assembly should be considered during the deadweight analysis of the component. In addition, consideration should be given to the conductive, convective, and radiation heat transfer from the component to the snubber.	
A	ASME NF-3 Rev. 11 4.2.4	b) Adequate margin against buckling collapse of the entire snubber assembly due to all combined axial and lateral loads, particularly while the snubber is in the restraint mode, should be considered.	
B	NE E 7-9	3.2.1 <u>Allowable Parameter Ranges.</u> The allowable parameter ranges established for the hydraulic and mechanical snubber characterizations parameters are based on the following criteria. 1. The response sensitivity to the parameters is in a stable range and the response is therefore predictable and repeatable. 2. The response at the snubber resulting from seismic excitation will be less than 0.10 in. 3. Impact loads and displacements can be bounded with reasonable assurance that predicted values will not be exceeded.	
B	NE E 7-9	The parameter limits established herein may be exceeded if it can be demonstrated analytically or by test that system response can be maintained within acceptable limits. The parameter limits shall be met if a linear spring representation of the snubber is to be assumed.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: ANALYSIS			
B	NE E 7-9	3.2.2.a <u>Structural Representation of Snubber Assembly</u> . The snubber characteristics shall be based on pin-to-pin properties. This includes extension tube flexibility and vibratory properties, end fitting clearances and flexibilities, and snubber characteristics. The snubber assembly shall be presented as a linear spring with a stiffness value equal to the frequency independent stiffness.	
B	NE E 7-9	3.2.2.b <u>Snubber Mass Properties</u> . The weight of that portion of the snubber assembly whose motion is dependent on the movement of the supported component shall be added to the mass of that component for the purpose of dynamic analysis. The mass of the snubber assembly whose movement is independent of component motion shall be considered as part of the support weight. A detailed dynamic structural model of the snubber assembly can be used in lieu of distributing snubber mass.	
C	NE E 7-9	3.2.2.c <u>Snubber Damping</u> . Snubber damping properties may affect overall system damping for seismic excitations. The inclusion of snubber damping properties in the overall system damping must be justified. Regulatory Guide 1.61 shall apply.	
C	NE E 7-9	3.2.2.d <u>Snubber Friction</u> . Frictional forces have negligible effects on the dynamic response of the system provided they are less than 40% of the snubber reaction forces.	
B	NE E 7-9	3.2.3 <u>Analysis Procedure</u> . The following analysis procedures are available for analyzing systems or components utilizing snubbers. <ol style="list-style-type: none">1. Time-history analysis (nonlinear).2. Time-history analysis (linear).3. Response spectrum analysis (linear).4. Static inertia analysis (nonlinear/linear).	

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Level	Document	Statement	Comments
CRITERION CATEGORY: ASSEMBLY			
B	CF Braun 400-20 Rev. 3	<p>5.4 Assembly. Components parts shall be assembled in accordance with a detailed assembly procedure prepared by the Seller and approved by the Engineer. To check fit-up and completeness, each assembly shall be assembled completely in the shop. The snubber assembly check shall be done for both the snubber unit and the surrogates, except when snubber units are to be held for fabrication and shipment at a later date. All assemblies may be partially disassembled where distated by shipping and packaging requirements. The procedure shall demonstrate that all components are included and fit properly, and that the assemblies fit as specified. The procedure shall also provide a method whereby components of the assembly shall have only the minimum of disassembly consistent with reasonable shipping requirements, and shall remain related to the particular assembly through shipment and installation. The procedure shall contain as a minimum:</p> <ul style="list-style-type: none">a) Assembly sequence.b) Cleaning procedures, sequence, and precautionary rules.c) Any special machining or fitting-at-assembly instructions.d) Intermediate and final inspection criteria and hold points.e) Tightening torques for threaded parts.f) Procedures for actuating or removing locking devices.g) Drawings or photographs as required to illustrate assembly techniques.h) Special data, measurements, or observations to be recorded in quality control records.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CODES AND STANDARDS			
B	GE 21A3502 Rev. 2	<p>2.2 <u>Codes and Standards</u></p> <p>2.2.1 All equipment furnished in accordance with this specification shall be manufactured and tested in accordance with the following codes and standards, and addenda of the issue in effect on the date of award of contract.</p> <p>a) American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code</p> <p>(1) ASME Section III, Nuclear Power Plant Components, Subsection NF</p> <p>(2) ASME Section IX, Welding Qualifications</p> <p>b) Steel Structures Painting Council (SSPC) Standards</p> <p>(1) SP-10-63T, No. 10, Near-White Blast Cleaning</p>	
B	GE 21A3502 Rev. 2	<p>4.1 <u>Codes</u></p> <p>4.1.1 The design and fabrication of all parts furnished in accordance with this specification shall satisfy the requirements for Class 1 components as set forth in the latest edition of Section III, Subsection NF of the ASME Boiler and Pressure Vessel Code, and mandatory addenda in effect on the date of contract award. Adoption of any later code issue, or addenda, shall be subject to the Buyer's approval.</p>	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CODES AND STANDARDS			
B	GE 21A3502 Rev. 2	<p>4.1.2 Where the requirements of this specification are more stringent than the requirements of the codes specified herein, this specification shall govern.</p> <p>4.1.3 The use of code cases is prohibited, unless prior Buyer approval is obtained.</p>	
B	CF Braun 400-20 Rev. 3	<p>3.0 <u>Codes and Standards</u>. All components furnished in accordance with this specification shall be designed, manufactured, examined, and tested in accordance with the following codes and standards. The effective ASME Codes and ANSI B31.1 Code shall be the latest edition and/or addenda in effect at the time of contract award. All other applicable documents shall be the latest edition, addenda, or revision in effect on date of invitation to bid. Any later issue, addenda, or case rulings shall not be used without prior Engineer approval.</p>	
B	CF Braun 400-20 Rev. 3	<p>3.1 <u>American Society of Mechanical Engineers (ASME)</u></p> <p>ASME Section II, Material Specifications</p> <p>ASME Section III, Nuclear Power Plant Components</p> <p>ASME Section V, Nondestructive Examination</p> <p>ASME Section IX, Welding and Brazing Qualifications</p> <p>ASME Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Division I</p> <p>Code Case 1644, Additional Materials for Component Supports and Alternate Design Requirements for Bolted Joints, Section III, Division I, Subsection NF, Class 1, 2, 3, and MC Construction</p>	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CODES AND STANDARDS			
B	CF Braun 400-20 Rev. 3	3.2 <u>American National Standards Institute (ANSI)</u> ANSI B.31.1, Power Piping ANSI N45.2.2, Packaging, Shipping, Receiving, Storage, and Handling of Items for Nuclear Power Plants	
B	CF Braun 400-20 REV. 3	3.3 <u>Manufacturer's Standardization Society (MSS)</u> MSS SP-58, Pipe Hangers and Supports, Materials and Design MSS SP-69, Pipe Hangers and Supports, Selection and Application	
B	CF Braun 400-20 Rev. 3	3.4 <u>American Society for Testing and Materials (ASTM)</u> A123, Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, and Strip A153, Zinc Coating (Hot Dip) on Iron and Steel Hardware	
B	CF Braun 400-20 Rev. 3	3.5 <u>Federal Specifications</u> Federal Specification 00-Z-325B, Zinc Coating, Electro-deposited	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CODES AND STANDARDS			
B	CF Braun 400-20 Rev. 3	<p>4.0 <u>Requirements</u></p> <p>4.1 <u>Code</u>. The design and fabrication of all Quality Group A, B, or C components furnished in accordance with this specification shall satisfy the requirements of ASME Section III, Subsection NF, Boiler and Pressure Vessel Code, Classes 1, 2, and 3, respectively. Alternate design requirements of Code Case 1644 may be used provided that the use is clearly described by the Seller and is approved by the Engineer. Quality Group D components shall satisfy the requirements of ANSI B31.1 Power Piping.</p>	
A	NE E 7-9	2.7.1 Appendix B to Draft Regulatory Guide SC-708-4 shall be used as a guide for the development of the qualification test plan and documentation required.	
A	NE E 7-9	2.7.2 Appendix C to Draft Regulatory Guide SC-708-4 shall be used as a guide for the development of the acceptance test plan and documentation required.	
B	NE E 7-9	4.4.2.c Degreasing shall be accomplished using technical-grade acetone, alcohol, TCTFE per MIL-C-81302b.	
B	NE E 7-9	4.5.2 <u>Steel Surface Painting</u> . Prior to application of a coating, the surface shall be prepared in accordance with SSPC Standard SP-10 to provide an anchor profile of 1 to 2 mils depth.	
B	NE E 7-9	6.1.1 Storage areas at the vendor's facility or at the construction site shall meet the requirements of ANSI N45.2-1972, Section 6.1.2, Level C, as a minimum.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CODES AND STANDARDS			
A	NE E 7-9	7.3.3 Procedures and Instructions. The ASME, "Examination and Performance Testing of Nuclear Power Plant Dynamic Restraints (Snubbers)," O&M-4, shall be used to develop procedures for in-service inspection and examination.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CLEANING AND PAINTING			
B	GE 21A3502 Rev. 2	<p><u>6.1 Cleaning and Painting</u></p> <p>6.1.1 All external carbon steel surfaces on all assemblies shall be cleaned <u>and</u> painted in accordance with the Buyer specification listed in Paragraph 2.1.3.a of this specification. Carbo-Weld II may be used in lieu of Carbo-Zinc II on surfaces to be welded. Threads and sliding surfaces shall not be painted, but shall be properly lubricated with a lubricant specified in Paragraphs 2.1.3.b and 2.1.3.c of this specification, or a Buyer-approved equivalent to those specified. The Buyer's prior approval is required for exempting other external carbon steel surfaces from painting.</p>	
B	CF Braun 400-20 Rev. 3	<p><u>7.0 Cleaning and Painting.</u> The fabrication of a part, combination of parts, subassembly, or complete snubber assembly shall be conducted to facilitate cleaning and inspection for cleanliness, and to minimize contamination during fabrication. Parts made of noncorrosion resistant materials shall be protected from atmospheric corrosion after cleaning. Surface preparation and priming shall be in accordance with the requirements of Specification 180.01. All snubbers and struts are classified as Area C, Group C, Subgroup C-1.a or C-2.a, as determined by surface temperature. As an alternate coating for components located in Areas 1 or 2, galvanizing in accordance with ASTM A123 and A153 may be used. External surfaces may be coated by electro depositing zinc in accordance with Federal Specification QQ-Z-325B, Type II.</p>	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CLEANING AND PAINTING			
B	NE E 7-9	4.4.2 <u>Mechanical Cleaning</u> . Mechanical cleaning tools such as grinding, polishing, filing, deburring, and brushing tools shall be clean and shall not have been used on aluminum, copper, lead or materials containing lead or lead compounds, or other low-melting point materials. One set of tools, not previously used on carbon or low alloy steels, shall be used on stainless steel only.	
B	NE E 7-9	4.4.2 Power-operated brushes shall not be used in cleaning areas that later will be liquid penetrant inspected unless that area is ground or machined prior to the inspection.	
B	NE E 7-9	4.4.2 <u>Abrasive Blasting</u> . Abrasive blasting shall be used only when approved by the Purchaser.	
B	NE E 7-9	4.4.2 <u>Degreasing Requirements</u> . Degreasing shall be accomplished using technical-grade acetone, alcohol, TCTFE per MIL-C-81302b.	
B	NE E 7-9	4.4.2 <u>Detergent Cleaning</u> . Stainless-steel surfaces containing no crevices and which are fully accessible and drainable may be cleaned with trisodium phosphate or other detergents approved by the Purchaser. Detergent cleaning of ferritic steels by usual commercial practices is allowed.	
B	NE E 7-9	4.4.2 <u>Acid Cleaning</u> . Acid cleaning shall be performed only with Purchaser approval of procedures and application prior to use.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: CLEANING AND PAINTING			
B	NE E 7-9	4.4.2 <u>Drying</u> . Drying, after completion of final cleaning, may be done by using still or forced, clean, dry, oil-free air or gas, in an oven, or by evacuation.	
B	NE E 7-9	4.5.1 <u>Surfaces To Be Coated, Vendor Procedure and Sketch</u> . Except for stainless steel members, all exposed parts except threaded, machined, and sliding surfaces shall be plated or painted to resist corrosion.	
B	NE E 7-9	4.5.2 <u>Steel Surface Painting</u> . Prior to application of a coating, the surface shall be prepared in accordance with SSPC Standard SP-10 to provide an anchor profile of 1 to 2 mils depth.	
B	NE E 7-9	4.5.2 The primer and top coats shall be epoxy polyamide or equivalent.	
B	NE E 7-9	4.5.2 On all steel parts which are to be welded during installation, the weld preparation and the area within two inches of the weld are to be prime-coated by the vendor with "Deoxaluminat" (made by Special Chemicals Corp., Ossining, N.Y.) or Purchaser-approved equal.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: DRAG LOADS			
C	GE 21A3502 Rev. 2 4.3.4.4.1	f) The snubber resistance to a normal movement shall be less than one percent (1%) of the rated load or 5 lb, whichever is greater. For a hydraulic snubber with a flow orifice instead of a poppet valve, the snubber resistance to a normal movement of 1.5 inches per minute shall be less than 2% of the rated load.	
C	ITT Grinnel PHD-7556-7S Rev. 2	4.5 Shock suppressor drag force will be the greater of 100 lb maximum or 2% of ASME Level A design loads for pipe thermal movement rates from 0-6 in./minute.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: END CONNECTIONS			
C	GE 21A3502 Rev. 2 4.3.4.4.1	b) Each end connection shall consist of spherical ball bushings permitting a minimum total of 10 degrees of angular rotation in any plane.	
B	NE E 7-9	2.3 The Design Specification shall define the jurisdictional boundaries of the component support.	
B	NE E 7-9	2.3 The snubber shall be attached to the building structure by some type of structural attachment and at the component by a pipe clamp or other special component attachment.	
B	NE E 7-9	2.3 The welds or bolts attaching the structural attachments to the building structure shall meet the requirements of Subsection NF of the ASME Code.	
B	NE E 7-9	2.3 Concrete expansion anchor bolts shall meet the requirements of ACI-349 - Appendix B.	
B	NE E 7-9	2.3 The building structure or steel shall be defined as non-ASME Code when the predominant load of the supporting steel is not due to component support loads. This shall be determined when 30% or less of the load acting on the structure is due to supporting a component or when the effect of stiffness does affect the component analysis, and, in addition, the structural steel is not being used as a stiffness type of support.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: END CONNECTIONS			
B	NE E 7-9	2.3 For component support attachments to the components, nonintegral attachments of the jurisdiction boundary between the component and the support shall be the interface surface.	
B	NE E 7-9	2.3 When the snubber line of action is not normal to the pipe centerline, trunnion attachments, integral attachments, or shear lugs adjacent to the clamp shall be installed on the pipe or component.	
B	NE E 7-9	2.3 The end connector shall be installed so that the spherical bushing of the snubber (when so equipped) is positioned in the same plane of action. The pins in each bushing should be parallel to each other and be perpendicular to the line of greatest movement.	

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CRITERION CATEGORY: ENVIRONMENT			
B	GE 21A3502 Rev. 2	4.3.1.2.1 Design Environment: a) Temperature: 70°F (prior to initial startup) 150°F (continuous operation) b) Relative Humidity: 40 to 55% (during normal operation) 90% (during shutdown) c) Radiation: 415 rads/hour (1.5×10^7 rads in 5 years)	
B	GE 21A3502 Rev. 2	4.3.2.2 <u>Environment</u> . The environment for normal and upset conditions are the same as for the design conditions.	
B	GE 21A3502 Rev. 2	4.3.3.2 <u>Environment</u> . The environment for the emergency and faulted conditions shall be as specified in Paragraph 4.3.3.2.1, abnormal environment transient. The equipment specified shall be capable of withstanding at least one occurrence of the abnormal environment without loss of operability.	
B	GE 21A3502 Rev. 2	4.3.3.2.1 <u>Abnormal environment transient</u> . Beginning with the normal environmental conditions stated in Paragraph 4.3.1.2.2, there will be a shift to the initial (Phase 1) transient condition, decaying progressively through the phases outlined as follows:	

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CRITERION CATEGORY: ENVIRONMENT			
B	GE 21A3502 Rev. 2	4.3.3.2.1 (Continued)	
		a) Phase 1 b) Phase 2 c) Phase 3	
		Temperature 340F 320F 250F	
		Pressure -2 to 45 psig -2 to 45 psig 0 to 20 psig	
		Relative Humidity all steam all steam 100%	
		Duration (1) 3 hours (1) 6 hours (1) 1 day (1)	
		(1) Durations shown are termination times measured from the initiation of the postulated accident; i.e., the 6-hour duration, is the period from 3 hours through 6 hours. The 1-day duration is the period from 6 hours through 1 day (24 hours).	
B	CF Braun 400-20 Rev. 3	4.3.3 <u>Environment</u> . The ambient conditions will vary for each particular area in the plant. Physical boundaries with corresponding normal ambient operating conditions and abnormal ambient conditions are specified below. The environmental area for each assembly is specified on the Pipe Support Assembly drawings.	
B	CF Braun 400-20 Rev. 3	4.3.3.1 <u>Area Definitions</u> . Area 1 is defined as inside the drywell. Area 2 is that area between the primary containment and the drywell. Area 3 is all areas outside the primary containment, including all support buildings.	

