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ISO/TC 108/WG 28 : Characterization of the Dynamic Mechanical Properties of Resilient Visco-Elastic Materials

활동 상황 보고

김 광 준
한국과학기술원 기계공학과

1. 서론

필자는 소음진동공학회가 품질기술원으로부터 ISO/TC108 기계진동 및 충격(Mechanical Vibration and Shock) 간사기관업무를 위탁 받은 후부터 SC6 진동 및 충격 발생시스템(Vibration and Shock Generating Systems)에 대한 한국측 위원으로 일을 해왔다. 그러던 중 작업반(Working Group) TC108/WG28 : 점탄성 재료의 동적 기계적 성질의 특성화(Characterization of the Dynamic Mechanical Properties of Resilient Visco-Elastic Materials)에 한 멤버로 가담하여 활동을 해오면서 있었던 상황을 보고하고자 한다.

작업반 TC108/WG28은 1999년 9월 17일의 코펜하겐 회의(ISO/TC108 N779) 결의안 8번으로 제안된 후, 1999년 11월 15일에 신규 작업초안(NP : New Work Item Proposal)으로서 P(Participating) 회원국가들에 전달되어 (ISO/TC108 N790 및 791) 가부 여부에 관하여 투표된 바 있다. 필자는 한국측 의견을 긍정적으로 피력한 바 있고(2000년 1월 7일), 각 국의 투표를 2000년 2월 15일 마감한 결과는 2000년 3월에 통보되었다 (ISO/TC108 N792). 슬로바키아, 이태리, 독일, 뉴질랜드, 한국, 러시아, 오스트리아, 프랑스, 미국 등 9개국 10명 위원이 참여하게 된 본 신규 작업 초안은 ISO/TC108에 의해 공식 승인되었으며, ISO AWI 18437로 등록되었다. 작업반 ISO/TC108/WG28은 제1차 회의를 2000년 11월 2일 미국 메릴랜드 주의 Gaithersburg에 있는 NIST(National Institute of Science and Technology : NBS(National Bureau of Standards)의 후신임)에서 열었다. 필자는 제1차 회의에 참석하지 못하였는데, 이 회의의 일사일정(Agenda) 및 회의록(Minutes)은 각각 부록 1 및 2와 같다. 제2차 회의는 2001년 3월 21일 오스트리아 비엔나의 ON (Austrian Standards Organization)에서 열렸으며 의사일정 및 회의록은 각각 부록 3 및 4와 같다.

2. 본론

WG28 회의 소집권자 (Convenor)인 미국의 Walter Madigosky가 2000년 7월 14일 전자메일로 보내 온 AWI 18437용 자료는 현재 미국에서 국가 규격으로 준비 중인 ANSI S.2.21-199X, S2.22-199X 및 S2.23-199X로서 그 내용을 살펴 보면 다음과 같다.

ANSI S2.21-199X : 동적 기계적 성질 측정을

위한 표준재료 준비법 (Method for Preparation of a Standard Material for Dynamic Mechanical Measurements)

ANSI S2.22-1999X : 점탄성 재료의 동적 기계적 성질 측정을 위한 공진법 (Resonance Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials)

ANSI S2.23-199X : 점탄성 재료의 동적 기계적 성질 측정을 위한 단일 외팔보법 (Single Cantilever Beam Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials)

ANSI S2.22-199X및 ANSI S2.23-199X에서 제안하는 시험방법은, Fig. 1 및 Fig. 2에 보인 바와 같이 각각, 막대형 시편에 대한 전달율 측정값 중 공진주파수에서의 값들을 이용하거나 단면이 일정한 외팔보를 대상으로 공진점에서 얻은 강성계수 측정치를 이용하는 것이다.

