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Analysis of Owner Design Specifications for Snubbers Report 2

J. H. Butler

Prepared for the U.S. Nuclear Regulatory Commission
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ANALYSIS OF OWNER DESIGN SPECIFICATIONS FOR SNUBBERS

REPORT 2

J. H. Butler

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34

CONTENTS

	<u>Page</u>
ABSTRACT	1
1. INTRODUCTION	1
2. GENERAL SEISMIC ANALYSIS METHODS	4
3. QUALIFICATION SUMMARY OF OWNER DESIGN SPECIFICATIONS	6
CONCLUSIONS	11
REFERENCES	16
APPENDIX A. LETTER SOLICITING COPIES OF BUYER SPECIFICATIONS ...	17
APPENDIX B. TYPICAL SNUBBER LOAD VS DISPLACEMENT CURVE	19

ANALYSIS OF OWNER DESIGN SPECIFICATIONS FOR SNUBBERS*

REPORT 2¹

J. H. Butler

ABSTRACT

This report, the second in a series on snubber performance, discusses and evaluates the adequacy of buyer specifications for snubbers. Technical specifications for snubbers (hydraulic and mechanical) were studied in detail in an effort to define the "fundamental needs" of the industry with respect to characteristics of snubbers during operation. In the course of this study, it was determined that there is insufficient consensus among users to make such a definition. Authorities in the fields of structural dynamics, structural systems design, and snubber design were also consulted for additional information. Information from these sources is incorporated to identify the fundamental areas of concern, areas where consensus is lacking, and problems to be resolved in order to establish meaningful standards for this equipment.

Key words: Snubbers, shock absorbers, shock arresters, seismic shock, lockup velocity, bleed velocity, dead band, spring constant.

1. INTRODUCTION

This report, the second in a series of reports on snubber performance, deals with the adequacy of owner design specifications for snubbers. Snubbers are devices that assume the shock of dynamic loading for pipes or piping components in a nuclear-reactor system and still allow the slower movements caused by heating and cooling. They are designed to be attached to a pipe or component that is considered vulnerable to earthquake damage and to allow it to move freely within a specified rate limit. If this limit is exceeded, the snubber locks and temporarily

*The author wishes to recognize the following individuals who contributed to this report: E. R. Dobyns, formerly of ITT Grinnell, J. Boyd of ITT Grinnell, and J. E. Clouser of Pacific Scientific Co.

provides rigid support for the component until the force acting on it ceases (see Report 1 of this series for a more detailed description of snubber design).¹ Initially, since all snubbers operated on hydraulic principles, it was natural that the machine tool industry, which was already equipped to manufacture hydraulic cylinders, would also produce these new devices. Unfortunately, this industry was accustomed to a different application for their product and could not anticipate many of the more esoteric questions which would arise as a result of structural design considerations. For this reason and as a result of the relatively little attention given to snubbers in the overall power plant design, many of the problems have remained partly or entirely unresolved. Although snubbers seem to fulfill the above stated purpose, details of system restraint during application are either ill-defined or pose problems which have not been solved. The purpose of this segment of the study is to investigate recent research in order to define current user requirements and to suggest additional ones.

Report 1 of this series¹ documented the results of an investigation of snubber malfunctions in nuclear reactors. This report reveals inconsistencies on the part of buyers when stipulating snubber specifications. This information will be combined with report 1 and eventually with report 3 (see Table 1) to form the basis for recommendations for regulatory guidelines and proposals for necessary research. Section 2 of this report describes the methods and limitations of seismic analyses used by snubber purchasers. Section 3, which contains a breakdown of qualifications of the owner design specifications, determines the consistency, if any, of buyers in their criteria for snubber performance. Section 4 contains a summary which includes comments by seismic experts and snubber manufacturers regarding snubber performance.