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CRITERION CATEGORY: ENVIRONMENT			
B	CF Braun 400-20 Rev. 3	<p>4.3.3.2 <u>Normal Ambient</u>. Normal continuous ambient operating conditions are as follows:</p> <p>a) Area 1</p> <p>(1) Temperature 40F, 185F maximum</p> <p>(2) Relative humidity 40 to 55% normal, 90% maximum</p> <p>(3) Static pressure (-) 0.5 to (+) 2.0 psig</p> <p>b) Areas 2 and 3</p> <p>(1) Temperature 40F, 148F maximum</p> <p>(2) Relative humidity 40 to 55% normal, 98% maximum</p> <p>(3) Static pressure 0.0 in. to (-) 1.0 in. water gage</p>	
B	CF Braun 400-20 Rev. 3	<p>4.3.3.3 <u>Abnormal Ambient</u>. The normal ambient conditions are as follows. Durations shown are termination times measured from start of abnormal ambient conditions.</p> <p>a) Area 1</p> <p>(1) Phase 1 330F, (-) 2 to (+) 15 psig, all steam for 3 hours 330F, (+) 30 psig, all steam for 45 seconds</p> <p>(2) Phase 2 310F, (-) 2 to (+) 15 psig, all steam for 6 hours</p> <p>(3) Phase 3 250F, 0 to (+) 15 psig 100% relative humidity (RH) for 24 hours</p> <p>(4) Phase 4 250F to 100F, 0 to 15 psig 100% relative humidity (RH) for 100 days</p> <p>b) Area 2</p> <p>(1) Phase 1 330F, 0 to 15 psig, 100% RH for 3 hours</p> <p>(2) Phase 2 310F, 0 to 15 psig, 100% RH for 6 hours</p> <p>(3) Phase 3 185F to 100F, 0 to 15 psig, 100% RH for 100 days</p> <p>c) Area 3</p> <p>(1) Phase 1 325F to 212F, 2 psig, all steam for 2 hours</p> <p>(2) Phase 2 212F, 2 psig, all steam for 6 hours</p> <p>(3) Phase 3 150F, 0.5 psig, 90% RH for 100 days</p>	

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CRITERION CATEGORY: ENVIRONMENT			
B	CF Braun 400-20 Rev. 3	4.3.3.4 <u>Radiation</u> . During the maintenance life period of the assemblies each component will be exposed to the following radiation doses. Materials used for the components shall not have a loss of physical properties during maintenance life sufficient to result in malfunction or inadequate performance of the assembly.	
		<u>Maintenance Life</u>	<u>Design Requirements To Meet Maintenance Life</u>
	a) Area 1	40 years	Gamma 6.0×10^7 rads Fast neutron 6.5×10^{14} nvt
		5 years	Gamma 3.3×10^7 rads Fast neutron 8.0×10^{13} nvt
	b) Area 2	40 years	Gamma 4.0×10^7 rads
		5 years	Gamma 4.0×10^7 rads
	c) Area 3	40 years	Gamma 5.0×10^7 rads
		5 years	Gamma 6.0×10^7 rads

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CRITERION CATEGORY: ENVIRONMENT			
B	ITT Grinnell PHD-7556-7S Rev. 2	4.12 Designed for corrosion resistance inside and outside. Resistant to the following environmental conditions: a) Continuous exposure at 250°F at 40-90% relative humidity. b) Salt spray in accordance with Military Specification MIL-E-5272C Procedure 1. c) Sand and dust in accordance with Military Specification MIL-E-5272C Procedure 1.	
A	NE E 7-9	3.1.1 The ability of a snubber to function under anticipated environmental effects such as temperature, humidity, radiation, vibration or other, shall be considered.	
B	NE E 7-9	3.1.1 The ability of the snubber to function under repeated activations resulting from normal plant operations such as turbine trip, valve discharge, pump vibration, or other shall be demonstrated.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: FABRICATION			
B	GE 21A3502 Rev. 2	4.4 <u>Fabrication</u> 4.4.1 Welding of parts of the assemblies shall develop full strength of the connected parts and attachment of assemblies to building structures shall develop full strength of the assembly. The finished surfaces of the weld shall be free of undercut, slag and spatter.	
A	GE 21A3502 Rev. 2	4.4.2 Welding procedure qualification and welder performance qualification shall be in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.	
B	GE 21A3502 Rev. 2	4.4.3 Exposed sharp corners and edges shall be rounded or chamfered. 4.4.3.1 Clamps shall be designed to allow for the differential radial expansion of the pipe and clamp at the pipe operating temperature without exceeding the stress limit of the clamp.	
B	GE 12A3502 Rev. 2	4.4.3.2 Welded attachments or clamps with shear lugs shall be avoided if possible. Prior GE approval is required for the use of welded attachments or clamps.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: FABRICATION			
B	CF Braun 400-20 Rev. 3	<p>5.0 <u>Fabrication</u></p> <p>5.1 <u>Welding Procedures</u>. The Seller, and each of his subcontractors shall prepare written welding procedures. Each procedure must be prepared and qualified in accordance with the requirements of ASME Section III and Section IX, and this specification. The Seller shall submit the written welding procedures, including heat treatment, and qualification records for review and approval by the Engineer before fabrication begins. Procedures and procedure qualification test records shall be in the form of clear, sharp, reproducible prints similar to Forms QW-482 and QW-483 shown in the ASME Code Section IX. The finished surfaces of the weld shall be free of undercut, slag, and spatter. Fillet welds shall be of the specified size with full throat and legs of uniform size. Welding may be performed only by welders qualified to ASME Section IX. The Buyer may review and approve welder or welding operator qualification records prior to fabrication.</p>	
B	CF Braun 400-20 Rev. 3	<p>4.2 <u>Forming</u>. Cutting, bending, and forming procedures shall be in accordance with the applicable codes and standards. The Seller shall evaluate the need for stress relief heat treatment following bending or forming to ensure dimensional stability. Exposed sharp corners and edges shall be rounded or chamfered. Structural steel assemblies or frames that are not classified components standard supports shall satisfy the applicable code requirements.</p>	

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Level	Document	Statement	Comments
CRITERION CATEGORY: FABRICATION			
B	CF Braun 400-20 Rev. 3	5.3 <u>Repair of Weld Defects.</u> A weld is defective and shall be repaired if it does not meet the acceptance standards of each applicable nondestructive examination. The Seller shall submit the details of any repair and his proposed procedure and procedure qualification record to the Engineer for approval prior to carrying out any repair. A detailed written report of weld repairs shall state the nature and location of the defect, how repaired, subsequent heat treatment, and include copies of all examination records.	
A	NE E 7-9	4.3.5 All heating and cooling used during fabrication shall be in accordance with the Code.	
B	NE E 7-9	4.3.5 The minimum preheat temperature shall be 60°F. This value also applies to any tack welding, flame, or carbon arc-cutting.	
B	NE E 7-9	4.3.5 For austenitic stainless steels, the maximum interpass temperature shall be 350°F.	
B	NE E 7-9	4.3.5 A minimum of 1/8-inch material must be removed by machining following any thermal cutting or arc-gouging.	
B	NE E 7-9	4.3.6 <u>Surface Finish.</u> The vendor shall select fabrication processes to give the following surface finishes (AA): 1. Mating surfaces: 63 microinches or better. 2. All other surfaces: 250 microinches or better. 3. Arc-strikes shall be removed by repair grinding and/or repair welding, if necessary.	

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CRITERION CATEGORY: FABRICATION			
A	NE E 7-9	4.3.7 <u>Repair by Welding</u> . Repairs of base materials shall be in accordance with Code Paragraph NF-2500. Welders and procedures to be used shall be qualified in accordance with Code Paragraph NF-4000 for the process proposed.	
A	NE E 7-9	4.2 <u>Resistance to Corrosion</u> . Manufacturing operations shall not reduce the compatibility of materials in the snubbers with the environment described in the Purchaser's Design Specification.	
A	NE E 7-9	4.3.1 <u>General</u> . All fabrication operations shall be in accordance with Code Subsection NF-4000, Code Case 1644, and this standard.	
A	NE E 7-9	4.3.3 <u>Machining</u> . All machining operations, including cutting, bending, or forming, shall be in accordance with Code Paragraph NF-4210.	
A	NE E 7-9	4.3.4 <u>Welding</u> . Welding procedures and qualifications shall be in accordance with the Code NF-4300 and Code Case 1644, as applicable.	
A	NE E 7-9	4.3.4 The vendor shall be responsible for satisfactory performance of all welding and weld qualification testing.	
B	NE E 7-9	4.3.5 <u>Starting Materials</u> . All austenitic starting material shall be solution annealed and must meet the mechanical properties required by this standard.	

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CRITERION CATEGORY: FABRICATION			
A	NE E 7-9	4.3.5 Ferritic materials may be heat treated (Code Paragraph NF-2170) to enhance their impact properties.	
B	NE E 7-9	4.3.5 Fracture toughness tests are required on structural materials used in supports for components which have been tested for fracture toughness.	
A	NE E 7-9	4.4.1 Rust and/or pitting are not acceptable on stainless steel surfaces, and the cause of the rust shall be determined before proceeding with fabrication.	
A	NE E 7-9	4.4.1 All surfaces to be welded shall be prepared by a machining or grinding operation. The surfaces shall be free of all scale, foreign materials, lubricants, marking materials, or cleaning compounds.	
B	NE E 7-9	4.4.1 Austenitic stainless steel, which has been sensitized by exposure to temperatures of 800°F, shall be re-solution annealed.	
A	NE E 7-9	4.4.1 Threaded, machined, and sliding surfaces shall be thoroughly lubricated as required prior to shipment. The general composition of lubricants must be known. The vendor is to provide data to demonstrate the lubricant's satisfactory resistance to deterioration under the service conditions where it is to be used.	

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CRITERION CATEGORY: INSPECTION AND EXAMINATION			
A	GE 21A3502 Rev. 2	<p>5.3 <u>Code Required Examinations and Tests for All Components</u></p> <p>5.3.1 The Seller shall perform nondestructive examinations and tests on all components according to the codes specified in Paragraph 2.2. Seller shall prepare and submit for Buyer's approval the procedures and reports.</p>	
A	GE 21A3502 Rev. 2	<p>5.4 <u>Quality Control Inspection</u></p> <p>5.4.1 The following items shall be used as a guide by the Seller's quality control department, and the results shall be made available for the Buyer's review:</p> <ul style="list-style-type: none"> a) Visually and dimensionally inspect weldments, attachments, pins, and pin-to-pin length. b) Verify functional performance of hangers and snubbers. c) Verify that the ball bushings can move freely. d) Review quality control records containing the manufacturer and serial numbers for the cylinders and valves for snubbers, as applicable, and production test results. e) Verify parts inventory to approved sketches. f) Check parts marking. g) Check part cleanliness. h) Check protection, painting requirements, and packaging. i) Check cylinders for fluid level and leaks (hydraulic snubber only). j) Verify that installation instructions or manual drawings, parts list and certification of seal material, lubricant, and hydraulic fluid for each size and model are included in the shipment. 	

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CRITERION CATEGORY: INSPECTION AND EXAMINATION			
A	GE 21A3502 Rev. 2	5.4.2 <u>Inspection Facility</u> . All components shall be grouped at one facility before being shipped to the designated site.	
A	CF Braun 400-20 Rev. 3	<p>6.0 <u>Examination and Test</u>. Components supplied in accordance with this specification shall be examined and tested according to the Codes referenced and all other requirements of this specification. The following checklist shall be used as a guide for quality control of examinations.</p> <ul style="list-style-type: none"> a) Visual and dimensional check of weldments and attachments. b) Verification of functional performance of assembled units. c) Review or witness nondestructive examinations. d) Quality control records review. e) Visual review for workmanship, damage, and cleanliness. f) Parts inventory to approved drawings. g) Confirm parts marking. h) Protection, painting, and packaging requirements. i) Installation instruction manual and drawings. j) Check cylinders for fluid level and leaks (hydraulic snubber only). <p>The Seller shall be responsible for nondestructive examination of the components furnished under this specification. Radiography shall be in accordance with ASME Section III, NF-5000. All radiographic film, certificates, records and reports generated for the work, are to be on file at the Seller's shop for the duration of the job, or as required by the applicable Codes. Qualified NDE procedures shall be submitted for the Engineer approval before examinations begin. Personnel Qualification Records shall be available at the Seller's shop for Buyer review.</p>	

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Level	Document	Statement	Comments
CRITERION CATEGORY: INSPECTION AND EXAMINATION			
A	NE E 7-9	5.1 <u>Quality Assurance Program</u> . The vendor and subcontractors shall establish and implement a quality assurance program in accordance with ASME Code Section III, NCA-3500, NCA-4000, NF-5000, and NE(RDT) Standard F2-4, including the optional provisions of Sections 7b, 7c, 7d, and 7h.	
B	NE E 7-9	5.3.3 <u>Certifications</u> . A certificate of load-carrying capacity, minimum dynamic stiffness and damping factors shall be furnished for each snubber.	
A	NE E 7-9	5.3.3 The Vendor shall prepare and submit a Code Data Report Form per NCA-8419 to cover each snubber.	
-	NE E 7-9	7.1 <u>General</u> . The following must be considered prior to installation. 1. Accessibility provisions for maintenance. 2. In-service inspection and testing. 3. Repair or replacement criteria.	
A	NE E 7-9	7.1 In-service tests shall be performed either during normal system operation or plant outages.	
B	NE E 7-9	7.1 A representative sample of 10% of the total number of safety-related snubbers in a single power plant whose load rating is less than 50 kips shall be tested each inspection period. This representative sample shall include snubbers from various locations and systems taking into consideration service and environment. Each representative sample shall consist of previously untested snubbers. After all nonexempt snubbers in the plant have been tested, the tests shall be repeated, taking the same snubbers (or their replacement) in the same sequence as in the original tests.	

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CRITERION CATEGORY: INSPECTION AND EXAMINATION																	
C	NE E 7-9	7.1 The required inspection interval shall be based on the number of snubbers found inoperable during inspection or during the inspection interval as follows:															
		<table><tr><th><u>Number Found Inoperable</u></th><th><u>Next Required Inspection Interval</u></th></tr><tr><td>0</td><td>18 months $\pm$ 30%</td></tr><tr><td>1</td><td>12 months $\pm$ 30%</td></tr><tr><td>2</td><td>6 months $\pm$ 25%</td></tr><tr><td>3,4</td><td>4 months $\pm$ 25%</td></tr><tr><td>5,6,7</td><td>62 days $\pm$ 25%</td></tr><tr><td>8</td><td>31 days $\pm$ 25%</td></tr></table>	<u>Number Found Inoperable</u>	<u>Next Required Inspection Interval</u>	0	18 months $\pm$ 30%	1	12 months $\pm$ 30%	2	6 months $\pm$ 25%	3,4	4 months $\pm$ 25%	5,6,7	62 days $\pm$ 25%	8	31 days $\pm$ 25%	
<u>Number Found Inoperable</u>	<u>Next Required Inspection Interval</u>																
0	18 months $\pm$ 30%																
1	12 months $\pm$ 30%																
2	6 months $\pm$ 25%																
3,4	4 months $\pm$ 25%																
5,6,7	62 days $\pm$ 25%																
8	31 days $\pm$ 25%																
		The required inspection interval shall not be lengthened more than one step at a time.															
B	NE E 7-9	7.1 Snubbers may be categorized in two groups, "accessible" or "inaccessible," based on their accessibility for inspection during reactor operation. These two groups may be inspected independently according to the above schedule.															
A	NE E 7-9	7.1 Any snubbers that are determined to be inoperable shall be replaced or made operable.															

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CRITERION CATEGORY: INSPECTION AND EXAMINATION			
A	NE E 7-9	<p>7.2 <u>Representative Sample</u>. The sample selection shall be based on:</p> <ol style="list-style-type: none">1. Manufacturer and type<ol style="list-style-type: none">a) Capacityb) Componentsc) Materiald) Generic criteria2. Service location and conditions<ol style="list-style-type: none">a) Accessibilityb) Temperaturec) Humidityd) Radiatione) Previous trouble reports	
B	NE E 7-9	<p>7.3.1 <u>Hydraulic Snubbers</u>. All hydraulic snubbers whose seal material has been demonstrated by operating experience, laboratory testing or analysis to be compatible with the operating environment shall be visually inspected. This inspection shall include, but not necessarily be limited to, inspection of the hydraulic fluid reservoir, fluid connections, and linkage connections to the piping and building to verify snubber operability.</p>	
C	NE E 7-9	<p>7.3.1 All hydraulic snubbers whose seal materials are other than ethylene propylene or other material that has been demonstrated to be compatible with the operating environment shall be visually inspected for operability every 31 days.</p>	

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CRITERION CATEGORY: INSPECTION AND EXAMINATION			
B	NE E 7-9	7.3.1 Once each refueling cycle, a representative sample of 10 hydraulic snubbers or approximately 10% of the hydraulic snubbers whichever is less, shall be functionally tested for operability, including verification of proper piston movement, lockup and bleed. For each unit and subsequent unit found inoperable, an additional 10% or 10 hydraulic snubbers shall be so tested until no more failures are found or all units have been tested.	
B	NE E 7-9	<p>7.3.1 In-service tests for hydraulic snubbers shall verify that:</p> <ol style="list-style-type: none"> 1. During low velocity displacements, the specified maximum drag or free movement force will initiate motion of the snubber rod in both tension and compression. 2. Activation (restraining action) is achieved within the specified range of velocity or acceleration in both tension and compression. 3. Snubber bleed, or release rate, where required, is within the specified range in compression or tension. For units specifically required not to displace under continuous load, the ability of the snubber to withstand load without displacement shall be demonstrated. 4. Snubbers that fail in-service tests shall be repaired in accordance with NF-4000 and retested. An additional sample of 10% of the total number of snubbers shall also be tested at that time. Additional sample testing shall be continued until all units within the sample have met the requirements. 5. Components whose supports fail the test requirement shall be evaluated to ensure that the supported component has not been impaired. 6. Inspection and test results shall be recorded for each snubber. 	