현재까지 관련 연구소나 산업체에서 많이 쓰여지고 있는 다른 방법들에서는, Fig. 3에 보인 바와 같이 자유표면 감쇠처리(unconstrained layer damping treatment)되어 두 층으로 이루어진 외팔보, 혹은 Fig. 4에 보인 바와 같이 구속표면 감쇠처리(constrained layer damping treatment)되어 세 층으로 이루어진 외팔보를 대상으로, R-K-U(Ross-Kerwin-Ungar)식으로 알려진 지배 방정식을 적용하여 복소탄성계수를 주파수와 온도의 함수로 구하고 있다.[1] 한편, 고무류 재료를 대상으로 여러 가지 성질을 규명하기 위한 표준시험법을 규정하고 있는 ASTM Vol 09.01[2] & 09.02[3]를 살펴보면, 수많은 내용의 시험법이 규정되어 있으나, 탄성계수와 관련하여서는 정적 탄성계수에 국한된 하나의 방법[4]만이 규정되어 있다. 이외에도 미국 자동차 공학회(SAE: Society of Automotive Engineers)표준이 있겠으나, 차량용 부품을 대상으로 한 강성계수 시험법 위주로 구성되어 있는 것으로 판단된다.

점탄성재료의 복소탄성계수는 진동 저감이 필요한 관련 제품의 설계단계에서 필수적 정보이나, 위에 언급한 바와 같이 표준시험법이 제대로 잘 규정되어 있지 않은 탓에, 이번 작업반 ISO/TC108/WG28의 작업대상이 된 것으로 판단된다. 그러나, 예비단계로 작성된 ANSI S2.21~23-199X에 대하여 필자가 검토한 후 제출한, 부록 5에 보인 의견서에서 볼 수 있듯이 미비한 점이 적지 않았다.

필자뿐만 아니라 다른 작업반원들도 의견을 제출한 바 있는데, 이 의견들을 감안하여 1차 회의에서[부록 2 참조] 내용을 조정하였다. 조정의 중요한 골자는 표준재료준비법(S2.21)을 TC108의 대상 업무 밖이라는 이유로 삭제하고, 반면에 임피던스법을 추가하기로 하였으며, 필자가 제안한 바 있는 정하중의 영향 고려문제는 현재 ISO/TC43에서 준비중이라는 이유로 다루지 않기로 하였다. 종합적인 조정단계를 거쳐, 비엔나에서의 2차 회의용 검토대상으로 수정된 내용은 다음과 같다.

ISO/WD(Working Draft) 18437-1: Mechanical Vibration and Shock-Characterization of the Dynamic Mechanical properties of Resilient Materials-Part1 : Principle and Guidelines

ISO/WD 18437-2: Mechanical Vibration and Shock-Characterization of the Dynamic Mechanical properties of Resilient Materials-Part2: Resonance Method

ISO/WD 18437-3: Mechanical Vibration and Shock-Characterization of the Dynamic Mechanical properties of Resilient Materials-Part3: Single Cantilever Beam Method

ISO/WD 18437-4: Mechanical Vibration and Shock-Characterization of the Dynamic Mechanical properties of Resilient Materials-Part4: Impedance Method

위에서 언급된 세가지 방법; 공진법, 단일외팔보법, 임피던스법 등을 간략히 그림으로 나타내면 Fig. 5, 6, 7과 같고, 이들의 특성을 비교적으로 작성하여 보면 Table1과 같다.

비엔나의 제 2차 회의에서는 참석자들이 여러가지 의견을 교환한 후, 부록4에 보인 회의록에서 볼 수 있듯이, 위에 보인 4개 WD중 Part2및 Part3은 CD(Committee Draft)단계로 진행시키고 Part1 및 Part4는 좀 더 수정을 기하기로 하였다.

3. 결론

필자는 이번 비엔나에서의 ISO/TC108회의에서 직접작업반원으로 참여하고 있는 WG28뿐만 아니라, ISO/TC108 총회(plenary)를 비롯하여

WG 1: Terminology
WG23: Resilient Mounting Systems-Information For the Application of Source and Receiver Isolation
WG24: Condition Assessment of Structural Systems from Dynamic Response Measurements.
WG25: Condition Monitoring of Structure
WG27: Signal Processing Methods for the Analysis of Non-stationary Mechanical Vibration and Shock