The best sources of information for snubber requirements are the purchase specifications written and distributed by users and/or their consultants. These include utilities, architects-engineers, nuclear seismic shock suppressor (NSSS) manufacturers, and the ASME Task Group on Snubbers. Copies of these specifications were solicited (see Appendix A) to determine areas of commonality in basic requirements which

Table 1. Snubber evaluation

Report	Task schedule	Draft completion date	Publishing date
1	A thorough review and categorization of failure histories using abnormal occurrence (AO) reports supplied by NRC and test reports supplied by the manufacturers (completed in FY 1976)	FY 76	11/76
2	A review and report on the adequacy of methods used by utilities and reactor vendors for determining snubber specifications	3/77	8/77
3	Evaluation of the snubber manufacturers' design practices with emphasis on the following areas: (a) analytical analyses performed (b) experimental analyses performed, including environmental-compatibility testing (c) quality assurance procedures (d) construction and assembly procedures	8/77	5/78
4	A comprehensive review and analysis of available test data supplied by snubber manufacturers for meeting design requirements	5/78	3/78
5	A report indicating required experimentation to resolve deficiencies in qualification test data and modeling for dynamic analysis and performance specifications	8/77	Not to be published
6	Synthesis of tasks 1 to 5 to formulate a basis for a regulatory guide on snubbers	5/78	8/78

would lead to a definition of general technical requirements which would in turn provide input for establishment of a regulatory guide.

Since the major snubber problems of 1973, reported in Ref. 1, significant work has been done relating to snubber applications by individuals and agencies within the nuclear power community. In addition, the technology of structural dynamics has progressed and can be applied to form a clearer definition of requirements for snubber operation. These sources were also consulted and studied. As a result of this study, it is apparent that there exists little consensus of performance requirements for snubbers among the users. There is also ambiguity in terminology such as "spring rate," "deflection," "shock absorption," etc. While general agreement exists regarding the need for snubbers in the structural support systems of piping and equipment, the specification requirements are either hazy or not at all defined.

2. GENERAL SEISMIC ANALYSIS METHODS²⁻⁴

This report deals with the adequacy of the owner design specifications for snubbers. The reader should be aware of the limitations and problems involved with current methods of seismic analysis of reactor systems since seismic considerations form the basis for many snubber specifications. Uncertainty can cause problems in determining appropriate snubber locations, spring constants and tolerances, lockup velocities, and load capacities. These parameters will be discussed in more detail in Sections 3 and 4.

Two approaches to dynamic analysis are available. In one approach, response spectra are used to describe the input to the structure; in the other, an actual time history of seismic motion is used for the input. However, difficulties are encountered in both approaches as related to accurately predicting seismic effects on reactor systems. In the response spectra approach, the frequencies and participation factors are computed for each mode of the structure. Employing an appropriate value of damping, the response spectra are used to find the contributions of each mode. However, there is a difficulty in superimposing the various modes since response spectra give the maximum response but do

not give the time the maximum occurs. It is thus impossible to know whether the modes have their maxima at the same time, so that the modal contributions can simply be added or whether the peak responses occur at different times, so that the peak response of the entire system is less than the sum of the contributions of the individual modes. Although there are rules suggesting how to weigh the individual maxima so as to get an approximate but conservative result, there remains an inherent uncertainty in the modal approach. The alternative is to run the actual time history of seismic disturbances through the structure and carry out a detailed computation that gives the time history of the response of each portion. If the structure could be modeled accurately, such an analysis would precisely determine the response of the structure to this particular ground motion. The limitation of this approach is the difficulty in modeling the structure. Since earthquakes have a large frequency spectrum, the natural frequency of the structure must be established precisely to yield accurate system responses. Also, if only a single ground motion is input, there is a danger of badly underestimating the response to a future earthquake. Although both methods of analysis give a general idea of seismic response, the complexity of seismic input and restraint and structure modeling has resulted in a high degree of uncertainty in determining system response parameters during seismic conditions. Snubber specifications reflect this uncertainty.