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CRITERION CATEGORY: INSPECTION AND EXAMINATION			
B	NE E 7-9	7.3.1 Any snubber that fails an in-service test shall be retested during the next test period.	
B	NE E 7-9	7.3.2 Mechanical Snubbers. All mechanical snubbers shall be visually inspected. This inspection shall include, but not necessarily be limited to, inspection of all attachments including extension struts and end fittings, inspection for wear and lockup.	
B	NE E 7-9	7.3.2 Once each refueling cycle, a representative sample of 10 mechanical snubbers or approximately 10% of the mechanical snubbers, whichever is less, shall be functionally tested for operability.	
B	NE E 7-9	7.3.2 In-service tests for mechanical snubbers shall verify that: <ol style="list-style-type: none"> 1. The specified maximum drag or free movement force will initiate motion of the snubber rod in both tension and compression. 2. Activation (restraining action) is achieved within the specified range of velocity or acceleration in both tension and compression. 3. Release rate, where required, is within the specified range in compression or tension. For units specifically required not to displace under continuous load, the ability of the snubber to withstand load without displacement shall be demonstrated. 4. Snubbers that fail the in-service tests shall be repaired in accordance with NF-4000 and retested. An additional 10% of the total number of mechanical snubbers shall also be tested at that time. Additional sample testing shall be continued until all units within the sample have met the requirements. 	

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CRITERION CATEGORY: INSPECTION AND EXAMINATION			
(Continued)		5. Components whose supports fail the test requirements shall be evaluated to ensure that the supported component has not been impaired.	
		6. Inspection and test results shall be recorded for each snubber.	
A	NE E 7-9	7.3.3 <u>Procedures and Instructions</u> . The ASME, "Examination and Performance Testing of Nuclear Power Plant Dynamic Restraints (Snubbers)," O&M-4, shall be used to develop procedures for in-service inspection and examination.	
A	NE E 7-9	7.3.4 <u>Degradation</u> . Where examination indicates degradation of the structural elements of the snubber and/or the impairment of its functional operability, further examinations and tests shall be performed on similar snubbers in the same environment. If these examinations and tests indicate the defects are generic to a particular type, design, or function of the snubber, a sample plan shall be made to inspect and test the manufacturer's snubber for this suspected defect. Those snubbers found defective shall be repaired or replaced.	

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CRITERION CATEGORY: INSTALLATION			
C	GE 21A3502 Rev. 2	4.3.4.4.1 <u>All Snubbers.</u> a) All snubbers shall be provided with tight fitting pipe clamps. Pipe clamps shall be able to take all normal and faulted loads without slippage around the pipe, when the snubber load on the pipe clamp has a misalignment, through the spherical ball bushing, of less than 5 degrees. Also, the pipe clamp shall not slip along the pipe when the snubber load is applied at an angle not exceeding 15 degrees from the normal to the axis of the pipe.	
B	GE 21A3502 Rev. 2 4.2.4.4.1	d) Set the midpoint of thermal travel of snubber at the midpoint of total snubber stroke when the pipe is hot. Establish both hot and cold settings for snubber installation.	
C	CF Braun 400-20 Rev. 3	11.0 <u>Installation</u> 11.1 <u>Installation Tolerances.</u> Unless otherwise noted, the following erection tolerances apply to all snubber installations. a) Location of clamp on pipe $\pm$ 6 in. or pipe diameter, whichever is smaller. b) Centerline inclination $\pm$ 2 1/2° any axis. c) Installed length pin to pin $\pm$ 1/2 in. d) Snubber displacement from center travel $\pm$ 1/4 in. e) Location of attachment to wall plate. Center of attachment may be located within or on a circle 2 in. radius scribed from the center of the plate.	

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CRITERION CATEGORY: INSTALLATION			
A	ASME NF-3 Rev. 11	4.4 <u>Installation</u> 4.4.1 Snubbers should be installed in accordance with manufacturer's installation instructions.	
A	ASME NF-3 Rev. 11	4.4.2 Snubbers should be installed at the point in the system as specified by the installation requirements. Location tolerance should be specified.	
A	ASME NF-3 Rev. 11	4.4.3 Snubbers should be installed such that the line of action is as specified by the installation requirements. Tolerances should be specified.	
A	ASME NF-3 Rev. 11	4.4.4 An inspection should be made to ensure that all bolting and adjustments are tight and locked. The position of the travel indicator or actuation rod shall be checked to assure conformance to the installation drawing.	
B	NE E 7-9	8. Any testing of snubbers shall be performed in their "as-found" condition to the fullest extent as is practical regarding the features to be tested. No adjustments, tightening, fluid addition, or other maintenance is to be performed prior to or during the testing.	
B	NE E 7-9	8.d Assurance that all snubbers are properly installed prior to preoperational piping vibration and plant startup tests should be provided. Visual observation of piping systems and measurement of thermal movements during plant startup tests could verify that snubbers are operable (not locked up).	

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Level	Document	Statement	Comments
CRITERION CATEGORY: INSTALLATION			
B	NE E 7-9	6.2.3 <u>Welding</u> . Welding directly onto the finished snubber mechanism is not permitted. For example, any welding on struts which attach the snubber mechanism to component or support must be done with the mechanism removed or fully isolated electrically.	
B	NE E 7-9	6.2.4.a <u>Examination of Snubber Mechanism</u> . Each snubber mechanism shall be visually examined before assembling extension struts and other hardware connecting to it. At this time the snubber shall be manually moved twice through its full travel. Any extraneous noises such as "grinding" or "rubbing"; and any measured, sudden change in frictional resistance during travel in either direction shall be brought to the attention of the owner.	
B	NE E 7-9	6.2.4.b <u>Assembly of Snubber and Extensions</u> . Extension struts, brackets, and any other hardware needed to complete the installation to suit design documents shall be attached as specified by the snubber designer; by welding, bolting, or combination. All threaded fasteners shall be mechanically locked in their final position in accordance with NF-4000.	
A	NE E 7-9	6.2.4.c.1 After final assembly with its load-carrying extensions, each snubber shall be shown to meet the installation tolerances.	
B	NE E 7-9	6.2.4.c.2 Prior to installation, each snubber shall be demonstrated to have enough linear movement available to permit movement of the component relative to the support structure over the range from length-at-installation conditions (set point) to the maximum potential movement during plant operations. At least 1/2-inch additional motion shall be available at either end of the travel. The tolerance on the set point shall be 1/8 inch.	

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CRITERION CATEGORY: INSTALLATION			
C	NE E 7-9	6.2.4.c.3 The relative angular variation between the two mounting pins at the ends of the snubber assembly shall not be more than 2 degrees from the value used for design analysis.	
A	NE E 7-9	6.3.1 Snubbers shall be installed only at the locations designated in the approved component support-system drawings, certified stress report, and other design documents appropriate to the project.	
-	NE E 7-9	6.3.2 Each snubber shall be attached to the component it protects; and the other end of the snubber shall be attached to the stationary member of the structure supporting the component.	
C	NE E 7-9	6.3.2.a <u>Location</u> . For piping, each clamp and structural attachment shall be within the greater of 3 in. or one pipe diameter of its planned location on the system design and analysis. The design orientation shall be maintained.	
B	NE E 7-9	6.3.2.b <u>Load/Snubber Alignment</u> . Loads shall be imposed axially on the snubber within the tolerance established by the snubber manufacturer.	
C	NE E 7-9	6.3.2.c <u>Concentricity of Snubber/Extension Assembly</u> . The assembled snubber and load-carrying extensions shall be concentric from end to end within 0.010-in. total indicator runout.	
A	NE E 7-9	2.4 When locating snubbers, consideration shall be given to the requirements for accessibility for maintenance and in-service inspection.	

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CRITERION CATEGORY: LIFE			
B	GE 21A3502 Rev. 2	4.3.1.3 <u>Design Life</u> . All equipment components, except lubricants, seals, rod wipers, hydraulic fluids, and other non-metallic parts, shall be designed for a useful life of 40 years, accounting for corrosion, erosion, and material fatigue based upon 100% use.	
B	GE 21A3502 Rev. 2	4.3.1.4 <u>Maintenance</u> . The components furnished under this specification shall not require maintenance more often than once every 5 years.	
B	CF Braun 400-20 Rev. 3	4.3.3.5 <u>Design Life</u> . All components except seals and hydraulic fluid shall be designed for a useful life of 40 years, accounting for corrosion, erosion, and material fatigue based upon continuous service. Seals and hydraulic fluid shall be designed for a minimum useful life of 5 years.	
B	ITT Grinnell PHD-7556-7S Rev. 2	4.6 Allows for a minimum 1,000 thermal stroke cycles, or power plant startup and cooldowns.	
C	ITT Grinnell PHD-7556-7S Rev. 2	4.7 Restrains dynamic Level A & B design loads applied at 3 Hz for a minimum of 10,000 cycles.	

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CRITERION CATEGORY: LOADS			
B	GE 21A3502 Rev. 2	4.3.1.1 <u>Loads</u> . The design mechanical loads on hangers and snubbers are defined on the Buyer's drawing and are in accordance with ASME Code, Section III, NF-3112.2.	
B	GE 21A3502 Rev. 2	4.3.2.1 <u>Loads</u> . The mechanical loads for component supports for normal and upset conditions are the same as those specified for the design conditions, Paragraph 4.3.1.1. The pipe movements for all normal and upset conditions of piping systems are shown on the Buyer's drawings.	
B	GE 21A3502 Rev. 2	4.3.3.1 <u>Loads</u> . The loads for hangers under emergency and faulted conditions shall be as specified for the design conditions, Paragraph 4.3.1.1. The emergency loads for snubbers shall be 1.33 times the design load, Paragraph 4.3.1.1. The faulted loads for snubbers shall be 1.5 times the design loads. The snubber shall be capable of carrying the faulted load without exceeding the stress limits for the faulted condition.	
B	CF Braun 400-20 Rev. 3	4.3.4 <u>Design, Normal, and Upset Conditions</u> . The design mechanical loads for normal and upset conditions shall include those loads due to thermal expansion, anchor movement, and any sustained mechanical loads. In addition, upset conditions shall include loads due to an OBE. See loading matrix in Table I. For Quality Group A, the abnormal ambient environment condition in Paragraph 4.3.3.3 shall be considered as upset condition.	

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CRITERION CATEGORY: LOADS			
B	CF Braun 400-20 Rev. 3	4.3.4.1 <u>Emergency, Faulted, and Test Conditions.</u> Emergency conditions shall include loads due to normal conditions plus loads resulting from any system defined emergency mechanical load. Faulted conditions shall include loads due to normal conditions plus loads resulting from any faulted dynamic event, or loads due to SSE inertia. See loading matrix, Table I.	
B	CF Braun 400-20 Rev. 3	4.3.5 <u>Service Level Limits.</u> Loading conditions referred to in this specification as Design, Normal, Upset, Emergency, and Faulted correspond to Design Limits and Service Level Limits A, B, C, and D, respectively, of ASME Section III.	

TABLE I - LOAD COMBINATION MATRIX - ASME III

Design Conditions	Snubbers		Strut	
	Deflections	Loads	Deflections	Loads
Design	2,8,12*	4,5,6+	N/A	1,3,4,5,6
Normal & Upset	2,8,12*	4,5,6+	N/A	1,3,4,5,6
Emergency	2,8,12*	6+	N/A	1,6
Faulted	2,8,12*,13	6+,9,10	N/A	1,6,9,10
Test	2,8,12*	6+	N/A	3,6,11

Deflections	Loads
2=Thermal expansion deflection	1=Dead weight with operating fluid
7=OBE maximum deflection	3=Thermal expansion load
8=Dead weight deflection	4=OBE inertia load
12=Deflection due to mechanical load	5=OBE seismic anchor movement load
13=Deflection due to jet impingement	6=Mechanical load
14=SSE maximum deflection	9=SSE inertia load
	10=Jet impingement force
	11=Dead weight with test fluid

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Level	Document	Statement	Comments
CRITERION CATEGORY: LOADS			
B	CF Braun 400-20 Rev. 3	4.3.5 (Continued) <u>Notes</u> 1) Anchor movement includes differential settlement where applicable. 2) More than one combination of loads may be required for UPSET CONDITIONS when a different number of cycles are specified (Class 1 only). 3) Dead weight for TEST CONDITIONS includes weight of test fluids. 4) Load and deflection combinations listed are axially applied to the snubber or strut. Additional deflections may occur due to lateral movements of attachment points, and are required to be considered in design. *Static mechanical loads only +Dynamic mechanical loads only	
-	ASME NF-3 Rev. 11	3.1.2 Occasional Loads. The snubber may be used to resist loads associated with the following occasional load conditions such as:	
A	ASME NF-3 Ref. 11	3.1.2.1 Dynamic inertial loads due to the components inertial effects shall be determined per Appendix N, ASME B&PV Section III, Division 1, Item N1210.	
A	ASME NF-3 Rev. 11	3.1.2.2 <u>Seismic Anchor Displacement</u> . The greatest relative displacements of the structure shall be determined as described in Appendix N, ASME B&PV Section III, Division 1, Item N1228.3.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: LOADS			
A	ASME NF-3 Rev. 11	3.1.2.3 <u>Hydraulic Transient Loads</u> . Flow induced transient loads may result from the following conditions: a) Water hammer. b) Steam hammer. c) Pump startup and shutdown. d) Safety relief valve discharge (open or closed system). e) Other applicable dynamic loads.	
A	ASME NF-3 Rev. 11	3.1.2.4 <u>Pipe Whip</u> . Snubbers may be used to control the system responses due to postulated pipe break effects.	
A	ASME NF-3 Rev. 11	3.1.2.5 <u>Operational Vibration</u> . Snubbers may be incorporated to control vibrations provided that they are properly designed to accept prolonged and/or continuous cyclic loading.	
A	ASME NF-3 Rev. 11	3.1.3 <u>Dead Weight</u> . Snubbers are not designed to support piping or component dead weight.	
A	ASME NF-3 Rev. 11	3.1.4 <u>Pressure</u> . Snubbers have no effect on the system steady or transient state operating pressure of the component.	
B	ITT Grinnell PHD-7556-7S Rev. 2	4.1 Hydraulic shock suppressor for piping in nuclear power plants with 7 sizes for ASME Level A & B design loads from 1 to 110 kips. ASME Level C load ratings will be a minimum of 1.33 times Level A, and a Level D of 1.5 times Level A. The Part Number Design Loads, and Dimensions will be as noted on Figure B. All Figure 670 designs will be offered with 5 and 10-in. strokes.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: LOADS			
-	NE E 7-9	3.4 <u>Definition of Loads</u> . Loads acting on snubbers shall be identified and considered for the purposes of (1) justifying the need for snubber support, (2) providing guidance for selection and placement, (3) establishing structural integrity of components and support assemblies, and (4) ensuring operability during anticipated plant operational modes.	
A	NE E 7-9	3.4.1 <u>Thermal Movement</u> . Anticipated thermal expansion movements shall be identified for all potential plant operating conditions for the purposes of (1) providing justification for snubber usage, (2) defining stroke and clearance requirements (pipe whip restraints), (3) providing guidance for snubber placement, and (4) identifying special requirements resulting from thermal expansion combined with snubber activation.	
A	NE E 7-9	3.4.2 <u>Drag Forces</u> . The effects of snubber drag loads or breakaway forces on resulting thermal stresses shall be considered.	
A	NE E 7-9	3.4.3 <u>Seismic</u> . Seismic loadings shall be identified for the purposes of (1) providing justification for snubber usage and placement, (2) identifying snubber response characteristic requirements (frequency, lost motion, stiffness, etc.), and (3) establishing load rating requirements.	
A	NE E 7-9	3.4.4 <u>Operational Vibrations</u> . Normal operating vibration loads such as those created by pumps, fluid flow, valves or any other sources shall be identified to establish high frequency fatigue requirements for snubbers. The number of cycles of loading and amplitude shall be established for all snubber locations.	