등의 회의에 참석한 바 있는데, 참석한 다른 작업반원들의 특성을 살펴보면, 표준화작업에 직접적으로 영향을 받을 위치에 있는 산업체 종사자가 주류를 이루고 있고, 필자와 같은 대학이나 공공연구소 근무자들도 적지 않았다. 필자가 예상하지 못했던 현상 하나는, 한 사람이 여러 개의 작업반에 동시에 가담하여 작업을 하고 있다는 점이었다. 즉, 각 나라별로 소수의 전문인력이 TC108 업무를 오랫동안 지속적으로 담당함으로써 효율을 극대화하고 있다는 점이다. 또 하나의 특성은 여러 가지 작업반 회의에 필자와 같이 참석하였던 TC108 회장 Bruce Douglas(U.S.A)의 의견 개진이었는데, 그는 ISO의 표준화작업 자체를, 표준자료 판매 등,영리적 관점에서의 한 사업으로 강조하면서, 사용자가 관심 있어 하는 표준내용을 신속히 제정, 개정해야 한다는 것이었다.

필자가 작업반원으로 참여한 WG28에서 추진중인 ISO/WD 18437-1~4가 완전한 국제기준(ISO)으로 되는 것은 1년 정도의 기간이 더 필요할 것으로 보이는데, 국제기준화 결정이 이루어지면, 아직 이러한 시험장비를 상업용으로 제작하고 있지 않은 우리나라는 큰 영향이 없겠지만, 유사 시험장비를 제작해오던 외국의 여러 업체들 사이에는 명암이 엇갈리는 현상이 발생할 것으로 기대된다.

참 고 문 헌

1. A. D Nashif, D.I.G. Jones, J.P. Henderson, Vibration Damping, John Wiley & Sons, Ins., 1985.
2. ASTM Volume 09.01: Rubber, Natural and Synthetic-General Test Methods ; Carton Black, 1989.
3. ASTM Volume 09.02: Rubber Products, Industrial-Specifications and Related Test Methods ; Gaskets ; Tires, 1989.
4. ASTM § D797-89: Test Methods for Rubber Property-Young's Modulus at Normal and Subnormal Temperatures, 1989.

Table 1 — Guidance for selection

	Resonance method	Single cantilever beam method	Impedance method
Frequency range (Hz)[1]	**200-10000**	**0,01-50**	**1-300 (typically)**
Mode of deformation	**Extensional**	**Flexural**	**Compressive with a shape factor**
Typical sample size (m)	**0,006x0,1**	**0,003x0,03**	**0,012x0,06**
Material type	**rubber, plastic, polyurethane**	**rubber, plastic, polyurethane**	**rubber, polyurethane**
Young's Modulus range (MPa)	**0.1-1000**	**0.1-1000**	**0.1-1000??**
Loss factor range	**0,01-2**	**0,01-2**	**0,01-2????**
Sensitivity to creep	**low**	**Very low**	**low**
Preload	**limited**	**no**	**yes**
Cost	**low**	**high**	**low**
User friendly	**high**	**medium**	**high??**

Note 1 The frequency range of each instrument may be extended through the use of the time-temperature superposition principle.