The restraint systems in both methods can be modeled as rigid members, springs, or forcing functions. Most snubbers are modeled as pure springs with spring constants derived from analytical considerations and supplied by the snubber manufacturers. Since snubbers exhibit nonlinear load-deflection characteristics, modeling them as rigid members or pure elastic springs may produce misleading system response results. However, because of the complexity of modeling the snubber as a nonlinear forcing function derived from experimental data (data that are presently unavailable), this approach is not used. The elastic contributions of the walls and other connecting devices are normally determined by the utilities and architect-engineers. The implications of treating the snubber as a pure elastic spring in both methods of seismic analysis have not been investigated; there is a great deal of confusion regarding the correct

method of spring constant determination, tolerance, and even whether or not a spring constant approximation does provide a conservative estimate of system response.

3. QUALIFICATION SUMMARY OF OWNER DESIGN SPECIFICATIONS

Snubber specifications are usually written by an architect-engineer firm or reactor vendor in cooperation with a contracting utility. Examination of seven different owner design specifications shows an over-generalization of what should be precise and complete specifications for many important snubber performance parameters. Since the only applicable code dealing with snubber performance (ASME Section III, Subsection NF) is presently limited in scope, the specifications have little commonality and available data to improve them is approximate at best. It is thus virtually impossible for buyers to make the analytical correlations required to form the basis for definitive owner design specifications.

Tables 2 and 3 compare the content and adequacy of three owner design specifications. These three documents were chosen since they covered more important areas in more detail than the others surveyed. The three documents were evaluated by examining the content of the individual specifications as related to coverage of items designated as essential to snubber performance (see items to be considered, Table 2). These items were derived from report 1, the owner's design specifications, comments from manufacturers and architect-engineer firms, and the ASME Task Group on Snubbers. These items should not be considered as all-inclusive for insuring satisfactory snubber performance, but they are a basis of mandatory consideration. Each document was judged for its adequacy in coverage of the related specification as follows: (1) CA — considered adequately, (2) CI — considered, but not in sufficient detail, and (3) NC — not considered. The judgment criteria were (1) the extent of coverage (i.e., consideration of all contributing parameters to an individual specification) was considered; (2) the conciseness of coverage (statements such as "must function properly" and "must not be injuriously affected" were considered inadequate); (3) the adequacy of the

Table 2. Comparison of owner's design specifications for snubbers

CA considered adequate; CI considered but not
in sufficient detail; SC not considered

Item to be considered	Adequacy of con- sideration			Category	Applicable code
	Document No.				
	1	2	3		
A. Materials (structural)	CA	CA	CA	1	ASME Sect. III Div. 1, NF-3000
B. Materials (seals)					
1. Property tolerance					
a. Tensile strength	CI	SC	SC	4	
b. Elongation	CI	SC	SC	4	
c. Modulus	CI	SC	SC	4	
d. Compression set (ASTM-D-195)	CI	SC	SC	4	
e. Hardness (shore A)	CI	SC	SC	4	
2. Effect of the following on seal performance					
a. Radiation	CI	CI	CI	2	
b. Humidity	CA	CI	CI	2	
c. Temperature	CA	CI	CI	2	
d. Fluid compatibility	CA	CI	CI	2	
e. Aging	SC	SC	SC	3	
f. Wear	SC	SC	SC	3	
g. Fatigue	SC	CI	SC	4	
C. Materials (hydraulic fluid)					
1. Kinematic viscosity	CA	SC	CI	3	
2. Pour point	CA	SC	CI	3	
3. Compressibility (bulk modulus)	CA	SC	CI	3	
4. Lubricity	CI	SC	CI	4	
5. Corrosion protection	CI	SC	CI	4	
6. Fire resistance					
a. Flash point	CA	CI	CI	2	
b. Fire point	CA	CI	CI	2	
c. Spontaneous ignition temperature	CA	CI	CI	2	
7. Radiation life	CA	CI	CI	2	
8. Pority	SC	SC	SC	3	
9. Air content	CI	SC	SC	4	
10. Stability	CA	CA	SC	4	
11. Compatibility	SC	CI	SC	4	
D. Materials (mechanical snubbers)					
1. Effect of the following on material performance					
a. Humidity	CA	CA	?	2	
b. Corrosion	SC	SC	?	3	
c. Wear and galling	SC	SC	?	3	
d. Temperature	CA	CA	?	2	
e. Radiation	CA	CA	?	2	
f. Dust infiltration	SC	SC	?	3	
E. Design (structural)	CA	CA	CA	1	ASME Sect. III Div. 1 NF-3000
F. Design (general requirements)					
1. Attaching means and tolerances	CI	CI	CI	2	ASME Sect. III Div. 1 NF-3000
2. Load rating	CA	CA	CA	1	
3. Fluid level indicator	CA	CA	CA	1	
4. Leakage rate tolerance	SC	SC	CA	3	
G. Design (performance factors)					
1. Activation velocity or acceleration and tolerance	CI	CI	CI	4	
2. Normal operating loads					
a. System vibration loads	SC	SC	SC	3	
b. Frictional resistance loads	CA	CA	CA	1	
3. Release rate (bleed rate)	CI	CI	CI	2	
4. Stroke length	CI	CI	CA	2	
5. Spring rate	CI	SC	SC	4	
6. Dead band	CA	SC	SC	3	