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CRITERION CATEGORY: LOADS			
A	NE E 7-9	3.4.5 <u>Impact Loads</u> . Impact loads produced by steam and water hammer, pump startup and shutdown, or other applicable dynamic loads shall be considered for the purpose of (1) justification of selection and placement, (2) establishing load requirements, and (3) establishing fatigue requirements, if applicable. If the number of cycles of snubber activation exceed 1% of the total number of cycles identified under Operational Vibrations, the fatigue requirements for impact loads shall be considered as Operational Vibrations.	
A	NE E 7-9	3.4.6 <u>Pipe Whip</u> . Pipe whip loads are based on postulated pipe breaks based on appropriate criteria. Pipe whip loads are established for the purpose of (1) justifying snubber requirements, (2) establishing snubber placement, and (3) sizing supports.	
A	NE E 7-9	3.4.7 <u>Seismic Anchor Displacement</u> . Since the relative displacement of the supported structure and its supported building structure affect the input loads to the system, dynamic interaction loads resulting from structural resonances shall be considered for the purpose of identifying true system loadings or inputs.	
A	NE E 7-9	<u>Combined Loading Effects</u> . Combinations of loadings shall be considered when a combination of events identified as part of plant operation cause combined loadings. Conditions such as lockup during a thermal transient and seismic disturbance, valve discharge during an earthquake or others shall be considered.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: LOST MOTION			
C	GE 21A3502 Rev. 2	4.3.4.4.1 e) The total lost movement, excluding that due to compressibility of fluid and major structural parts, shall not exceed 0.040 in. for dynamic cyclic loading up to 33 cycles per second. The 0.040 movement includes mechanical gaps, valve movement, and other movements that are not in proportion to the load.	
C	ITT Grinnell PHD-7556-7S Rev. 2	4.14 Total lost motion from pin to pin, excluding that due to compressibility of fluid and major structural parts, shall not exceed ± 0.015 in. for dynamic cyclic loading at a minimum frequency of 3 Hz.	
A	NE E 7-9	3.2.1 Evaluation of clearance at a specific support location shall be based on snubber lost motion (free play), end fitting clearances, pipe clamp tolerances, and other clearances not indicated. The support clearance is the summation of individual gaps existing between the snubber backup support structure and the center of gravity (or geometry) of the component being supported.	
C	NE E 7-9	3.2.1 The total gap shall not exceed 0.05 in.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: MATERIALS			
A	GE 21A3502 Rev. 2	<p>4.2 <u>Materials</u></p> <p>4.2.1 All structural materials shall be in accordance with ASME Section III, Article NF-2000. Materials without established minimum tensile strength shall not be used for structural parts.</p>	
C	GE 21A3502 Rev. 2	<p>4.2.2 Lubricants, seals, rod wipers, hydraulic fluids, and other non-metallic parts in the suspension system shall be capable of withstanding the effects of an equivalent gamma radiation dose of 1.5×10^7 rads without impairment of operational capabilities. All materials to be used in the assemblies shall have specific Buyer approval.</p>	
B	GE 21A3502 Rev. 2	<p>4.2.4 The elastomeric seal material for all hydraulic snubbers shall be ethylene-propylene. The use of other elastomeric seal material requires prior Buyer approval.</p>	
B	GE 21A3502 Rev. 2	<p>4.2.5 The hydraulic fluid used in all hydraulic snubbers shall be GE Silicone Fluid SF1154 or Buyer-approved equivalent.</p>	
B	GE 21A3502 Rev. 2	<p>7.3 <u>Hydraulic Fluid</u></p> <p>7.3.1 If the hydraulic fluid used is different from GE Silicone Fluid SF1154, Seller shall submit for Buyer's approval the following information about the hydraulic fluid:</p> <ol style="list-style-type: none"> Manufacturer's number. Identification, including name and manufacturer's identification. Chemical composition. Characteristics such as radiation properties, physical properties, mechanical properties. Compliance with the requirements of Paragraph 4.2.5. 	

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CRITERION CATEGORY: MATERIALS			
A	CF Braun 400-20 Rev. 3	<p>4.2 <u>Materials</u>. All materials for Quality Group A, B, and C shall be in accordance with ASME Section III, Article NF-2000. Materials in conformance with ASTM specifications are acceptable for Quality Group components. Unidentified materials shall not be used nor shall materials without established minimum tensile strength be used for load-carrying components. Carbon steel components of integral supports shall be impact-tested as required by ASME III, NF-2300. The test temperature shall be equal to or less than the minimum ambient temperature specified by 4.3.3.2. Carbon steel for use on nonintegral supports and B31.1 supports will not require impact testing. The Seller shall furnish material certifications in accordance with NF-2130 for Quality Group A, B, and C components. Materials allowed by Code Case 1644, as accepted and modified by Regulatory Guide 1.85, may be used only with the engineer's approval. Proposed use of materials allowed by Code Case 1644 shall include identification of the part or parts involved and a description of the resulting advantages and disadvantages associated with the use of the proposed materials.</p>	
C	CF Braun 400-20 Rev. 3	<p>4.3.6.2.1 <u>Hydraulic Snubbers</u>. The specification of the fluid used in all hydraulic snubbers shall have the following characteristics:</p> <ul style="list-style-type: none"> a) The Kinematic Viscosity at 77°F shall be 175 Centistokes minimum. b) Pour Point shall be minus 30°F or below. c) Compressibility - Bulk Modulus of 190 ksi or more. d) Corrosion Protection - The hydraulic fluid must have the capacity to retard rust and corrosion normally caused by minute quantities of moisture and air present in any hydraulic system. e) Stability - The hydraulic fluid must retain constant properties without oxidation, aeration, foaming or demulsibility under all circumstances specified herein. 	

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CRITERION CATEGORY: MATERIALS			
C	CF Braun 400-20 Rev. 3	4.3.6.2.1 <u>Hydraulic Snubbers</u> (Continued)	
		f) Material Compatibility - The hydraulic fluid must be compatible with all seals, materials, assembly parts, coatings, and paint under all circumstances specified herein.	
		g) Fire Resistance - Flash Point 550°F or above Fire Point 650°F or above Spontaneous Ignition Temp 860°F or above	
		h) Radiation Life - The hydraulic fluid shall have resistance to the damaging effect of radiation as specified in Paragraph 4.3.3.4.	
A	ASME NF-3 Rev. 11	2.2.4 <u>Materials</u> . Snubber materials shall conform to the ASME B&PV Code, Section III, Division 1, and applicable code cases. Materials exempt under the Code must be capable of withstanding the effects of environment, temperature, humidity, and the radiation conditions specified.	
A	ASME NF-3 Rev. 11	A.4.2 <u>Materials</u> . All materials shall be in accordance with ASME Section III, Division 1, Subsection NF-2000. Any special requirements for exempted items shall also be addressed.	

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CRITERION CATEGORY: MATERIALS			
A	ASME NF-3 Rev. 11	<p>A.4.2.1 Properties of the following items should be considered in detail:</p> <p>a) Hydraulic fluid</p> <ul style="list-style-type: none">(1) compatibility(2) stability(3) corrosion protection(4) fire resistance(5) radiation life(6) cleanliness(7) air content <p>b) Seals</p> <ul style="list-style-type: none">(1) radiation(2) humidity(3) temperature(4) fluid compatibility(5) aging <p>c) Ball screw shaft, ball nut, capstan spring, mandrel, and friction clutch.</p> <ul style="list-style-type: none">(1) humidity(2) corrosion(3) wear and galling(4) temperature(5) radiation(6) dust infiltration	

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CRITERION CATEGORY: MATERIALS			
A	ASME NF-3 Rev. 11	<p>2.2.4.1 Fluid used in a hydraulic snubber is a major load carrying member and is an exempt material under the Code; therefore, its selection requires special attention. Experience has shown that certain properties are important.</p> <p>a) Lubricity should be considered in conjunction with seal material in order to prevent damage to the snubber cylinder bore, piston, piston rod, and seals, and to assure low friction forces in the cylinder.</p> <p>b) Compatibility should be considered to assure that the fluid is not injurious to either the seals or other elements of the snubber.</p> <p>c) Stability should be considered to assure that the fluid does not significantly change critical characteristics during its design life due to the combined effects of the environment and time.</p> <p>d) Corrosion protection should be considered, as the fluid is often the only corrosion protection for the interior of the snubber. The importance of this factor may be decreased by the manufacturer through the use of corrosion resistant materials and coating on the interior of the snubber.</p> <p>e) Fire resistance should be considered because snubbers are often in close proximity to components operating at high temperatures. Flash points and fire points are particularly important characteristics.</p> <p>f) Radiation life should be considered.</p> <p>g) Filtration and particle size should be considered to ensure cleanliness.</p> <p>h) The effect of gas content (entrained or dissolved) on the fluid bulk modulus should be considered.</p>	

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CRITERION CATEGORY: MATERIALS			
A	ASME NF-3 Rev. 11	<p>2.2.4.2 Seals are necessary to contain the fluid in the hydraulic snubber, and are exempt from Code material requirements. Special attention should be given to seal materials. Experience has shown that certain environmental conditions and other characteristics should be considered.</p> <p>a) Radiation can alter the chemical structure of polymeric seal materials.</p> <p>b) Certain seal materials are extremely vulnerable to humidity.</p> <p>c) Most polymeric seal materials are thermoplastics and deform or change characteristics at high temperatures.</p> <p>d) Fluid used in snubbers must be compatible with seal materials.</p> <p>e) Aging of polymeric seal materials over extended periods of time changes both the chemical makeup and physical shape of seals.</p>	
A	ASME NF-3 Rev. 11	<p>2.2.4.3 Springs, when used to control the characteristics of hydraulic or mechanical snubbers should be evaluated with respect to the following:</p> <p>a) Stability relaxation and creep with elevated temperature exposure.</p> <p>b) Corrosion protection in applications where springs are exposed to the atmosphere.</p> <p>c) Friction and galling properties of the spring material.</p> <p>d) Spring wire selection and fabrication must be controlled to minimize structural defects and ensure quality.</p>	

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CRITERION CATEGORY: MATERIALS			
A	ITT Grinnell PHD-7556-7S Rev. 2	4.2 Design, material, fabrication, and quality assurance will be per the requirements of ASME Section III, Division 1, Subsection NF, 1977 Edition for Component Standard Supports. Additionally, ASME Code Cases N-71-9 (1644-9) and N-249, additional materials for component supports, will be used.	
B	ITT Grinnell PHD-7556-7S Rev. 2	4.3 Radiation and temperature resistant seal material (tefzel or metal) and hydraulic fluid (GE SF-1154) are used. This seal material and fluid has 1×10^8 rad gamma radiation resistance and 250°F operability.	
B	NE E 7-9	2.5.1 <u>General</u> . Materials for all items other than these exempted per 2.5.6 shall conform to Subsection NF and MSS SP-58 for the applicable Code Class.	
A	NE E 7-9	2.5.2 <u>Documentation</u> . Certificates of Compliance or Certified Material Test Reports shall be submitted to the owner. These shall include impact testing procedures and acceptance criteria where required.	
A	NE E 7-9	2.5.3 <u>Marking Materials</u> . Materials used for marking parts and assemblies shall be in accordance with NE (RDT) F7-3.	
A	NE E 7-9	2.5.4 <u>Impact Testing</u> . Impact testing of materials is required in accordance with Code Subsection NF-2300 as it applies to nonintegral attachments.	
A	NE E 7-9	2.5.4 Cast or ductile iron shall not be used for primary load-bearing parts unless specifically authorized by the Purchaser.	

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CRITERION CATEGORY: MATERIALS			
A	NE E 7-9	<p>2.5.4 Primary load-bearing parts fabricated from ferritic materials shall be sufficiently ductile to permit safe handling at any temperature expected in service. For test purposes, the use temperature shall be assumed as 10°F. Assurance that this requirement is satisfied shall be provided by the Supplier per 1 or 2 below as follows:</p> <ol style="list-style-type: none"> 1. The material and welds shall meet the impact test requirements of the ASME Boiler and Pressure Vessel Code, NF-2300, at the lowest temperature specified. 2. The vendor shall submit published or proprietary impact test data or appropriate industry standards which show that the materials, welding, and heat treatment (if any), in the material thickness employed, provide adequate resistance to brittle fracture at the temperature specified above. 	
A	NE E 7-9	<p>2.5.5 <u>Weld Filler Materials</u>. The selection and testing of weld-filler materials shall be in accordance with Code Article NF-2000. Shielded metal arc welding of carbon and alloy steels shall be performed using low hydrogen electrodes conforming to ASME SFA 5.1. These electrodes shall be dried in ovens at 275°F ± 15°F for at least 8 hours immediately prior to use. Dried electrodes shall not be used if exposed to ambient conditions for more than 4 hours. These requirements or vendor-proposed alternatives are to be a part of the vendor's welding procedures.</p>	
A	NE E 7-9	<p>2.5.6 <u>Exemptions</u>. The requirements of 2.5.1 through 2.5.5 do not apply to seals, springs, hydraulic fluids, wear shoes, lubricants, retaining rings, and bearings. The materials for these items shall be compatible with other materials used in construction of the snubbers. They shall not adversely affect snubber performance during the environmental conditions (temperature, humidity, radiation, etc.) given in the Design Specification. The vendor's drawings submitted for approval shall show the specifications used for purchase of materials for these non-Code items.</p>	

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CRITERION CATEGORY: PERFORMANCE REQUIREMENTS			
C	CF Braun 400-20 Rev. 3	<p>4.3.6.2 <u>Vibration Snubber</u>. The vibration snubber assembly may be designed using a hydraulic cylinder or a mechanical design with no hydraulic damper. The functional resistance to gradual movements caused by thermal expansion shall not exceed 1% of the rated load. The total lost motion (dead band) including clearances, during cyclic loading of 3.0 to 33 Hz shall not exceed 0.03 in. All snubber assemblies shall be designed for a life of 5000 cycles at rated load. Assemblies requiring a greater number of design cycles will be identified and the required number of cycles shown on the Pipe Support Assembly drawings.</p> <p>The Seller shall provide the design or test data that qualifies the selected snubber for the defined cycle loading. The required minimum spring constants at 200°F for various snubber assembly rated loads are shown in Figure 1. Snubbers used in pairs have matched spring rates within 5%. For purposes of establishing spring constants, the snubber assembly is defined as the minimum pin-to-pin length snubber (no extension piece) for each load rating. In some cases the use of a higher than necessary load rated snubber may be required to satisfy the minimum spring constant criteria. The Seller shall submit a table giving the snubber spring constants for each rated load (refer to Paragraph 6.2) and shall provide, as a separate item, spring constants for the wall brackets. Pipe clamps are to have a stiffness 4 times that of the snubber attaching to them. The end connections shall have ball-type joints or spherical bushings that will allow angular motion of + 5 degrees. Each snubber assembly shall provide a means of visually determining if the snubber is working properly and is not frozen in a locked position. All snubbers shall perform as required by this specification in any spatial orientation.</p>	

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CRITERION CATEGORY: PERFORMANCE REQUIREMENTS			
C	CF Braun 400-20 Rev. 3	<p>4.3.6.2.1 <u>Hydraulic Snubber</u>. The hydraulic-type snubber shall utilize double-acting hydraulic cylinders, fitting with fixed or adjustable orifices to control the velocity of the piston at a given resistive force. The cylinders shall comply with Joint Industrial Conference Standards with hard chrome-plated piston rods and seals selected for minimum leakage and long life. Fluid reservoirs shall be integral with the snubber assembly and shall have a means of visually indicating the level or reserve fluid. The seal material shall be subject to approval by the Engineer. The length of stroke required is determined with the piston centered. However, if it is desirable to utilize more of the stroke in one direction by positioning the piston off center, a safety factor of 20% shall be allowed to prevent bottoming out the cylinder. The bleed rate and lockup rate (lockup rate defined as the pipe velocity that caused the snubber to lock) shall be set and recorded for each snubber. The proper setting of adjustment screws, if applicable, shall be provided to prevent tampering in the field. Drag, bleed rate and lockup rate information for each snubber shall be provided to the Buyer as part of the permanent records. Poppet valve snubbers shall allow unrestricted movement of the pipe up to a velocity of 6 in. per minute with a drag force not exceeding 1% of rated load. The lockup velocity shall be between 6 and 25 in. per minute and the bleed rate shall be between 1 and 6 in. per minute. Fixed orifice snubbers shall limit the pipe velocity at rated load of 6 to 10 in. per minute. The drag load limit during thermal expansion at 1% of rated load does not apply to fixed orifice snubbers. Performance requirements shall be met at 75% and 200°F in both tension and compression loading.</p>	

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CRITERION CATEGORY: PERFORMANCE REQUIREMENTS			
B	CF Braun 400-20 Rev. 3	4.3.6.4 <u>Snubber Surrogates</u> . The Seller shall furnish snubber surrogates which will be used by the field installers to position and install the pipe clamps and structural brackets at the time of pipe erection. The surrogates shall be designed and supplied such that they would duplicate the snubbers in the cold position. The surrogates shall be adjustable by ± 2 in. in their axial direction. Surrogates are to be used for erection purposes only and need not be in accordance with the ASME or ANSI Codes. The surrogates shall be packaged and shipped with the snubber unit attachments. This assembly will be referred to as the snubber/surrogate assembly and shall be packaged, shipped and stored independent of the snubber unit.	

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CRITERION CATEGORY: PERFORMANCE TESTS			
B	ASME NF-3 Rev. 11	<u>A.5.2 Performance Testing</u> Each unit shall be subjected to a performance test to verify the following: a) Full stroke and freedom of motion. b) Velocity or acceleration activation level as applicable. c) Release rate based on design or operating condition load, after activation. d) Fluid pressure integrity.	