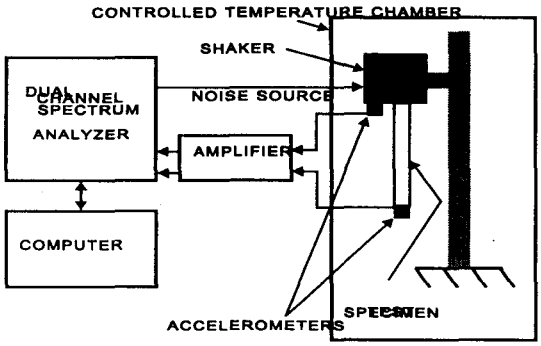

Figure 1 Test Apparatus in ANSI S2.22-199X

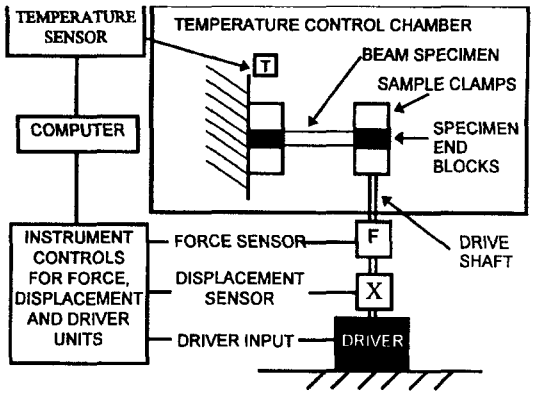

Figure 2 Test Apparatus in ANSI S2.23-199X

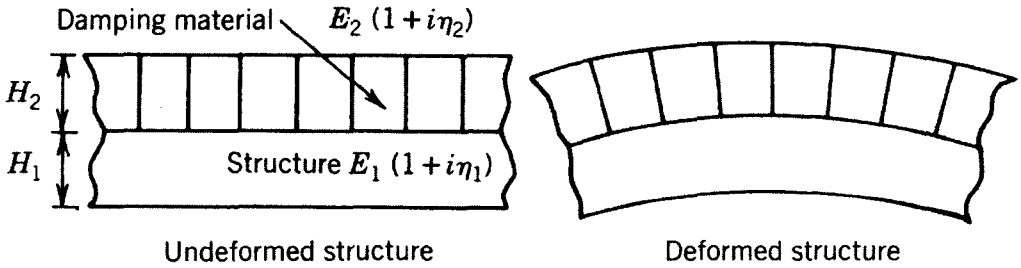

Figure 3 Unconstrained Layer Beam

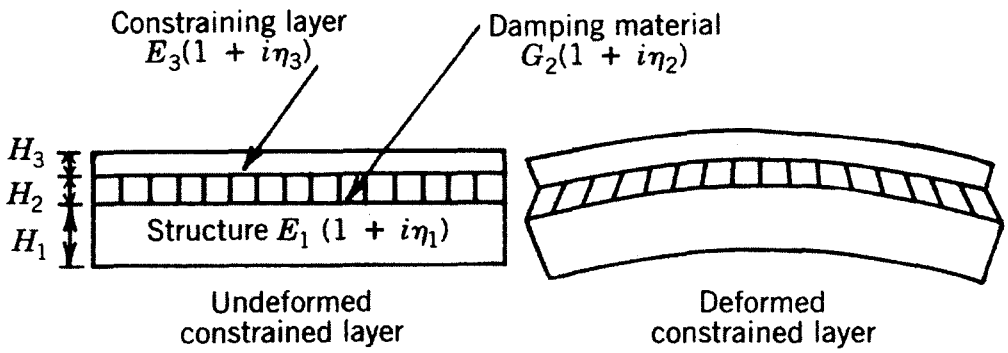

Figure 4 Constrained Layer Beam

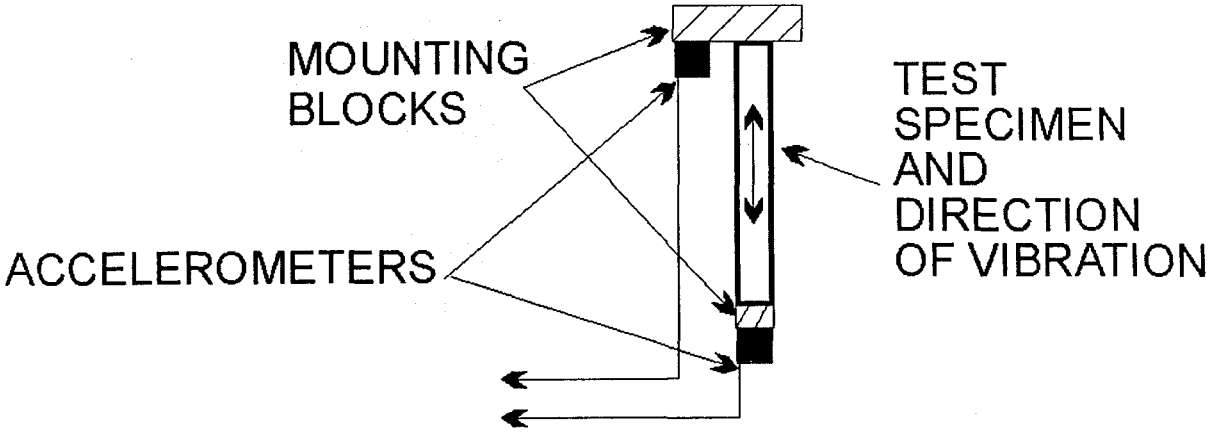

Figure 5 Principle of Resonance Method

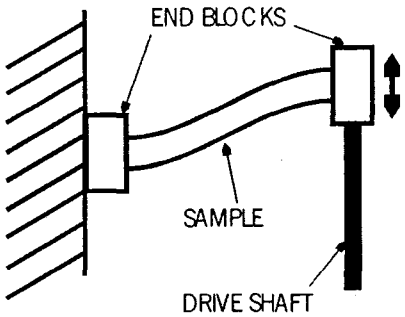

Figure 6 Schematic Diagram of Cantilever Beam Method

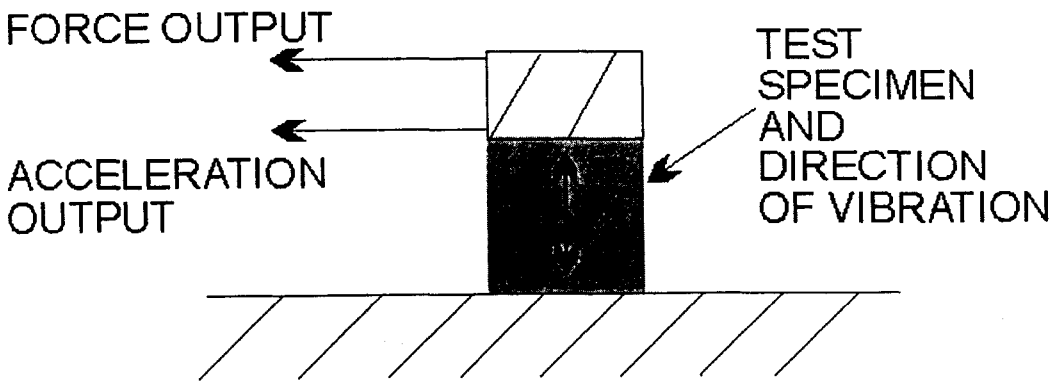

Figure 7 Schematic Diagram of Impedance Method

부록 1

ISO/TC 108/WG 28 N 1

ISO/TC 108/WG 28
"Characterization of the Dynamic Mechanical Properties of Resilent Visco-Elastic Materials"

Agenda for the first meeting of ISO/TC 108/WG 28

MATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY
GAITHERSBURG, MARYLAND, USA

Thursday, 2 November 2000

Agenda

1. Opening Remarks and Introduction of those present
2. Review of Membership
3. Discussion of Goals and Objectives
4. Discussion of Priorities
5. Consideration of Three Draft Documents: ANSI S2.21, S2.22 and S2.23
6. Distribution of Comments Recieved
7. Open discussion on Draft Document ANSI S2.21
8. Open discussion on Draft Document ANSI S2.22
9. Open discussion on Draft Document ANSI S2.23
10. Plans and assignments for progress of work with target dates
11. Other buisness
12. Approval of Draft Minutes and Resolutions
13. Date and place of next meeting
14. Adjournment

부록 2

6 November 2000 ISO/TC 108/WG 28 N 3

Minutes for the first meeting of ISO/TC 108/WG 28 "Characterization of the Dynamic Mechanical Properties of Resilient Visco-Elastic Materials" held on Thursday, 2 November 2000 at the National Institute of Science and Technology Gaithersburg,