¹Document 3 did not consider mechanical snubbers.

Table 2 (continued)

Item to be considered	Adequacy of consideration			Category	Applicable code
	Document No.				
	1	2	3		
7. Overall deflection	CA	CA	CA	1	
8. Transverse loading	NC	NC	CA	3	
9. Hot position setting	CA	CA	CA	1	
10. Cold position setting	CA	CA	CA	1	
M. Design (environmental conditions)					
1. Temperature	CI	CI	CI	2	
2. Relative humidity	CI	CI	CI	2	
3. Radiation	CI	CI	CI	2	
4. Pressure	CA	CA	CA	1	
5. Dust exposure	NC	NC	NC	3	
6. Salt, sand, etc.	NC	NC	NC	3	
7. Accident operating environment	CA	NC	CA	5	
I. Design life	CI	CI	CI	2	
J. Fabrication	CA	CA	CA	1	ASME Sect. III NP-4000
K. Installation					
1. Location and tolerance	NC	NC	NC	3	
2. Axial alignment	CA	CA	CA	1	
3. Installation manual	CI	CI	CI	2	
4. Orientation	NC	NC	CA	3	
L. Examination	CI	CI	CI	2	ASME Sect. III NP-5000
M. Maintenance					
1. Instruction manual and personnel training requirements	CI	CI	CI	2	
N. Testing					
1. Prototype (dynamic response analysis including performance parameter correlations)	NC	NC	CI	4	
2. Qualification testing					
a. Frictional resistance	CA	CA	CA	1	
b. Velocity or acceleration lockup rate	CI	CI	CI	2	
c. Release rate	CI	CI	CI	2	
d. Dynamic characteristics	CI	CI	CI	2	
e. Abnormal environmental test	CI	NC	CI	3	
f. Static test	CI	CI	CI	1	
g. Fatigue	NC	CA	NC	4	
h. Wear	NC	NC	NC	3	
i. Seal test	CI	NC	NC	4	
3. Performance testing					
a. Full stroke and freedom of movement	NC	CA	CA	5	
b. Velocity or acceleration lockup rate	CI	CI	CI	2	
c. Release rate test	CI	CI	CI	2	
d. Fluid pressure integrity	NC	NC	CI	4	

Numerical summary of categories

Category No.	Number of entries
1	13
2	26
3	19
4	17
5	2

Table 3. Comparison of the most important snubber performance characteristics with specified values derived from the owner design specification documents