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CRITERION CATEGORY: PLACEMENT			
B	ASME NF-3 Rev. 11	<p>Snubbers are used in a piping system or at a component where a thermal growth must be accommodated and where a restraining force is required during a seismic or other dynamic event.</p> <p>a) At points of large concentrated loads such as valves, large primary components, flanges, and other components that are not anchored.</p> <p>b) Changes in piping direction.</p> <p>c) Within long vertical risers.</p> <p>d) On long straight pipe runs, as determined by the piping analysis.</p>	

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CRITERION CATEGORY: QUALIFICATION TESTS			
-	GE 21A3502 Rev. 2	<p>5.1 <u>Product Qualification Tests of Snubbers</u></p> <p>5.1.1 The Seller shall perform each test specified below on two randomly selected production snubbers of each size and model. The tests shall be performed in accordance with the Seller prepared, Buyer-approved test procedures.</p>	
B	GE 21A3502 Rev. 2	<p>5.1.1.1 <u>Dynamic Characteristic Test at Rated Load</u></p> <p>a) The snubber shall be subjected to either force or displacement that varies approximately as the sine wave.</p> <p>b) The frequency (Hz) of the input motion or force shall be verified at increments of 5 Hz within the range 3 Hz to 33 Hz.</p> <p>c) The resulting relative displacements including lost motion, and the loads across the snubber shall be recorded.</p> <p>d) The test shall be conducted with the snubber at room temperature and at 200°F.</p> <p>e) The peak load in both tension and compression shall be equal to or higher than the rated load.</p> <p>f) The duration of the test at each frequency shall be approximately 10 seconds if possible.</p>	

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CRITERION CATEGORY: QUALIFICATION TESTS			
C	GE 21A3502 Rev. 2	5.1.1.2 <u>Friction Test</u> . Verify that the resistance to motion in both expansion and contraction, at a velocity of 5 in. per minute and below for hydraulic snubbers, or at an acceleration of 0.02 g and below for a mechanical snubber, is less than 1% of the rated load of the snubber, or 5 lb, whichever is greater, at room temperature and at 200°F. For a hydraulic snubber with a flow orifice instead of a poppet valve, verify that the resistance to motion in both expansion and contraction, at a velocity of 1.5 in. per minute and below, is less than 2% of the rated load of the snubber at room temperature and at 200°F.	
C	GE 21A3502 Rev. 2	5.1.1.3 <u>Velocity Lockup Rate Test</u> . Hydraulic snubbers shall be tested at room temperature and at 200°F for velocity lockup rate in accordance with Paragraph 4.3.4.4.2.a.	
C	GE 21A3502 Rev. 2	5.1.1.4 <u>Bleed Rate Test</u> . Hydraulic snubbers shall be tested at room temperature and at 200°F for bleed rate as per Paragraph 4.3.4.4.2.b.	
C	GE 21A3502 Rev. 2	5.1.1.5 <u>Acceleration Lockup Rate Test</u> . Mechanical snubbers shall be tested at room temperature and at 200°F for acceleration lockup rate in accordance with Paragraph 4.3.4.4.3.a. The test results shall include a plot of acceleration vs time and displacement vs time.	
B	GE 21A3502 Rev. 2	5.1.5 <u>Faulted Condition Tests</u> 5.1.5.1 <u>Faulted Load</u> . The snubber shall be tested dynamically at a frequency between 3 and 33 Hz and at a minimum temperature of 200°F for the faulted load. Test duration shall be approximately 10 seconds.	

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CRITERION CATEGORY: QUALIFICATION TESTS																	
B	GE 21A3502 Rev. 2	5.1.5.2 <u>Abnormal Environment Transient Tests</u> . The snubber shall be tested for the abnormal environment transient condition in accordance with Paragraph 4.3.3.2.1. The snubber shall be tested dynamically, at a frequency between 3 and 33 Hz after the completion of the Abnormal Environment Transient Tests. The snubber shall operate normally during the dynamic test. The test duration shall be approximately 10 seconds.															
B	GE 21A3502 Rev. 2	5.1.6 <u>Elastomeric Seal Material Test</u> 5.1.6.1 Each compound of elastomeric seal material used shall be qualified by the following two tests: a) Immerse in water at 212°F for 100 hours. b) Immerse in the silicone fluid to be used in the snubber through the temperature transient listed in Paragraph 4.3.3.2.1.															
C	GE 21A3502 Rev. 2	5.1.6.2 The variation of properties in the listed categories of the seal material after each immersion test shall be as described below:															
		<table><tr><th><u>Physical Properties</u></th><th><u>Typical Acceptable Changes in Properties After Immersion</u></th></tr><tr><td>Hardness shore A</td><td>5 points</td></tr><tr><td>Tensile strength, psi</td><td>10%</td></tr><tr><td>Elongation</td><td>3%</td></tr><tr><td>Modulus, at 100%, psi</td><td>5%</td></tr><tr><td>Volume</td><td>5%</td></tr><tr><td>Compression set per ASTM-D-395</td><td>20%</td></tr></table>	<u>Physical Properties</u>	<u>Typical Acceptable Changes in Properties After Immersion</u>	Hardness shore A	5 points	Tensile strength, psi	10%	Elongation	3%	Modulus, at 100%, psi	5%	Volume	5%	Compression set per ASTM-D-395	20%	
<u>Physical Properties</u>	<u>Typical Acceptable Changes in Properties After Immersion</u>																
Hardness shore A	5 points																
Tensile strength, psi	10%																
Elongation	3%																
Modulus, at 100%, psi	5%																
Volume	5%																
Compression set per ASTM-D-395	20%																

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C	CF Braun 400-20 Rev. 3	<p>6.1 <u>Seals</u>. The seal material for all hydraulic snubbers shall have a high temperature test as follows:</p> <p>a) Immersion in water at 212°F for 100 hours, followed by</p> <p>b) Immersion in silicone fluid through the conditions specified per Paragraph 4.3.3.3a. For testing purposes, both temperature and pressure may be assumed to decrease linearly.</p> <p>Upon completion of the above tests, the Seller shall demonstrate that the seals are capable of performing their intended function. The silicone fluid test may be performed concurrently with the assembly test required by Paragraph 6.2d. If tested separately from the completed assembly, two seals each of the smallest, largest and an intermediate size shall be tested and the pressure requirements of 4.3.3.3a may be deleted.</p>	
B	CF Braun 400-20 Rev. 3	<p>6.2 <u>Hydraulic Snubber Assemblies</u>. Certified test data shall be submitted to demonstrate that the snubbers perform as required by Paragraph 4.6.2. The test shall include the following procedures:</p> <p>a) The snubbers shall be subjected to either force or displacement that varies approximately as the sine wave.</p> <p>b) The frequency (Hz) of the input motion or force shall be verified at increments of 5 Hz within the range 3.0 Hz to 33 Hz. All tests shall be conducted for a minimum of 10 seconds at each test frequency.</p>	

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	c)	The resulting maximum relative displacements across the snubber shall be recorded at 75°F. The effective spring constant from pin to pin with no extension pieces shall be determined at rated load. The effective spring constant is the value of the load range divided by the total deflection including any lost motion due to clearances, tolerances, fluid compression, etc. Any movements that are required to lock snubber in dynamic conditions are not to be included.	
	d)	The Seller shall test the snubbers for drag, lockup rate, and bleed rate at room temperature (75°F). Fixed orifice snubbers shall be tested for load versus velocity.	
	e)	The Seller shall subject the snubbers to the abnormal ambient conditions set forth by Paragraph 4.3.3.3a. For testing purposes, both temperature and pressure may be assumed to decrease linearly. The 100% humidity, 100 day duration may be reduced to one day duration.	
	f)	Following exposure to the abnormal ambient conditions, the snubbers shall be tested for spring constant, drag, lockup rate and bleed rate at 200°F by procedures identical to those performed at 75°F.	
	g)	All test data shall be obtained from production units randomly selected. Pins shall be installed to manufacturer's standard tolerances.	
	h)	The Seller shall test two snubbers of each size as outlined above. Both shall be tested at 75°F and 200°F. All results shall be included in the submitted report. Prior test results on identical units are acceptable.	

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CRITERION CATEGORY: QUALIFICATION TESTS			
C	CF Braun 400-20 Rev. 3	<p>6.3 <u>Hydraulic Snubber Test Report</u>. Certification shall be submitted in a test report for hydraulic snubbers to ensure that the following is satisfied.</p> <p>a) The seals function properly after testing per Paragraph 6.1.</p> <p>b) The snubber unit shall not have lost motion in excess of that allowed by Paragraph 4.3.6.2 for the load condition indicated.</p> <p>c) The snubber unit continues to offer rated restraint until the input motion/force ceases or reverses direction.</p> <p>d) The criteria for drag, lockup rate and bleed rate are met.</p> <p>e) The spring constant is determined and reported as required by Paragraph 6.2c.</p>	
C	CF Braun 400-20 Rev. 3	<p>6.4 <u>Mechanical Snubber Assemblies</u>. Certified test data shall be submitted to demonstrate that the mechanical snubbers perform as required by Paragraph 4.3.6.2. The test shall include the following procedures.</p> <p>a) The snubber shall be subjected to either force or displacement that varies approximately as the sine wave.</p> <p>b) The frequency (HZ) of the input motion or force shall be verified at increments of 5 Hz within the range 3 Hz to 33 Hz. All tests shall be conducted for a minimum of 10 seconds at each test frequency.</p> <p>c) The resulting maximum relative displacements across the snubber shall be recorded at 75°F. The effective spring rate shall be determined as described and defined in paragraph 6.2c.</p>	

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(Continued)	d)	The Seller shall test the snubbers for break-away load and acceleration limits at 75°F. Velocity limiting mechanical snubbers shall be tested for breakaway load, acceleration limits and slip rate.	
	e)	The Seller shall subject the mechanical snubbers to the abnormal ambient conditions of Paragraph 4.3.3.3a. For testing purposes, both temperature and pressure may be assumed to decrease linearly. The 100% humidity, 100 day duration, may be reduced to 1 day duration.	
	f)	Following exposure to the abnormal ambient conditions, the snubbers shall be tested for spring constant, breakaway load and acceleration limits at 200°F by procedures identical to those performed at 75°F. Velocity limiting snubbers shall be tested for spring constant, breakaway load, acceleration limits and slip rate at 200°F.	
	g)	All test data shall be obtained from production units, randomly selected. Pins shall be installed to manufacturer's standard tolerances.	
	h)	The Seller shall test two snubbers of each size as outlined above. Both shall be tested at 75°F and 200°F. All results shall be included in the submitted report. Prior test results on identical units are acceptable.	

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C	CF Braun 400-20 Rev. 3	<p>6.5 <u>Mechanical Snubber Test Report</u>. Certification shall be submitted in a test report for mechanical snubbers to ensure that the following is satisfied:</p> <p>a) The snubber unit shall not have lost motion in excess of that allowed by Paragraph 4.3.6.2 for the load condition indicated.</p> <p>b) The snubber unit continues to offer rated restraint until the input motion/force ceases or reverses direction.</p> <p>c) The criteria for breakaway, acceleration limits and slip rate are met.</p> <p>d) The spring constant is determined and reported as required by Paragraph 6.4c.</p>	
-	ASME NF-3 Rev. 11	A.5.1 <u>Qualification Testing</u> . Qualification testing shall be performed on a sample number of snubber units to demonstrate compliance with design requirements.	
B	ASME NF-3 Rev. 11	<p>The following qualification tests should be considered:</p> <p>a) Friction or breakaway test to demonstrate resistance to motion.</p> <p>b) Velocity or acceleration activation level, as applicable.</p> <p>c) Release rate based on design or operating condition load, after lockup.</p> <p>d) Dynamic characteristic test at design or operating condition load.</p>	

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(Continued)		e) Abnormal environment transient tests to determine the effects of temperature, pressure and humidity. Tests for the effects of salt spray, and other airborne particles should be performed when required.	
		f) Static test to verify manufacturer's established faulted condition load capacity.	
A	ASME NF-3 Rev. 11	A.5.1.2 Previous qualification test results on identical equipment shall be considered as acceptable, provided the results meet or exceed the design requirements.	
A	ASME NF-3 Rev. 11	A.5.1.3 Qualification test procedures and results should be submitted as required.	
A	ITT Grinnell PHD-7556-4P Rev. 2	10.0 <u>Test Sequence</u> 10.1 The test sequence shall be as shown in Figure 10.1-1.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.2 <u>Drag (75°F)</u> . The breakaway and drag force shall be measured at the conditions described in Section 5.0.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.2.1 The piston rod shall be retracted to within 1/2 in. of fully retracted. Input force (tension) shall then be gradually increased until piston motion is initiated and a steady-state velocity of 1 in./min is attained and maintained for a minimum of 4 in. of stroke and to a point where the piston rod is 1/2 in. from fully extended. Input force, velocity and displacement shall be recorded on a strip chart recorder.	

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B	ITT Grinnell PHD-7556-4P Rev. 2	10.2.2 The procedure outlined in Paragraph 10.2.1 shall be repeated for the compression direction.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.2.3 Procedures outlined in Paragraphs 10.2.1 and 10.2.2 shall be repeated for velocities of 3 and 6 in./min.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.2.4 Maximum force (breakaway or drag) shall be recorded for each test.	
B	ITT Grinnell PHD-7556-4P Rev. 2	<p>10.3 <u>Activation Level/Release Rate (Limiting Velocity) at 75°F.</u> The velocity at which the piston moves for a given load input is known as the limiting velocity. The limiting velocity shall be determined in both the tension and compression direction at 25, 50, 100, and 133% (emergency) of normal load.</p> <p>Set the piston rod at 1 in. from fully retracted. With the ambient condition as described in Section 5.0, the load is now applied in the tension (extension) direction at 25% of the normal value (Table 2.0-1). Once the load stabilizes, record the resultant velocity and load for a period of 5 seconds. The suppressor should now be set so that the rod is 1 in. from fully extended. The load of 25% or normal is now applied in the compression (retraction) direction and the recording is repeated.</p> <p>The limiting velocity sequence is repeated at 50, 100, and 133% of normal load.</p>	

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B	ITT Grinnell PHD-7556-4P Rev. 2	<p>10.4 Midstroke Spring Rate/Dead Band (Dynamic) at 75°F. Each test sample shall be dynamically loaded with a sinusoidal displacement input to produce a minimum of the normal load in both the tension and compression directions.</p> <p>The test units shall be at 75 ± 10°F and the frequency range shall be 3 to 33 Hz.</p>	
B	ITT Grinnell PHD-7556-4P Rev. 2	<p>10.4.1 The test units shall be placed at mid-stroke and a 3 Hz sinusoidal displacement input shall be applied with sufficient amplitude to produce a minimum of the normal load (Table 2.0-1) in both the tension and compression directions. The maximum force in the compression direction shall be limited to twice the normal load. This may reduce the tension direction to a force less than normal load. The maximum cutoff force in tension should be set at 1.6 times the normal load for all cases. The ambient conditions shall be as described in Section 5.0. The input should be maintained for 10 seconds.</p> <p>Displacement across the suppressor (Figure 7.3-1) vs force applied to the suppressor shall be overlaid for a minimum of 5 cycles on the photographic record of the oscilloscope traces. The trace amplitude shall be sufficient to allow for easy interpretation. Displacement and force vs time shall also be recorded on a strip chart recorder.</p>	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.4.2 The test procedure described in 10.4.1 shall be repeated at 8, 13, 18, 23, 28 and 33 Hz. (In the process of testing through the frequency range the suppressor temperature may rise.)	

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B	ITT Grinnell PHD-7556-4P Rev. 2	10.5 <u>1/3 and 3/4 Stroke Spring Rate/Dead Band (Dynamic) at 75°F.</u> The test procedure described in 10.4.1 shall be repeated at the 1/4 and 3/4 stroke positions (1 1/4 and 3 3/4 in. from fully retracted) at frequencies of 3, 18, and 33 Hz.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.6 <u>Faulted Load Dynamic (75°F).</u> Each unit shall be subjected to 10 seconds of faulted load sinusoidal input at 18 Hz while at 75°F. The suppressors shall be loaded sinusoidally at 18 Hz to approximately 50% of normal load (Table 2.0-1) while at the conditions of Section 5.0. The piston rod shall then be slowly extended (or retracted) until the forces in both directions are the same. The displacement shall then be increased until the force input to the unit is equal to the faulted load (Table 2.0-1). Adjustments may be made to the rod position while bringing up the load. The faulted load shall be maintained for a period of 10 seconds. Maximum load cutoffs should be set at 1.6 times and normal load in tension and 2 times normal load in compression.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.7 <u>72-Hour/350°F/Saturated Steam.</u> The test specimen shall be placed within a sealed container and subjected to a 72-hour, 350°F, all steam environment. The temperature, pressure and humidity shall be recorded continuously during the test.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.8 <u>Mid Stroke Spring Rate / Dead Band (Dynamic) at 250°F.</u> Each test sample shall be dynamically loaded with a sinusoidal displacement input to produce a minimum of the normal load in both the tension and compression directions. The test units shall be at $250 \pm 10^\circ\text{F}$ and the frequency range shall be 3 to 33 Hz.	