Maryland, USA

1. The convenor of ISO/TC 108/WG23 opened the meeting at 9:10 hours and noted that the attendees had already introduced themselves. Those present were Talaat Tantawy (France) and Jeff Fedderly, Gilbert Lee, Walter Madigosky, and Dave Evans (USA).
2. The convenor introduced the project of the new working group and its objectives. He noted that many ISO standards can be used for background and he exhibited numerous documents that have been produced by ISO/TC45/SC2 (Rubber), ISO/TC61/SC2 (Plastics) as well as several ASTM documents. In particular he introduced ANSI S2.21, S2.22 and S2.23 that can be considered as a basis for new ISO standards by the working group. The convenor then distributed the working group member's comments on these documents and a discussion followed. Regarding the comments by Kim, the convenor noted that ISO/TC 43/SC1 has prepared a number of WD's on the measurement of transfer properties of resilient elements (materials) under load. Pending a review of the final documents, it was decided to limit the initial task to modulus characterization under no pre-strain.
3. Tantawy suggested that the working group limit their work according to the TC108 task. Accordingly, the group decided to eliminate any consideration of S2.21 (Method for Preparing a Standard Material) and to define the term "Dynamic Mechanical Properties (DMP) of resilient materials." In the framework of TC108 we mean by the phrase "Dynamic Mechanical Properties ", the determination of the fundamental elastic properties of the resilient material, i.e. the dynamic shear or Young's modulus as a function of frequency and temperature. The group decided that for clarity this definition should be inserted in both the introduction and scope of each document.
4. The working group also determined it was necessary to elaborate different parts, the first one being Part 1. "Principles and Guidelines" which will include the following: a definition of DMP, categories of resilient materials for applying the proposed methods, the different laboratory methods, whether loaded or unloaded, frequency range of the different methods, and differences between the methods (which method to use in a specific case). Part 2 will use ANSI S2.22 as a basis, and Part 3 will use ANSI S2.23. Popkov had suggested that the impedance method also be included. The group agrees and hereby accepts the offer of Popkov to prepare WD1 of Part 4 "The Impedance Method" by March 2001.
5. The group also tasked the convenor to prepare WD1 of Part 1 "Principles and Guidelines", WD2 of Part 2 "The Resonance Method" and WD3 of Part 3 "The Single Cantilevered Method" taking into account the comments received. The convenor will distribute copies via E-mail to the WG members by February 2001 so that comments may be received back before the next meeting.
6. The convenor distributed information regarding the next meeting. It will take place at the 24th plenary meeting of ISO/TC108 and its subcommittees to be held from 19 to 30 March in Vienna,

Austria and hosted by the Austrian Standards Organization.

7. The meeting was adjourned at 12:30pm

부록 3

ISO/TC 108/WG 28 N 4

ISO/TC 108/WG 28
"Characterization of the Dynamic Mechanical Properties of Resilent Visco-Elastic Materials"

Agenda for the second meeting of ISO/TC 108/WG 28

Austrian Standards Organization (ON)
Vienna, Austria
21 March 2001 (afternoon)

Agenda

1. Opening Remarks and and Introduction of those present
2. Review of minutes
3. Distribution of Comments Recieved
4. Open discussion on Draft Document s
5. Plans and assignments for progress of work with target dates
6. Other buisness
7. Approval of Draft Minutes and Resolutions
8. Date and place of next meeting
9. Adjournment

부록 4

ISO/TC 108/WG 28 **N 9**
Vienna 2001-03-21

ISO/TC 108/WG 28
" Characterisation of the dynamic properties of resilient visco-elastic materials"

Minutes of the meeting held on 21 March p.m. at ÖN, Vienna, Austria

- The meeting was opened by the convenor (14h00).
- The members introduced themselves, and an attendance sheet was distributed.
- The minutes from the last meeting, Document N 3, November 2000 in Gaithersburg were reviewed. At that meeting, it was agreed that additional parts 1 "Principles and guidelines" and 4 "Impedance method" needed to be written.
- It was noted that the correct number for the work item is 18437 and not 10999.
- A discussion took place concerning the distributed working drafts. It was noted that parts 2 "Resonance method" and 3 "Single cantilever beam method" are in advanced stage and are part of the initial work item. The scope of the two documents was rewritten to reflect the comments made by the chairman of TC 108 during the plenary session.
- Based on this a detailed discussion of parts 2 and 3 took place with the result that these parts may now advance to the CD stage.
- It was noted that parts 1 and 4 require additional refining but also need to be advanced as preliminary work items.
- **The following recommendations to TC 108 were unanimously accepted:**
  1) **that work item 18437 be split into two parts, 2, "Resonance method" and 3, "Single cantilever beam method" which are to be advanced to the CD stage. The convenor will, before 2001-05-01 forward the revised texts to the TC 108 secretariat for circulation to the member bodies as first CDs for comments;**
  2) **that that new preliminary work items entitled 18437-1 "Principles and guidelines" and 18437-4 "Impedance method" be included in the programme of work, allocated to WG 28; potential project leader: Mr. Walter Madigosky, USA.**
- The date and place of the next meeting will be determined according to the TC 108 schedule. In addition joint ISO/TC 108-TC 43/SC 1/WG 31 will be contacted to coordinate an additional meeting, if possible.
- The meeting was adjourned at 16h30.