Characteristics	Comments
Hydraulic snubbers	
A. Lost movement (dead band)	
1. 0.040 in.	The lost movement value is critical in spring constant determination as well as in characterization of snubber performance where system vibration is encountered.
2. X	
3. X	
B. Lockup velocity	
1. 0-10 in./min	The lockup velocity should be specified for each snubber to include the effect of temperature; also, the value of the lockup velocity should be a minimum while still allowing the snubber to accommodate normal system movement.
2. 20 in./min or as specified	
3. X	
C. Load deflection characteristics (spring constant)	
1. 10 K snubber ... 250 kips/in. 20 K snubber ... 400 kips/in. 30 K snubber ... 400 kips/in. 50 K snubber ... 600 kips/in. 70 K snubber ... 800 kips/in. 100 K snubber ... 800 kips/in.	The spring constant is important in the seismic analysis of the reactor support system. The wide variety of methods used to obtain a spring constant give rise to a large variance in values for the same support (see "Conclusions"). Documents 2 and 3 give a maximum displacement value instead of a spring constant. Displacement specifications make analytical analysis of the reactor system during seismic conditions difficult. No tolerance is given for the above spring constant listed in document 1 and the effect of the "dead band" and subsequent snubber impact loading is neglected. The spring constant is an area of great confusion due to lack of definitive data.
2. End-to-end displacement ± 0.15 in. maximum (all frequencies)	
3. End-to-end displacement 0.25 in. maximum	
D. Bleed velocity	
1. 0-6.0 in./min	The required bleed velocity can be determined reasonably well with traditional thermal analysis of the reactor system. It is important that a tolerance on the bleed velocity be specified and closely monitored. Also, it is unclear from the standpoint of the buyers what effect the bleed rate has on the lockup velocity and piston travel during a seismic event. In all cases the bleed rate should be specified at the appropriate temperature.
2. 5.0 in./min	
3. 0.25 in./min	
Mechanical snubbers	
A. Lost movement (dead band)	
1. 0.040 in.	
2. X	
3. Mechanical snubbers not considered	
B. Spring constant	
1. 10 K snubber ... 250 kips/in. 20 K snubber ... 400 kips/in. 30 K snubber ... 400 kips/in. 50 K snubber ... 600 kips/in. 70 K snubber ... 800 kips/in. 100 K snubber ... 800 kips/in.	
2. Total end-to-end deflection ± 0.06 in.	
C. Lockup acceleration	
1. 0.08; max	The lockup acceleration value should be a minimum while allowing the snubber to accommodate normal system movement.
2. 0.02; max	
D. Sustained load velocity	
1. 0.2 in. minimum for each second of loading	The rationale behind the sustained load velocity is unclear. Mechanical snubbers are acceleration-sensitive devices and the sustained load velocity will constantly be changing.
2. 0.2 in. minimum for each second of loading	

^a Document number.

X means not specified.

Numerous interviews with experts involved with seismic analysis of reactor components have indicated that the accuracy and tolerance requirements of the spring constant as supplied by the manufacturer have not been established. They believe that such a task would involve unreasonable computer time and cost.

technical basis for a specification was considered when possible; and (4) where applicable and possible, tolerance magnitudes were evaluated.

After evaluation of a particular item in the specification using the above criteria, the judgments were categorized as shown below. Each category represents an interpretive summation of the treatment given to each specification by the three documents as a whole.

<u>Category No.</u>	<u>Document No.</u>			<u>Category definition</u>
	1	2	3	
1	(a) CA	CA	CA	Good consensus by the owners for the need of this consideration as well as the availability of a sound technical basis for specification
2	(a) CA	CA	CI	Good consensus by the owners for the need of this consideration, but a uniform technical basis for writing a specification has not been established
	(b) CA	CI	CI	
	(c) CI	CI	CI	
3	(a) CA	NC	NC	Misunderstanding by the owners as to the importance and/or purpose of this consideration
	(b) CA	CI	NC	
	(c) NC	NC	NC	
4	(a) CI	CI	NC	Misunderstanding by the owners as to the importance and/or purpose of this consideration and a uniform technical basis for writing a specification has not been established
	(b) CI	NC	NC	
5	(a) CA	CA	NC	Oversight in one specification

For example, as shown in Table 2, documents 1 to 3 all considered the "Materials (structure)" item adequately; therefore, the category number is 1 as defined above. Document 1 considered "Effect of humidity on seal performance" adequately, and documents 2 and 3 considered it but not in sufficient detail. Therefore, the category number is 2.