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B	ITT Grinnell PHD-7556-4P Rev. 2	<p>10.8.1 The test units shall be placed at mid-stroke and a 3 Hz sinusoidal displacement input shall be applied with sufficient amplitude to produce a minimum of the normal load (Table 2.0-1) in both the tension and compression directions. The maximum force in the compression direction shall be limited to twice the normal load. This may reduce the tension direction to a force less than normal load. The maximum cutoff force in tension should be set at 1.6 times the normal load for all cases. The ambient conditions shall be as described in Section 6.0. The input should be maintained for 10 seconds.</p> <p>Displacement across the suppressor (Figure 7.3-1) vs force applied to the suppressor shall be overlaid for a minimum of 5 cycles on the photographic record of the oscilloscope traces. The trace amplitude shall be sufficient to allow for easy interpretation. Displacement and force vs time shall also be recorded on a strip chart recorder.</p>	
B	ITT Grinnell PHD-7556-4P Rev. 2	<p>10.9 <u>1/4 and 3/4 Stroke Spring Rate / Dead Band (Dynamic) at 250°F.</u> The test procedure described in 10.8.1 shall be repeated at the 1/4 and 3/4 stroke positions (1 1/4 and 3 3/4 in. from fully retracted) at frequencies of 3, 18, and 33 Hz.</p>	
B	ITT Grinnell PHD-7556-4P Rev. 2	<p>10.10 <u>Faulted Load Dynamic (250°F).</u> Each unit shall be subjected to 10 seconds of faulted load sinusoidal input at 18 Hz while at 250°F.</p> <p>The suppressors shall be loaded sinusoidally at 18 Hz to approximately 50% of normal load (Table 2.0-1) while at the conditions of Section 6.0. The piston rod shall then be slowly extended (or retracted) until the force in both directions are the same. The displacement shall then be increased until the force input to the unit is equal to the faulted load (Table 2.0-1). Adjustments may be made to the rod position while bringing up the load.</p>	

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(Continued)		The faulted load shall be maintained for a period of 10 seconds. The displacement vs force oscilloscope photographs shall include a minimum of 5 overlaid traces. Maximum load cutoffs should be set at 1.6 times the normal load in tension and 2 times normal load in compression.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.11 <u>Activation Level / Release Rate (Limiting Velocity at 250°F.</u> Set the piston rod at 1 in. from fully retracted. With the ambient condition as described in Section 6.0 the load is now applied in the tension (extension) direction at 25% of the normal value (Table 2.0-1). Once the load stabilizes, record the resultant velocity and load for a period of 5 seconds. The suppressor should now be set so that the rod is 1 in. from fully extended. The load of 25% of normal is now applied in the compression (retraction) direction and the recording is repeated. The limiting velocity sequence is repeated at 50, 100, and 133% of normal load.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.12 <u>Drag (250°F).</u> The breakaway and drag force shall be measured at the conditions described in Section 6.0.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.12.1 The piston rod shall be retracted to within 1/2 in. of fully retracted. Input force (tension) shall then be gradually increased until piston motion is initiated and a steady-state velocity of 1 in./min is attained and maintained for a minimum of 4 in. of stroke and to a point where the piston rod is 1/2 in. from fully extended. Input force, velocity and displacement shall be recorded on a strip chart recorder.	

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CRITERION CATEGORY: QUALIFICATION TESTS			
B	ITT Grinnell PHD-7556-4P Rev. 2	10.12.2 The procedure outlined in Paragraph 10.12.1 shall be repeated for the compression direction.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.12.3 Procedures outlined in Paragraphs 10.12.1 and 10.12.2 shall be repeated for velocities of 3 and 6 in./min.	
B	ITT Grinnell PHD-7556-4P Rev. 2	10.12.4 Maximum force (breakaway or drag) shall be recorded for each test.	
B	ITT Grinnell PHD-7556-4P Rev. 2	5.0 <u>Room Temperature Ambient Conditions.</u> Unless stated otherwise, the testing shall be conducted at room temperature ambient conditions with the following limitations:	
		<div>Temperature</div> <div>Relative Humidity</div> <div>75 $\pm$ 10°F</div> <div>90% or less</div>	
		The suppressors should be stored at these conditions for a period not less than 12 hours immediately preceding the testing. The temperature shall be measured in close proximity to the test snubber.	

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CRITERION CATEGORY: QUALIFICATION TESTS			
B	ITT Grinnell PHD-7556-4P Rev. 2	<p>6.0 <u>High Temperature Ambient</u>. The high temperature ambient tests shall be run within the following limitations.</p> <p>Temperature $250^{\circ}\text{F} \pm 10^{\circ}\text{F}$</p> <p>The snubber shall be soaked at this temperature for a period not less than 12 hours or for a sufficient time to bring the surface temperature of the cylinder to $250 \pm 10^{\circ}\text{F}$ for a period of not less than 4 hours. The surface temperature shall be measured with a thermocouple in direct contact with the heated air or direct view of the heating element.</p>	
B	ITT Grinnell PHD-7556-4P Rev. 1	<p>7.2 <u>Activation Level / Release Rate (Limiting Velocity) (75°F)</u>. The velocity at which the piston moves for a given load input is known as the limiting velocity. The limiting velocity shall be determined in both the tension and compression direction at 25, 50, 100, and 133% (emergency) of normal load.</p> <p>Set the piston rod at 1 in. from fully retracted. With the ambient condition as described in Section 7.0, the load is now applied in the tension (extension) direction at 25% of the normal value (Table 2.0-1). Once the load stabilizes, record the resultant velocity and load for a period of 5 seconds. The suppressor should now be set so that the rod is 1 in. from fully extended. The load of 25% of normal is now applied in the compression (retraction) direction and the recording is repeated.</p> <p>The limiting velocity sequence is repeated at 50, 100, and 133% of normal load.</p>	

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CRITERION CATEGORY: QUALIFICATION TESTS

- B ITT Grinnell 7.3 Low Amplitude Dynamic at 75°F. A displacement amplitude of 120% of the free movement of the suppressor shall be applied for a total of 5 million cycles.

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The suppressor shall be installed in the test machine at the mid-stroke position. A displacement transducer shall be placed such that the total movement across the suppressor, including that due to clearances in hardware can be measured.

A frequency between 20 and 50 Hz shall be selected, depending upon test rig stability. The input displacement at that frequency shall slowly be increased until the force vs displacement trace on an oscilloscope indicates a force buildup in both the tension and compression directions. The total motion without load shall be determined from a photograph of the trace, which shall become part of the test report.

The input displacement shall then be adjusted to at least 120% of this displacement.

An oscillograph trace of the displacement and force vs time shall be continuously run and the displacement shall not vary by more than 10% of the established amplitude. A significant change in force level shall be cause to stop the cycling and inspect the suppressor and it's attachments. Loose test fixture attachments shall be retightened.

The test shall be stopped at least once each 500,000 cycles to inspect the test specimen and fixturing. Additional breaks in the testing are permitted, however, the total accumulated cycles shall be 5×10^6 cycles.

The temperature of the test specimen may rise during the course of testing, however, the ambient temperature shall remain at $75 \pm 10^\circ\text{F}$.

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CRITERION CATEGORY: QUALIFICATION TESTS			
B	ITT Grinnell PHD-7556-8P Rev. 1	7.4 <u>Gamma Radiation</u> . The test suppressors shall be radiated at a dose rate of approximately 0.35 megarad/hr for 290 hours for a total integrated dosage of 1×10^8 rads.	
B	ITT Grinnell PHD-7556-8P Rev. 1	7.5 <u>Sand and Dust</u> . The sand and dust test shall be conducted per Military Specification, MIL-E-5272C, Procedure 1, as described in Paragraph 4.11.1. This procedure calls for a total of 12 hours of sand and dust environment at a particle velocity between 100 and 500 ft/min.	
B	ITT Grinnell PHD-7556-8P Rev. 1	7.6 <u>Salt Spray</u> . The salt spray test shall be conducted per Military Specification, MIL-E-5272C, Procedure 1, as described in Paragraph 4.6.1. The salt spray test shall be conducted for 168 hours. The suppressor shall not be stroked until after the 72 hour steam environment at 350°F described in Section 7.7. Photographs shall be taken of the suppressor following the salt spray.	
B	ITT Grinnell PHD-7556-8P Rev. 1	7.7 <u>72-Hour/350°F/Saturated Steam</u> . The test specimen shall be placed within a sealed container and subjected to a 72-hour, 350°F, all steam environment. The temperature, pressure and humidity shall be recorded continuously during the test.	
B	ITT Grinnell PHD-7556-8P Rev. 1	7.8 <u>Normal Load Dynamic Endurance (75°F)</u> 7.8.1 The test units shall be placed at mid-stroke and a sinusoidal displacement input shall be applied with sufficient amplitude to produce a minimum of the normal load (10,000 lbs) in both the tension and compression directions. The maximum force in the compression direction shall be limited to twice the normal load. This may reduce the tension direction to a force less than normal load. The maximum cutoff force in tension should be set at 1.6 times the normal load (16,000 lbs) for all cases.	

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CRITERION CATEGORY: QUALIFICATION TESTS			
(Continued)		The ambient conditions shall be as described in Section 7.0. The input should be maintained for 5,000 cycles.	
B	ITT Grinnell PHD-7556-8P Rev. 1	7.9 <u>Activation Level / Release Rate (Limiting Velocity) (75°F).</u> The procedure described in Section 7.2 shall be repeated.	
B	ITT Grinnell PHD-7556-8P Rev. 1	7.10 <u>Drag (75°F).</u> The procedure described in Section 7.1 shall be repeated.	
C	ITT Grinnell PHD-7556-8P Rev. 1	7.11 <u>Leakage (75°F).</u> The suppressor shall be thoroughly cleaned using Freon TF solvent such that no hydraulic fluid remains on external surfaces. The suppressor shall then be blown dry with clean air and solvent residue wiped off with a clean rag. The suppressor shall then be placed on clean white paper for a period of not less than 24 hours. Formation of oil spots on the paper or drops on the suppressor surface shall be grounds for test failure.	
C	ITT Grinnell PHD-7556-8P Rev. 1	2.0 <u>Acceptance Criteria.</u> The seals shall be deemed acceptable if the following criteria are met. 2.1 Adequate fluid remains in the reservoir for the design stroke length. 2.2 The suppressor passes the fluid leakage test as described in 7.11. 2.3 The drag and limiting velocity remains within the criteria of PHD-7556-7, "Figure 670, Hydraulic Shock Suppressor, Product Specification".	

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CRITERION CATEGORY: QUALIFICATION TESTS			
A	NE E 7-9	2.7 <u>Testing Requirements</u> . All snubbers shall be load rated. This shall be done by the performance of tests to failure. Testing shall be (or have been) performed to determine the mode of snubber failure. The mode of failure or item which fails first shall be defined by the snubber manufacturer.	
A	NE E 7-9	<p>2.7.1 <u>Qualification Tests</u>. The qualification of a snubber design shall be conducted by using a minimum of two prototypical units or two units randomly selected from the production line of the same design and rating. The design shall be qualified only when both units have passed the requirements set forth below. In the event that one or both units fail the requirements, the cause of failure shall be determined. The design shall then be revised according to the results of the failure analysis before it can again be tested for qualification. Units used for qualification testing shall not be supplied as part of the purchased number of snubbers.</p> <p>The qualification plan for functional parameters for snubbers shall, as a minimum, contain the following information:</p> <ol style="list-style-type: none"> 1) Snubber descriptions and specifications. 2) Snubber sampling requirements. 3) Material data requirements. 4) Mounting requirements. 5) The aging simulation requirements. 6) The service condition simulation requirements. 7) Functional parameters and environmental variables to be measured. 8) Test and monitor equipment requirements. 9) The test sequence. 10) Special tests. 11) Limits or failure definition for the test. 12) Ultimate load capacity. 	

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CRITERION CATEGORY: QUALIFICATION TESTS			
A	NE E 7-9	2.7.1 Appendix B to Draft Regulatory Guide SC-708-4 shall be used as a guide for the development of the qualification test plan and documentation required.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: RELEASE RATE			
C	GE 21A3502 Rev. 2	4.3.4.4.2 <u>Hydraulic Snubbers</u> b. The bleed rate (defined as a velocity of the snubber piston or pipe when the snubber is locked and loaded with the rated load) shall not be less than 1.0 in./min nor greater than 6 in./min at rated load at operating temperature. If the hydraulic snubber has a flow orifice instead of a poppet valve, then the unit shall resist motion with a force at least equal to the rated load of the snubber when the rod end velocity is 18 in./min.	
B	GE 21A3502 Rev. 2	4.3.4.4.2 <u>Hydraulic Snubbers</u> c. The bleedrate shall be set and recorded for each snubber. The proper setting of adjustment screws shall be marked on valves, and means shall be provided to prevent tampering in the field. Bleedrate information for each snubber shall be provided to Buyer as part of the permanent records.	
C	GE 21A3502 Rev. 2	4.3.4.4.2 <u>Mechanical Snubbers</u> b. When the snubber is exposed to a continuous load in either tension or compression, it shall continue to move at minimum of 0.2 in. for each second of loading.	
A	ASME NF-3 Rev. 11	2.3.5 <u>Release Rate</u> . Release rate as defined in Paragraph 2.1.4 should be sufficient to prevent overstressing of the piping or component.	

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Level	Document	Statement	Comments
CRITERION CATEGORY: RELEASE RATE			
C	NE E 7-9	<p>3.2.1.c <u>Release Rate</u>. The release rate is defined as the rate of snubber movement under load after the snubber is activated. The release rate may be dependent on the applied load and expressed in terms of the rated load, in which case the release rate shall not exceed X_B, where:</p> $X_B = 0.50 \times \frac{\text{Rated Load}}{\text{Component Weight}} \text{ in./min}$	

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Level	Document	Statement	Comments
CRITERION CATEGORY: SPRING RATE			

C GE 21A3502 4.3.4.4.1
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- j. The snubbers shall have, as a minimum, the following effective, average spring constants; measured pin-to-pin and under dynamic load conditions between 3 and 33 Hz:

10K snubber - 250 kips/inch
 20K snubber - 400 kips/inch
 30K snubber - 400 kips/inch
 50K snubber - 600 kips/inch
 70K snubber - 800 kips/inch
 100K snubber - 800 kips/inch

The effective average spring constant shall be calculated based on the maximum deflection at the rated load in tension and compression at the specific input frequency. The deflections are to be measured in a dynamic test using a minimum length adjustable snubber.

C ITT Grinnell 4.13 Minimum pin to pin dynamic spring rates, including free displacement (clearances) and elastic deflection of the pins themselves shall be as follows:
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Min. Pin to Pin Spring Rate (kips/in.)

<u>Size (kips)</u>	<u>At 75°F</u>	<u>At 200°F</u>
1	32	30
3	78	71
10	140	120
25	420	380
45	610	510
70	910	730
110	1330	1200

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CRITERION CATEGORY: SPRING RATE			
A	NE E 7-9	2.2.5 <u>Spring Rate</u> . The spring rate is a simplified expression of the load-displacement characteristics of the snubber. The definition of spring rate has been extended to include the combined stiffness of all hardware including, but not limited to, clamps, extension tubes and end-fitting hardware. The spring rate may vary as a function of the frequency and the magnitude of the applied load.	
A	NE E 7-9	2.2.5 Overall stiffness of the snubber assembly is generally not controlled by the snubber stiffness but instead by the stiffness of associated hardware such as clamps, pins, extension tubes, etc. In light of evaluating overall snubber assembly stiffness, it is apparent that the method selected for evaluating snubber stiffness (frequency or nonfrequency dependent) will have minimal effect on calculated overall stiffness.	
A	NE E 7-9	3.1.2 <u>Stiffness Requirements</u> . Minimum support stiffness requirements are recommended to maintain system response within acceptable limits. The support stiffness is the effective or combined stiffness of all the hardware between the geometric center of the component/pipe being supported and the location of the ground structure. Support stiffness shall be based on, but not limited to, snubber, snubber extension, flexibility of structural members, clamp/fittings and component distortion (it can usually be ignored).	

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CRITERION CATEGORY: SPRING RATE			
B	NE E 7-9	<p>3.1.2 The combined stiffness of the support assembly should not be less than 20 times greater than the stiffness of the pipe/component at the point of application. Pipe/component stiffness is expressed as:</p> $k_{\text{pipe}} = \frac{1}{(\text{pipe flexibility})}$ <p>The pipe flexibility represents the deflection produced by a unit load at the geometric center of the component at the plane of attachment, with other snubber locations having assumed rigid supports. Therefore:</p> $\frac{1}{k_{\text{snubber}}} + \frac{1}{k_{\text{clamp}}} + \frac{1}{k_{\text{support}}} + \dots = \frac{1}{20 k_{\text{pipe}}}$ <p>The individual stiffness calculations required for the above expression are made without consideration to clearance. The snubber stiffness is based on its structural compliance which is independent of frequency (or frequency 0 Hz).</p>	

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CRITERION CATEGORY: SNUBBER DESIGN			
A	ASME NF-3 Rev. 11	2.3.3 <u>Stroke Length</u> . The stroke length should include the thermal movement, erection tolerances, and an additional length as a margin of safety.	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.1 Designed for extended life and corrosion resistance with no scheduled seal replacement.	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.2 Radiation and temperature resistant fluid and seal material (10 ⁸ gamma rad, dosage, 250°F operability).	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.3 Temperature stable velocity limiting control valve (tamper-proof, unlocks immediately).	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.4 Sealed fluid reservoir (non-attitude sensitive, non-contaminated, fluid level indicator, spring loaded metal bellows accumulator / no dynamic seals).	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.5 Piston Position / Fluid Level Indicators (in service inspection).	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.6 Travel Stop (tamper-proofs cold piston settings).	