WG 28 expresses thanks to ÖN for hosting the meeting.

부록 5

Comments on ANSI S2.21-199X, S2.22-199X and S2.23-199X

1. General

It is typical that viscoelastic materials are used for **noise control** and **vibration damping** over a very wide frequency range under the condition of **no pre-strain** while those are used for **vibration isolation** over a low frequency range under a given **pre-strain**. Although there are several standards

for the former, e.g. ASTM and SAE, no standard is available for the latter to the commenter's knowledge. Admitting that non-existence of standards for the complex modulus characterization under the pre-strain is currently probably due to the high cost of equipment which can provide static and dynamic loading simultaneously, it is a truth that effective vibration isolation using viscoelastic materials essentially requires knowledge of complex modulus under the condition of pre-strain. Therefore, it is suggested that there should be two types of standards; complex modulus characterization under no pre-strain and the one under pre-strain.

As long as the complex modulus characterization **under no pre-strain** is concerned, it would be preferable that contents of the ISO follow those in other standards such as ASTM or SAE as they are, or take their slight modifications. For the complex modulus **under pre-strain**, it is suggested to develop a new ISO standard in such a way that the cost of testing equipment may be tolerable to the ordinary vibration engineers.

Conclusively, ANSI manuscripts in current form do not seem to be adequate as a basis for the ISO standards.

2. Comments on ANSI S2.22-199X

1) 3.1. Since many viscoleatic materials are often working under compressive strains, it is recommended to use 'compressive' or 'compressive(tensile)' in the description.
2) FIG.1. The direction of excitation is unclear.
3) 4.1. Electromagnetic shaker means a shaker which exerts magnetic forces to ferrous metals without contact. Electro-dynamic shaker is preferable.
4) 4.1. The force rating(> 5N) would yield a wide range of strain depending on the types of specimen. So, rating by dynamic strain is preferable.
5) 4.1. Are the piezoelectric accelerometers with built-in amplifier, which can be used with voltage amplifier instead of charge amplifier, unacceptable?
6) 4.2 (2). The subscript at the end should be clarified.
7) 4.5. The range of temperature in different standards such as S2.22 and S2.23 should be unified.
8) 5.1 Notes just above 5.2. According to the notes, it seems that a block is attached onto the end of the specimen and then an accelerometer is mounted on this while distinction between mount and accelerometer in Fig. 1 is not clear.

3. Comments on ANSI S2.23-199X

1) 1.1, 4.1 and 4.3. The frequency ranges do not match at all.
2) 3.1. The purpose of this standard is to obtain the complex modulus. Therefore, it would not be appropriate to describe that materials with specific range of Young's modulus are appropriate for this procedure. Instead, description in terms of hardness of the materials would be desirable.
3) 4.1. Electromechanical and electromagnetic are used mistakenly for electro-dynamic and

strain rating is preferred to force rating.

4) 4.2. Inference of excitation force from the current may not be accurate. Use of a force sensor is preferable as shown in the figure.
5) 4.3. It is not clear why non-contacting sensor should be used for the displacement measurement.
6) 4.4. Clamping system is not clear. Detailed drawing of the clamping region should be included for more clarity.
7) 6. Is rotational motion of the end block taken into account in dynamic modeling? Or, how is it prevented?

4. Comments on ANSI S2.21-199X

1) What is the reason for taking viscoelastic material as a standard material? Isn't an elastic material, e.g. steel or aluminum, more stable and reliable?