A numerical summary of the categories is included at the end of Table 2. Table 3 consists of items from the owner design specifications which were covered in Table 2 and considered (by the author) most crucial to snubber performance. These performance characteristics are listed with commentary to further illustrate the apparent confusion that exists regarding even the most basic snubber requirements. The

comments emphasize deficiencies and are not intended as recommendations, although they will be considered in detail when specific recommendations are made.

CONCLUSIONS

From a detailed examination of a representative sampling of snubber specifications presently in use in the nuclear power industry, it is evident that several technical questions remain unresolved. As a result, no standardized technical basis for writing a specification or regulatory guide exists.

At the present time, the user (or the user's consultant) relies on information and guidance furnished by the suppliers, since there are few other sources. In general, industry experience is minimal and ill-organized because, from a technological viewpoint, the use of snubbers began in the nuclear field recently (within the past 10 to 12 years) and specifications are not yet fully understood. Qualified analytical and experimental data, available only in relatively esoteric areas, are not recognized as standards in practical application. Compounding this problem is the fact that a significant portion of the snubber technical requirements stem from support system structural dynamic analysis, which depends upon individual design philosophy. There is also a considerable lack of consensus as to how the snubber should be treated in the structural dynamic analysis and to what degree the efficiency of this analysis is affected by improper snubber treatment.

On the basis of the specifications examined and the facts presented in this report, a number of technical difficulties remain unresolved.

The major areas of concern established by this report are outlined below.

A. Snubber modeling in structural dynamic analysis

1. Basic analytical limitations: Both methods of seismic analysis described in this report contain a degree of uncertainty.
2. Accuracy of snubber model: The degree to which quantitative accuracy in modeling the snubber within the structural dynamics program has not been determined. Authoritative data indicating

what effect, if any, quantitative inaccuracy in snubber modeling will have on the structural dynamic analysis results has not been found.

3. Adequacy of snubber modeling: Qualified determinations have not been made regarding the adequacy of current methods (e.g., continuous linear function vs discontinuous function containing nonlinear elements) of modeling the snubber in the structural dynamics analysis.
4. Snubber load-deflection characteristics: There is no authoritative consensus regarding how to establish and express the snubber load-deflection characteristics.

B. Performance criteria

1. Performance specification bases: There are, at best, doubtful bases for the specification of the following performance characteristics:
 - a. Lockup velocity
 - b. Bleed velocity
 - c. Lockup acceleration
 - d. Release rate (analogous to "bleed velocity" for mechanical snubbers)
 - e. Frictional resistance
 - f. Dead band (displacement before lockup)
2. Loading criteria: Specifications generally contain static loading criteria. All applied loads are dynamic in nature. The conversion from dynamic to static loading is considerably influenced by the snubber load-deflection characteristics.
3. Criteria consistency: There are apparent inconsistencies in specified performance criteria for mechanical and hydraulic snubbers. For example, hydraulic snubbers are limited by velocity without regard to acceleration levels, and mechanical snubbers are limited by acceleration without regard to velocity levels.
4. Snubber operation at temperature: Specifications do not require performance characteristics at quoted operating temperatures.

5. Iterative motion: Specifications generally do not take notice of the iterative motion phenomenon experienced by hydraulic snubbers under cyclic loading conditions.
6. Design life: Most specifications require a "40-year design life." This term needs further definition. It is unlikely that such a requirement can be enforced without resorting to individual interpretation. It will certainly be difficult to persuade a supplier to warrant his hardware for that period of time. The responsibility of the user, his consultant, and the supplier must be more clearly defined.

C. Inspection and maintenance requirements

1. ASME regulations: Snubbers are generally considered to be under the jurisdiction of Subsection NF, Section III, of the ASME Boiler and Pressure Vessel Code. Treatment of snubbers in the existing official code is inadequate. To date, although work is proceeding by the Snubber Task Group responsible to the NF Working Group, no significant guidance has been developed by ASME to solve most of the problems noted herein. No firm indication of what guidance is forthcoming or in what form it will appear has been given by ASME.
2. NRC regulations: Although limited regulations regarding in-service inspection and maintenance of snubbers have been issued by NRC in the form of bulletins, comprehensive regulatory control remains to be established.