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Level	Document	Statement	Comments
CRITERION CATEGORY: SNUBBER DESIGN			
A	ITT Grinnell PHD-7556-7S Rev. 2	3.7 Few external hydraulic fittings (metal seals, corrosion-resistant).	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.8 Stainless steel piston rod (corrosion-resistant, lower thermal conductivity).	
A	ITT Grinnell PHD-7556-7S Rev. 2	3.9 Stainless steel spherical bushings and attachment pins (corrosion-resistant, tight tolerances, staked bushing race for lateral seismic loads).	
A	ITT Grinnell PHD-7556-7S Rev. 2	4.8 Allows for simultaneous thermal movement of piping during seismic (dynamic) events, without excessive buildup of loads.	
A	ITT Grinnell PHD-7556-7S Rev. 2	4.9 Allows immediate free pipe thermal movement after a dynamic event.	
B	ITT Grinnell PHD-7556-7S Rev. 2	4.10 Designed for 6.5 g seismic lateral load capacity.	
B	ITT Grinnell PHD-7556-7S Rev. 2	4.11 Operability following simulated LOCA (loss of coolant accident) at 350°F, all steam for 72 hours.	

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CRITERION CATEGORY: SNUBBER DESIGN			
A	ITT Grinnell PHD-7556-7S Rev. 2	4.15 Non attitude sensitive fluid reservoir with a marked external indicator rod for fluid level. Metal bellows construction with metal gasket seals.	
A	ITT Grinnell PHD-7556-7S Rev. 2	4.16 Piston position indicator rod with marking for indication of stroke position of the piston. Used for correlation with minimum allowable fluid level in the reservoir for stroke position.	

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CRITERION CATEGORY: SNUBBER COMBINATIONS			
B	ASME NF-3 Rev. 11	<p>4.2.3 <u>Snubber Combinations</u></p> <p>a) Snubbers should not be used at more than one point of restraint on straight pipe runs to absorb an axial dynamic force unless simultaneous activation is provided.</p> <p>b) Multiple snubbers may be used at one point of restraint if simultaneous activation is provided.</p>	
A	ASME NF-3 Rev. 11	4.2.2 Rigidity of the restrained piping system and component shall be considered since deflection of the piping system and component is required to activate the snubber.	
-	NE E 7-9	<p>3.3.1 <u>Multiple Snubber Supports</u>. A multiple snubber support exists when more than one snubber is used at a support location to apply restraint in a given direction. Specific problems to be addressed with multiple snubber supports include:</p> <ol style="list-style-type: none"> 1) Snubber load sharing. 2) Effects on system response of replacing a single large snubber with several smaller snubbers. 3) Effects of snubber mismatch on component or system stresses. 	
-	NE E 7-9	3.3.1 Load sharing is a strong function of mismatch of lost motion and end fitting clearances and a lesser function of mismatch of activation level and release rate.	

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CRITERION CATEGORY: SNUBBER COMBINATIONS			
C	NE E 7-9	3.3.1.a <u>Clearance / Lost Motion</u> . The differential clearance / lost motion between any two snubbers shall not exceed 0.02 inches.	
C	NE E 7-9	3.3.1.b <u>Activation Level</u> . The differential between any two snubbers shall not exceed (10 in./min) (0.005 g), or 50% of the smallest activation level.	
C	NE E 7-9	3.3.1.c <u>Release Rate</u> . The differential between any two snubbers shall not exceed (10 in./min) (0.005 g), or 100% of the smallest release rate. The maximum release rate shall not be less than 4 in./min or 0.001 g.	
B	NE E 7-9	3.3.1.d <u>Load Sharing</u> . The peak snubber load shall be assumed to be 1.2 times the average snubber load (total support load divided by the number of snubbers).	
B	NE E 7-9	3.3.2 <u>Axial Restraints</u> . Snubbers should not be used at more than one point of restraint on straight pipe runs to absorb an axial dynamic force unless simultaneous activation is provided.	
B	NE E 7-9	3.3.3 <u>Snubbers in Series</u> . Snubbers in series can be used only if all single snubber requirements are met by the paired assembly.	

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CRITERION CATEGORY: STORAGE & HANDLING			
A	NE E 7-9	6.1.1 Storage areas at the vendor's facility or at the construction site shall meet the requirements of ANSI N45.2-1972, Section 6.1.2, Level C, as a minimum.	
A	NE E 7-9	6.1.2 Each snubber made to this standard shall be cleaned, packaged, and packed to assure delivery in a clean, undamaged condition.	
A	NE E 7-9	6.1.3 Design of packaging, packing, and provisions for storage shall be based on a maximum of 2 years in storage with no effect on snubber performance.	
A	NE E 7-9	6.1.4 Lifting and handling devices used during shipping, storage and installation shall have concurrence of vendor, purchaser and constructor that they minimize the hazard of physical damage from any conceivable accident.	

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A P P E N D I X D

P R O P O S E D F U T U R E

S N U B B E R S T U D I E S

D1. SNUBBER MALFUNCTION STUDY1.0 INTRODUCTION

The test program will determine the effects of sub-component malfunction failure on the operability of the snubber. It will yield valuable information regarding snubber failure modes and operability during both active and passive modes of operation. Several snubber designs will be studied (See 4.2 TEST HARDWARE for snubber descriptions).

2.0 TEST JUSTIFICATION

Snubber failures have created major concerns regarding nuclear plant safety. Locked failure modes create the potential for high thermal expansion stresses while free failure modes compromise the seismic restraint integrity of the system. In addition to the completely fixed or completely free failure modes, snubber malfunctions affect snubber operability by increasing drag loads or reducing restraint capability. The object of this test program is to evaluate the effects of sub-component malfunctions or failures on snubber operability.

Based on the above observations the following two specific test objectives have been identified:

- 1) Determine effects of sub-component malfunction or failure on the operability of the snubber for both seismic and non-seismic (e.g.,

vibratory) applications.

- 2) Determine effects of sub-component malfunction or failure on the operability of the snubber as a passive element.

3.0 METHODS

The test program consists of comparing system response of the simulated piping system described in 4.1 with a fully operable snubber and that of the same system with a "failed" snubber. System displacement response, snubber loads and piping stresses will be examined when evaluating the operability of the snubbers in their active mode. Snubber friction loads will be measured to evaluate the operability of the snubbers in their passive mode. The program will consist of the following elements:

- 1) Both high and low sinusoidal sweeps from 1 to 33 Hz will be performed. System response characteristics and system damping can be determined from this test.
- 2) Seismic tests will be conducted with random motion being input to the structure. The operability of the snubber as a seismic restraint will be evaluated.
- 3) Impulse tests will be conducted to determine the capability of the snubber to act as a shock restraint.

- 4) A progressively increasing velocity or acceleration motion to simulate piping thermal expansion will be input to the simulated piping system. This test will permit evaluation of the snubber as a passive element.

4.0 DISCUSSION OF APPROACH

4.1 DESCRIPTION OF SIMULATED PIPING SYSTEM

The test system is an existing hardware configuration that was used in the Single Versus Multiple Snubber test program (Reference 1). The test facility is located at the Autonetics Division of Rockwell International in Anaheim, California. The system is ideally suited for meeting test program objectives from a structural as well as financial standpoint. Fabrication costs will be minimal since 95% of the required hardware exists.

Figures 4.1.1 through 4.1.3 show sketches of the test facility in its present configuration. Instrumentation locations are indicated on Figure 4.1.4. The system is a 10 foot long beam (6 inch diameter, 0.5 inch wall tube) cantilevered from a hydraulic shaker table, oriented parallel to the ground with a 1000 pound mass at the end. A snubber attachment is located 4 1/2 feet from the base. The snubber loads are transmitted from the cantilevered beam through the snubbers to a strongback structure attached to a 50,000 pound seismic mass.

The test system has several desirable features. Large snubber loads and system deflection and stresses can be developed. Snubber loads in excess of 30,000 pounds, piping stresses of approximately 50,000 psi and displacement response of 0.75 inches can be developed at the snubber attachment.

The dynamic characteristics of the simulated piping system are similar to those of short to intermediate length piping systems found in nuclear plants - 4.5 Hz unrestrained natural frequency and 7.5 Hz with a snubber support.

4.2 TEST HARDWARE

Based on review of Licensee Event Reports (LER) and discussions with snubber manufacturers, nuclear plant constructors and consultants the following 4 snubber designs have been selected for this study.

- 1) Pacific Scientific, Mechanical Snubber
(Acceleration Activation)
- 2) Bergen Patterson, Hydraulic Snubber
(Poppet Valve, Velocity Activated)
- 3) E-Systems, Hydraulic Snubber
(Restricted Orifice)
- 4) Sanwa Tekki or Bergen Patterson, Mechanical Snubber

4.3 TEST SEQUENCE AND LOGIC

The objective is to verify snubber operability in both its passive and active modes. The test sequence is as follows:

- 1) The response of a fully operable snubber shall be evaluated when installed in the simulated piping test system. The following tests shall be performed:
 - (a) A low and high level sine sweep at 2 octaves/minute from 1 to 33 Hz shall be input at the shaker table. The low level sine sweep shall be at 0.2g and the high level sweep shall be at 0.5g. The sine sweep may be input from 33 - 1 Hz if manual control is difficult.
 - (b) Both high and low seismic loadings shall be input. The seismic input waveform shall correspond to the 1940 El Centro earthquake. The low level seismic input will be 50% of that given in Figure 4.3.1 and the high level input will be 100% of the specified level.
 - (c) An impulse loading shall be input to the test article. The impulse waveform is to be determined.
 - (d) A sub-component failure or malfunction is to be produced in the snubber as described in 4.4. The tests described in 1(a),

1(b), and 1(c) shall be performed with the "failed" snubber. The sequence shall be repeated as many times as necessary to examine all postulated failures described in 4.4.

- 2) Seismic and impulse loads shall be "programmed" to insure that input is repeatable within reason for all snubber configurations tested.

4.4 SNUBBER MALFUNCTIONS

Table 4.4.1 summarizes the malfunctions that will be studied during this program.

4.5 DATA

4.5.1 Data Handling

The data will be recorded on voice annotated FM magnetic tape for processing and data reduction at a later date. This would facilitate later playback to plotters and equipment compatible with ETEC equipment. The data will be recorded in a manner which will permit exact alignment of each data trace thus permitting simultaneous review.

4.5.2 Photographs

Photographic coverage shall be provided in sufficient detail to

show the test fixture, the test instrumentation and the test articles. The photographs shall clearly depict the desired subject so as to be meaningful to reviewing personnel.

4.5.3 Final Report

ETEC will provide the results of this test program in a Topical Report. The final report shall include the test procedure (to be prepared by the Test Performer), fixture drawings and sketches, a detailed list of instrumentation used including manufacturer, model, range, calibration interval and date, description of test hardware, pertinent information relating to test setup and procedures, and results of the tests. A final test report will be submitted in addition to a Topical Report.

5.0 COST & SCHEDULE

5.1 COST

Estimated cost in 1982 dollars \$140,000

5.2 SCHEDULE

Hardware Procurement (Snubbers)
 Identification of Malfunction
 Fabrication of Special Hardware
 Perform Test
 Evaluation of Data and Report
 Writing

Figure 4.3.1 Required Response Spectra

Table 4.4.1 Malfunctions to be Studied

SNUBBER MANUFACTURER	TYPE*	MALFUNCTION
Pacific Scientific	M	Broken Capstan Tang Broken Capstan Spring Loss of Lubricant
Bergen-Patterson	H	Frozen Poppet Valve Broken Poppet Spring Air in System
E-Systems	H	Loss of Reservoir Pressure Air in System
TBD	TBD	TBD

*M: Mechanical

H: Hydraulic

TBD: To Be Determined

Figure 4.1.1 Plan View of Test Hardware

Figure 4.1.2 Snubber Characterization Fixture

Figure 4.1.3 Snubber Attachment Locations

Figure 4.1.4 Instrumentation Placement

IMPERIAL VALLEY (EL-CENTRO) 1940 ACCEL. (500E) TIME INC. = .02 SEC

*0717626-10
052478 0002

Figure 4.3.1 El Centro Acceleration Seismic Input

D2. SNUBBER DRAG LOAD STUDY

1.0 INTRODUCTION

In the nonactivated condition, snubbers characteristically exert a drag resistance to motion. It is current industry practice to specify an upper limit drag resistance of 1 to 2% of rated load for snubbers used as seismic restraints on piping systems. The basis for the current drag limit appears to be largely judgemental and undocumented. It is presumed that drag loads which do not exceed the drag limit will not result in significant piping stresses during thermal expansion. The validity of this assumption needs to be checked so that meaningful drag limits can be established. In addition, the possibility exists that since increased drag load could result from wear and/or friction, drag load data could provide an indication of incipient failure to meet other snubber parameter limits.

The objectives of this study are to assess the adequacy of current drag limits by evaluating the impact of drag on thermal expansion stresses (nozzle loads), evaluate the significance of drag on snubber reliability by correlating Inspection and Surveillance I/S Test data on a service life basis, evaluate potential cost impact of drag limit revisions, and perform snubber tests to validate service life.

2.0 TEST JUSTIFICATION

Current drag limits are arbitrary and may not be restrictive enough to avoid increases in thermal expansion stresses that could compromise reliability where margins are slight. Conversely, the imposition of excessively restrictive drag limits could force unnecessary repair and/or replacement with associated plant operating cost impact. Verification of appropriate drag limits is needed to resolve these uncertainties concerning the effect of drag load limits on thermal expansion stresses and nozzle loads.

In addition, the significance of drag resistance relative to snubber performance has not been clearly established. Prior analytical studies suggest that friction does not exert a significant influence on the dynamic response of snubbers hence if it is verified by test results that the analytical conclusion that the drag load effect on thermal expansion stresses/nozzle loads is not significant, only indirect effects remain to be considered. Since frictional drag is likely to be sensitive to wear, drag load could provide an advance indication of impending changes in activation level or in other snubber performance parameters. Such advance warning could provide a basis for replacement of snubbers to meet specified performance limits and can accelerate the (I/S) schedule with major cost impact due to associated plant shut down costs. Replacement of snubbers at imminent failure could reduce plant downtime and enhance system reliability. For hydraulic snubbers where viscous drag could be predominant, drag is less likely to be wear sensitive.

3.0 METHODS

3.1 EFFECT OF DRAG LOAD

The adequacy of current drag limits will be assessed by evaluating the increase in stresses and nozzle loads that results from the addition of drag loads to the thermal expansion analysis. Conventional linear piping analysis will be used to determine the increased stresses/loads at various levels of drag load for three pipe sizes in a representative piping configuration. Drag loads will be oriented in the most adverse direction to obtain an upper bound. Initial analysis runs will be used to locate dead weight supports. A thermal expansion analysis without drag loads will be run to establish reference stress/load levels. Seismic analysis will be run to establish appropriate locations and sizes for snubbers. The thermal expansion analysis would then be repeated with added drag loads (at various fractions of rated load) to determine the increase in stress and loads. The increases in stresses and loads will be considered relative to stress allowable to assess the need for revised drag limits or for additional design guidance relative to snubber selection and location.

3.2 DRAG IMPACT ON SNUBBER RELIABILITY

The correlation of I/S test data with service life will be examined to assess trends of drag load and other snubber characteristics that might reflect increased friction or wear and could impact snubber reliability. Alternative

parameters such as accumulated stroke motion, the product of plant power cycles and design stroke length, and full power hours of operation are being considered as measures of service life. Service environment will also be considered in the correlation to account for dust, moisture, and vibration effects. One goal of the correlation study is to develop a predictable drag-time (service life) curve that would provide a reliable basis for sensing impending deficiencies in snubber performance. Drag-time curves for snubbers in comparable service environments will indicate variability which is relevant to selecting appropriate drag limits and I/S intervals. Since drag can be indicative of friction or wear, a strong correlation of drag with other snubber performance parameters could establish increased drag as an advance indication of failure. A consistent drag-time curve could be the basis for replacing snubbers before they exceed performance limits resulting in increased reliability, reduced downtime and corresponding cost savings.

3.3 ECONOMIC IMPACT OF SNUBBER PERFORMANCE LIMITS

With established curves for variation of snubber characteristics with time, the effect of revised performance limits can be transformed into revised failure rates which can be costed to assess economic impact. Failure rates consistent with a normal shutdown schedule would have minimum impact while higher failure rates would increase downtime with major cost impact. Some characterization of representative operating service conditions is required as part of the transformation of drag-time curves to failure rates.

3.4 VALIDATION OF PERFORMANCE-TIME DATA

In order to validate the performance-time curves, five snubbers of an identical type and size (load rating) will be cyclically stroked to failure. Failure will be deemed to occur if any of the snubber performance limits are exceeded. Stroking will be done at a rate such that 90% of the activation level is not exceeded. Principal test variables are length of the test stroke and the test environment. Three tests will be run in clean, dry air environment, one test will be run in a dusty environment, and the last test will be run in a humid environment.

4.0 DISCUSSION OF APPROACH

4.1 STUDY OF DRAG LOAD EFFECT

The configuration in Figure 4.1 will be analyzed for three sizes of piping (2 in., 8 in., and 24 in.). The length of individual pipe runs will be adjusted by the square root of the ratio of the diameters. The dead weight, seismic, and thermal expansion analyses with and without drag will be performed.

4.2 STUDY OF EXISTING SNUBBER PERFORMANCE DATA

Discussions with NRR personnel indicate that functional performance data are recorded at the plant site but are not reported except in general terms in Licensee Event Reports (LER) when failures occur. Site visits will be made to

collect snubber functional test data along with data available to characterize the individual snubber service experience. A standard format will be developed for collecting the data which will be analyzed to determine relationships between snubber parameters and service life characteristics.