E. Data requirements

1. Available data: Very little experimental and/or qualified analytical information having a generic application is available.
2. Specification analytical requirements: In the specifications reviewed, analytical requirements were ill-defined and not sufficiently specific.
3. Analytical/actual data correlation: Little correlation exists between analytical (static) deflection values and actual dynamic deflection characteristics.

4. Static/dynamic deflection characteristics: The relationship between load-deflection characteristics for static loading and those for dynamic loading are not known.
5. Fatigue data: Specifications generally do not contain fatigue requirements where snubbers are subjected to long-term cyclic loading.
6. Fluid modulus data: The effect of strain rate on fluid modulus is not known. This relates to the problem of converting from static to dynamic loading deflection characteristics.
7. Materials performance data: Only scattered data exist indicating the reliability of materials (e.g., seal and fluid materials) with respect to performance of a desired function after extended exposure to various adverse environmental conditions. Performance at operating temperatures, for example, is often not specified or defined. Data regarding snubber performance after extended exposure to neutron fluence are neither required by the users nor offered by suppliers at this time.

Another important aspect of snubber specification is the determination of the value of the snubber spring constant. There is a great deal of discrepancy between snubber manufacturers concerning the appropriate method of determining this constant. Using a typical snubber load vs displacement curve (Appendix B), it is possible to calculate the spring constant from experimental data using five different methods. The results are tabulated below.

	<u>K (kips/in.)</u>
Double average method	260
Single average method	421
L. K. Liu method ^a	159
Energy dissipation method ^a	215
Averaged time period method ^a	250

^aLetter, I. T. Yin to E. O. Swain.

Many manufacturers use still another method of spring constant determination which consists of simply calculating the constant from the elastic strength of the structural components and the bulk modulus of the hydraulic fluid. This method does not include the effect of the

"dead band" or hysteresis action of the load displacement curve. As indicated by the large discrepancy in the spring constant values determined by the preceding methods, as well as the apparent confusion in the owner design specifications regarding this parameter, it is obvious that a clarification of the appropriate method of spring constant determination is essential.

It is evident from Tables 1 and 2 that a great deal of confusion exists regarding appropriate specifications for most of the important snubber performance variables. This confusion has been promulgated by many factors, but probably the greatest contributor has been the lack of good analytical correlations to actual snubber performance data. Since little data have been accumulated on snubber performance in reactor service conditions by the manufacturers, it is virtually impossible at this point to make the required correlations. The next report (report 3) in the assessment of snubber performance and requirements will deal with the adequacy of the manufacturer design practices.

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APPENDIX A

LETTER SOLICITING COPIES OF BUYER SPECIFICATIONS

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POST OFFICE BOX Y
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Dear

I am presently investigating (under the auspices of NRC) the performance requirements of seismic shock arrestors (snubbers) as used in reactor facilities across the country. Please forward this letter to the individual(s) responsible for the seismic analysis of your piping and/or reactor components. I am particularly interested in the way snubber requirements are specified by the reactor vendors and A&E firms, with emphasis in the following areas:

1. The method of seismic analysis used with emphasis on the modeling of the seismic restraint (snubber).
2. If the snubber is assumed to be a spring, what is the required accuracy of the spring constant and how is this spring constant determined.
3. Any deficiencies or limitations related to the seismic analysis, or snubber specifications you see as an expert in the field.

Also, if you could, supply me with a typical example of your specification sheet(s) used when you order your snubbers.

This investigation is designed primarily to define more clearly the performance requirements of snubbers and any comments you feel warranted will be greatly appreciated.

Thank you for your cooperation.

Sincerely,

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JHB/lad

APPENDIX B

TYPICAL SNUBBER LOAD VS DISPLACEMENT CURVE

Fig. B.1. Snubber load-deflection curve at 10 Hz.