4.3 ECONOMIC IMPACT STUDY

The conceptual transformation of performance-time relationships into a performance characteristic failure rate curve is illustrated in Figure 4.3a. The effects of the performance limit and the shape variability of the performance-time curve on the failure rate are obvious.

Snubbers installed in a particular power plant will accumulate different distances of travel depending upon their specific location within a system and upon the operating history of that system. Conceptually, for a scheduled operating sequence, it would be possible to construct a service life distribution as shown in Figure 4.3b for any time t in the plant life.

Between the two figures and considering sampling effects, the expected number of snubber failures can be determined for the given plant life t . This would establish the maximum period to the next surveillance inspection. In addition to the direct replacement costs for the failed snubbers, the cost of power loss due to increased downtime will be included.

The cost impact for various performance limits and performance-time curve variability can be found by repeating the transformation calculations at other

conditions.

4.4 VALIDATION OF PERFORMANCE-TIME CURVE

The existing test facility will be used to impose sinusoidal displacement cycles at a rate such that 90% of the activation level is not exceeded. Five snubbers of the same type and size will be subjected to the following test sequences:

- 1) Apply prescribed extension, followed by 100 oscillations with a range equal to 1/4 of the initial extension, apply prescribed contraction, followed by 100 oscillations with a range equal to 1/4 of the initial extension, repeat the preceding cycle 25 times and then run characterization test.
- 2) Repeat test sequence 1) until one or more of the snubber performance parameters exceeds the specified limits.

Test 1 - equal extension and contraction of 1/2 inch

Test 2 - equal extension and contraction of 1 inch

Test 3 - equal extension and contraction of 2 inches

Test 4 - repeat Test 3 in dusty environment

Test 5 - repeat Test 3 in moist air environment.

5.0 COST AND SCHEDULE

5.1 COST

Estimated cost in 1982 dollars - \$120,000.

5.2 SCHEDULE

Figure 4.1 Pipe System Geometry

Figure 4.3a

Figure 4.3b

D3. SNUBBER SENSITIVITY STUDY

1.0 INTRODUCTION

The existing study of snubber response sensitivity considered only acceleration-activated mechanical snubbers and poppet valve hydraulic snubbers. New snubber designs are being produced which include velocity-activated mechanical and orifice hydraulic snubbers. Response of the new designs could differ substantially from current snubber types.

2.0 JUSTIFICATION

Response differences of the new designs could reflect substantially different sensitivity to snubber parameters which may require modification of current criteria to achieve satisfactory snubber performance. Response differences could shift the relative criticality of failure modes or reveal failure modes which previously were not apparent.

3.0 METHODS

Computer and closed form solutions of simple structural models will be obtained in order to examine response sensitivity. Consideration will be given to activation level, release rate, stiffness, lost motion, drag or friction loads, and fluid properties when applicable. Designs that will be considered are the velocity activated mechanical snubber and the restricted orifice hydraulic snubber.

4.0 DISCUSSION OF APPROACH

The computer and/or mathematical models will use the same four forcing functions that were used in ETEC-TDR-78-17 (Snubber Sensitivity Study, Final Report FY78). This will provide a common base to permit correlation with the previous study.

The results of the snubber response characteristics studies will be used to evaluate the impact of these two new type snubbers on existing snubber criteria. Emphasis will be placed on establishing acceptable ranges of pipe stress, displacement and snubber loads for frequency range of 3 to 33 Hertz.

COST & SCHEDULE

5.1 COST

Estimated cost in 1982 dollars \$120,000

5.2 SCHEDULE

- 1) Identify Snubber Parameter
- 2) Make Snubber Analytical Models
- 3) Evaluate Response Sensitivity
- 4) Establish Acceptable Limits for
the Snubber Parameters
- 5) Final Report

D4. MULTIPLE AXIAL SNUBBERS

1.0 INTRODUCTION

Due to the relatively high stiffness of the pipe along the pipe axis, multiple axial snubbers act in parallel so that mismatch of snubber characteristics will result in perturbations in the snubber response. Early activation of a snubber will cause it to react a greater proportion of the total load and in some cases might exceed the rated load of the snubber. In addition, with the snubbers acting individually during a portion of the loading cycle, the effective stiffness is likely to be lower than nominal so that the maximum response is likely to be greater. Current design practice for multiple axial snubbers on straight pipe runs ranges from a prohibition of multiple axial snubbers to the specification of simultaneous activation with or without an arbitrary tolerance. Arbitrary load distribution factors are also applied which effectively reduce the design load capacity of the snubber.

The objective of this study is to establish appropriate guidelines and limitations on the use of multiple axial snubbers based on analysis and confirmatory testing.

2.0 JUSTIFICATION

Since axial snubbers are most effective means of restraint of axial motion, excessively restrictive limits on the use of multiple axial snubbers is likely to increase the total number of snubbers required with corresponding increased initial snubber costs as well as subsequent increased surveillance/replace-ment costs. Conversely, load distribution factors which are overly optimistic for the specified mismatch in snubber characteristics could result in snubber overload that could compromise system reliability. The wide range in current design practice on multiple axial snubbers reflects the urgent need for validated design guidance.

The analytical and experimental studies will provide a firm basis for establishing minimum values of response amplification and load redistribution relative to the magnitude of the mismatch between snubber parameters (i.e. activation level, dead band, stiffness, and drag load). The need for additional qualification testing for paired snubbers will be assessed.

3.0 METHOD

3.1 ANALYTICAL STUDY

Due to the relatively high stiffness along the pipe axis, the pipe can

be modeled by a single mass and spring while the essential mismatch can be represented with two parallel snubbers. Incremental time history analysis will be used to obtain the maximum response of snubbers with identical or mismatched characteristics as a measure of the effect of mismatch. Mean and standard deviation of the individual snubber characteristics (activation level, dead band, drag load, and stiffness) from existing Qualification and Inspection/Surveillance test data will be used to determine the two sigma value for the respective mismatch parameter. The effect of mismatch parameters will be evaluated separately in order to evaluate the snubber response sensitivity to each mismatch parameter. These data would be useful for design improvements to enhance snubber simultaneity. The statistical combination of the effects of individual parameters will provide design limits on the expected response amplification and load redistribution.

3.2 VALIDATION TESTS

The objective of this effort is to validate or refine design guides for the use of multiple axial snubbers with respect to response prediction. A test matrix will be set up to include the more significant of the snubber performance parameters. The significance of snubber parameters will be assessed from results of the correlation study of Surveillance Test data proposed as part of the drag load study. For example, an existing sensitivity analysis and dual snubber test data suggest that snubber response is sensitive to dead band motion, but insensitive to drag load over a wide range of values.

Some modification of the existing test fixtures or facility will be required since previous testing indicated an extraneous torsional response that parallel (multiple axial) snubbers would be likely to excite. It is anticipated that test snubbers will be selected to maximize the range of significant snubber characteristics and that analysis of variance would be used to assess interaction effects.

4.0 DISCUSSION OF APPROACH

4.1 ANALYTICAL STUDY

Since the principal need for paired snubbers is for axial restraint of long runs of straight pipe, the essential characteristics of the problem can be represented by modeling the straight pipe as a single mass and spring restrained by two snubbers in parallel. Each snubber is modeled by a group of four elements; the combination of a lockup (snubber activation) element in parallel with a viscous drag element in series connected to a gap element and a spring element. The system models are shown in Figure 4.1.1.

FIGURE 4.1.1 SNUBBER MODELS

The incremental time history method will be used to calculate the dynamic response for various degrees of mismatch. Due to the elemental nature of the system, a special purpose computer program is judged to be most effective for this study. The program will be checked out by comparison with classical solutions for a single degree of freedom system subjected to specific force time histories. Preliminary studies may neglect drag forces for convenience in checking the program. Those mismatch parameters which are found to be significant will be correlated with response amplification and load redistribution for comparison with validation test data.

If the design load factors used for multiple axial snubbers are too low, the potential for snubber overloading is increased with some attendant decrease in

reliability. Conversely, if the design load factors are too high, the number of axial snubbers increase or snubbers are added beyond the elbows at the end of the straight run. With an increase in the number of axial snubbers, the probability of overloading failure is reduced but the probability of failure due to other causes is increased. In the case where the axial load is reacted by support(s) beyond the elbows at the end of the run, the stress in the elbow is aggravated. However, a large data base is needed to assess the enhanced reliability with any degree of accuracy so that the cost benefit is difficult to estimate.

4.2 VALIDATION TESTS

Multiple axial snubbers have basically the same loading condition as that of paired snubbers except that axial snubbers tend to be skewed rather than parallel to the pipe axis due to structural restraint limitations. Multiple axial snubber tests are needed to assess the potential for increased interaction of mismatched snubber parameters with the skewed load component. Modification of existing test facility/fixtures will be required to accommodate the skewed load components. In addition, some duplication of previous paired snubber tests may be needed to resolve observed anomalies.

In order to optimize the test matrix, it is proposed to defer these tests until the results of the site survey of performance test data are available.

5.0 COST AND SCHEDULE

5.1 COST

Estimated cost in 1982 dollars \$140,000

5.2 SCHEDULE

See Table 5.2.1

TABLE 5.2.1

D5. EVALUATION OF SNUBBER QUALIFICATION TEST REQUIREMENTS**1.0 INTRODUCTION**

Prototypic piping systems are subject to a wide range of operating conditions. Some lines are subject to regular cyclic motion as a result of power level changes or to repeated startup/shutdown cycles due to on/off mode of system operation. For other lines, including a number of safety lines, there is virtually no fluid flow except during shutdown and recovery from upset operating conditions.

Current practice for qualification testing is to perform breakaway and drag tests after stroking of the snubber or, in some cases, after activation and release rate tests have been completed. However, experience indicates that greater breakaway loads are obtained after a period of inactivity. This condition would be typical of lines with normally stagnant flow as mentioned previously.

Also, under current qualification procedures, snubbers are generally immobile during environmental exposure. Although the test environments are quite severe, total immobility of the snubber while subject to adverse environmental conditions is unlikely for many snubber applications. Partial stroking of snubbers is quite common due to pipeline thermal motions in response to plant

operating temperature cycles. Stroking in conjunction with adverse environment could be more detrimental than stroking after environmental exposure and subsequent cleaning.

2.0 JUSTIFICATION

Qualification testing in a more benign environment or in a less detrimental sequence than the service conditions could result in unanticipated service failures. Experience suggests that the current qualification test sequence can be less severe than service conditions and modification may be required to assure snubber reliability. The effects of the sequential order of qualification testing, of joint variation of test parameters, and the validity of accelerated aging assumptions are to be considered in this study.

3.0 METHOD

Snubber qualification parameters (activation level, dead band, stiffness, release rate, breakaway load, and drag load) will be measured during variations of testing sequence and then compared to assess relative severity of individual tests of the different phases of qualification testing, of varying the duration of intervening hold periods, and of running combined rather than individual parameter tests (e.g., environment with stroking, environment with vibration, etc.). Comparisons will be made between successive tests on the

same snubber to exclude variability between snubbers. Sequential order will be alternated to indicate order and/or wear effects.

4.0 DISCUSSION OF APPROACH

Data from the performance-time tests performed as part of the drag load study will be used to the extent possible as a reference data base. Since the performance-time data will reflect wear as well as data variability, some additional reference testing may be necessary. Cost and schedule estimates will be provided when the scope of additional reference testing is established. The alternative to repeated measurements on a specific snubber (which includes wear effects) is comparable acceptance measurements on a large population of snubbers (which includes the variation of characteristics between snubbers). Acceptance testing is not generally specified so data of the latter type are likely to be scarce.

5.0 COST & SCHEDULE

5.1 COST

Estimated cost in 1982 dollars \$250,000

5.2 SCHEDULE

D6. IDENTIFICATION AND EVALUATION OF EXISTING TEST DATA1.0 INTRODUCTION

The accuracy of seismic response predictions for piping is dependent on the adequacy of the analytical modeling of piping supports. Two types of tests have been run that are relevant to snubber modeling, snubber qualification tests and piping loop response tests. The primary purpose of the qualification test is to enhance snubber reliability by verifying that the snubber performance parameters fall within prescribed limits. However, the snubber model parameters are generally constructed from or based on qualification test data. Studies have been made of the correlation of analytical predictions of individual snubber response with qualification test data to assess the adequacy of various analytical models for snubbers. Since individual snubber tests such as qualification tests do not reflect any interaction of snubbers with other parts of the support train (i.e., pipe clamps, pins and clevis parts, extension rods, and structural support steel), piping loop tests have been run to assess overall system response. The effects of non-linear characteristics such as clearances are difficult to assess analytically with confidence.

Experience indicates that design features which are specific to particular snubber configurations may limit their effectiveness or reliability under certain applications. Some snubber configurations are susceptible to increased wear by repeated stroking without activation

while other snubber configurations may be more adversely affected by repeated activation and release cycles. The combined effects of clearances and stiffnesses in the full support train (clamps, end fittings, etc.) could shift the snubber response into an adverse operating mode or a badly imbalanced load distribution. Pipe loop response data appear to be the most effective means to resolve these uncertainties, but care in the data interpretation is necessary due to unequal scaling of the pipe loop components.

2.0 JUSTIFICATION

Snubber parameter limitations on the use of linear seismic analysis have been proposed based on analytical studies. Review of existing pipe loop response data is needed to validate or to refine these proposed limits.

Pipe loop response tests are generally restricted to small or moderate pipe sizes due to facility limitations. In some instances, many of the pipe loop dimensions have been selected so that the moderate size piping represents a scaled down simulation of a large size piping configuration.

However, snubbers, pipe clamps and end fittings, and especially tolerance/clearance and friction aspects are extremely difficult to scale. A critical review of these data is required to assess the adequacy of the simulation and the

appropriateness of conclusions based on partially scaled test data. The review will give careful consideration to the basic snubber mechanism (hydraulic poppet valve, mechanical capstan, mechanical friction disc) in assessing analytical models for snubber response.

3.0 METHOD

Of the more recent loop tests run to measure vibratory response, "typical" 1 and 4 inch piping loop tests by HEDL and a 1/4 scale test of the MONJU hot leg (8 inch pipe size) by the Japanese have been completed and a "typical" 8 inch pipe loop test is being conducted by Westinghouse ARD. A literature search will be made to extend the collection of pipe loop response data. The extent of comparative assessment of analytical snubber models will be reviewed and the consistency of conclusions between the various tests will be assessed. Should the snubber model evaluation appear less than adequate, supplementary correlation analyses will be considered.

4.0 DISCUSSION OF APPROACH

Variation in the dynamic response of a piping loop that results from unrecognized parameters or from parameters that are not amenable to systematic control (i.e., friction, damping) may obscure other trends and may be attributed to data scatter. Comparative review of independent

tests has the potential for revealing response variations by means of; differences in testing methods (multiple excitation inputs vs. rigid fixture excitation), different snubber designs (mechanical capstan type vs. mechanical friction disc type), and different attachment designs (clearance, etc.). However, test parameters are so numerous that direct comparison does not seem feasible. Furthermore, direct application of scale test results to prototype piping loops may be questionable since friction, damping, and clearances are not susceptible to accurate scaling. Scaling of snubbers is not practical so correlation through analytical modeling is the only practical basis for comparison.

5.0 COST & SCHEDULE

5.1 COST

Estimated cost in 1982 dollars - \$60,000.

5.2 SCHEDULE

D7. REVIEW OF NON-FUNCTIONAL REQUIREMENTS FOR SNUBBERS1.0 INTRODUCTION

"Non-functional" requirements, such as cleaning, painting, lubrication, packaging, and marking, are often extracted from specifications developed for other than snubber applications. These non-functional requirements may not consider unique aspects of snubber operation. For example, conventional surface preparation procedures (blast cleaning, painting, etc) may compromise surface conditions that are critical to performance for some types of snubbers. Degreasing solutions or lubricants could prove to be incompatible with snubber seals or other snubber components at operating temperature.

2.0 JUSTIFICATION

The basis for non-functional requirements needs to be critically reviewed with respect to snubber functional characteristics to assess the potential for operational problems. Radiation effects on seal materials and the incompatibility of austenitic stainless steel with halides are relatively obvious but potential aging effects on the frictional characteristics of sliding surfaces or the potential clogging of tight internal clearances due to deterioration of paints may be less apparent.

3.0 METHODS

A literature search of existing Mil Specification and Standards, ASTM Specifications, MSS Standard Practices, Federal Specifications and Standards, etc., will be made in regard to deterioration of different materials due to their service environments.

The following specific items will be considered:

- (1) Galvanic action of dissimilar materials
- (2) Corrosion
- (3) Oxidation
- (4) Galling
- (5) Radiation
- (6) Hydraulic Fluid
 - a. Compatibility with seals
 - b. Stability
 - c. Fire Resistance
 - d. Foaming
- (7) Surface treatment (paint, sand blasting etc.)
- (8) Maintenance, Dusting, Greasing, and Fluid Level
- (9) Packaging & Storage
- (10) Installation

4.0 DISCUSSION OF APPROACH

A matrix covering the 10 items mentioned in Section 3 will be made. It will list the major prohibitions and/or lack of information concerning a specific item for the materials that are presently being used in the manufacture of snubbers. This matrix will serve as a guide or checklist for all existing and new snubbers.

5.0 COST & SCHEDULE

5.1 COST

Estimated cost in 1982 dollars - \$80,000.

5.2 SCHEDULE

1. Literature Survey
2. Obtain & Review Reports
3. Fill in matrix
4. Final Report