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SINGLE FIGURE TRANSMISSION LOSS RATINGS FOR DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

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INTRODUCTION & SCOPE

This paper arises from some recent project work involving a prestigeous hotel conference centre development in the north of England in which the published specifications of a proprietary partition system were called into question. In an attempt to resolve the resulting impasse the sound transmission properties of an installed screen system were measured on site under carefully controlled conditions, with some interesting results.

This paper sets out to present the results of these measurements in the belief that the information may be of benefit to specifying architects and acousticians involved in conference room design and in the hope that manufacturers may take a more realistic and honest approach to the formulation of the specifications published in their sales literature. It also calls into question the value of the Standards used to specify the performance of such products.

THE SITE

Fig 1 shows a representative plan of the conference suite and Fig 2 a section through. It is a fairly typical layout in which either the whole space can be used as a single function room, or it can be divided into two or three smaller units as required by means of a system of moveable partitions running in an overhead track. To one side is a service corridor and to the other the access or circulation corridor. Note that when divided into multiple units these corridors provide both a communicating link and a flanking path between the three separate conference units.

The other major flanking path is via the roof void, although in anticipation of this problem the architects have provided a well specified and insulated ceiling system, sealed lighting fittings and separate ventilation systems servicing each of the three units. Originally there was no closure of the roof void above either partition although subsequently a plasterboard and mineral quilt screen was constructed to separate units 2 and 3.

Because of the luxury specification of the building interior the reverberation time in the conference units themselves and in the main corridor is extremely low - in the order of 0.3 to 0.5 seconds. This is due to a lined absorbent ceiling, deep pile carpeting, heavy lined curtains and upholstered furniture. Because of the low reverberation time and the high level of insulation against external noise afforded by the two enclosing corridors, the ambient noise is exceptionally low at 34dB(A).

The services corridor however is highly reverberant, being without even a suspended ceiling and consequently the noise of service trolleys full of crockery being wheeled up and down the corridor and of staff shouting at each other in the adjoining kitchen can be clearly heard inside the conference units.

SINGLE FIGURE TRANSMISSION LOSS RATINGS FOR DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

THE PROBLEM

Since the conference facility was opened in early 1987 it has proved impossible to run separate meetings in adjoining units because of the level of sound transmission from one unit to another. Therefore, only two of the three available units can be let at any one time thus significantly decreasing revenue and under using the kitchen, restaurant, bars, leisure club and accommodation facilities provided to support the conference centre operation. So we have a major capital investment by a major hotel group falling well short of its commercial performance targets because of the failure of the room partition system to perform to the level expected by its specifiers.

THE PARTITIONS

Upon inspection the proprietary partition system appears to be of sound design, being well engineered, well made and has been installed in accordance with the system manufacturer's directions. Fig 3 shows the general form of construction. The manufacturer's published specification gives "48STC" as the sound reduction figure and superficial mass as 35Kg/sq.m.

THE STC RATING SYSTEM

This is an American ASTM standard (1), originally issued in 1973 and re-approved in 1980. Its object is to provide a simple single figure rating for partition constructions for general building design purposes to:-

"...correlate with subjective impressions of the sound insulation provided against the sounds of speech, radio, television, music and similar sources of noise in offices and dwellings."

The system is based on the sixteen 1/3rd octave bands between 125Hz and 4KHz in which measured transmission loss data is compared to a set of standard rating curves or tables. The STC rating is determined when:-

"...The sum of the deviations below the contour shall not be greater than 32dB and the maximum deficiency at a single test point shall not exceed 8dB. When the contour is adjusted to the highest value that meets the above requirements the Sound Transmission Class for the specimen is the TL value corresponding to the intersection of the contour and the 500Hz ordinate."

Thus there is considerable scope for deviation in level and for frequency weighting within a given STC rating.

BS5821 Pt.1:1984 & ISO717/1-1982 - Rw RATING

BS5821:1984 (2) and ISO717-1982 (3) are identical and their purpose and scope are very similar to the ASTM E413 standard. The basic methodology in comparing measured TL data to a standard reference curve is the same, the reference curves are the same and the deviation criteria, although expressed as a 2dB mean deviation instead of a 32dB sum deviation, are in effect the same. The only apparent difference is that whereas the sixteen 1/3rd octave frequency bands used in the ASTM standard are 125Hz thru 4KHz, in the BSI/ISO standard these become 100Hz thru 3.15KHz. In most instances the effect of this difference will be minimal and therefore a given Rw rating may invariably be directly assigned the same value as an STC rating.

SINGLE FIGURE TRANSMISSION LOSS RATINGS FOR
DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

VERIFICATION OF PUBLISHED STC FIGURE

Given that design incorporates well engineered compression seals at every joint so that the assembled partition would be expected to behave almost as if it were a continuous panel, a good starting point seemed to be the old faithful mass law equation:-

$$TL = 20 \log W + 20 \operatorname{Log} F - 47.5$$

Where W = mass in Kg/sq.m, F = the 1/3rd octave band of interest.

Although this is primarily applicable to solid constructions it does at least provide a basis for the investigation with the results given in the upper row of figures of Table 1. The lower row gives the 42STC contour which just comes within the permitted deviation criteria giving a difference sum of 31.9dB. Therefore, if the theoretical best case performance were to be attained in practice these panels would just scrape by with a rating of 42STC, leaving a shortfall of at least six STC grades (or effectively 6dB) when compared to the manufacturer's data.

FIELD MEASUREMENTS

In an attempt to establish the TL performance attained on site a series of measurements were undertaken (4) with a representative from the partition manufacturer in attendance. The equipment used comprised an Ivie IE-30A spectrum analyser/precision SPL meter, an Ivie IE-17A processor and HP type 7010B XY recorder. For this exercise both sets of partitions were tracked out and positioned and the manufacturer's representative invited to personally supervise the setting out of the panels and the tightening of the compression seals. This done, Unit #2, which is interposed between Units #2 and #3, was used as a source room and a pink noise diffuse sound field of approximately 100dB(A) generated.

The transmitted noise levels were measured in Units #1 and #3 at a distance of 2m from each respective partition to produce residual SPL values of 67dB(A) and 63dB(A) respectively. This is some 30dB above the ambient noise in the rooms and suggested that we should expect average transmission loss values in the region of 33dB and 37dB respectively. The plotted 1/3rd octave results are shown in Fig 5 and Fig 6. The upper plot in each instance shows the spectrum shape and 1/3rd octave levels of the excitation signal, the lower the corresponding levels in the respective receive rooms. The TL table shows the transmission loss value in each 1/3rd octave band derived by subtraction between the two plots.

Table 2 shows the TL data taken from Fig 5 arranged over the 32STC contour showing a total deviation of 30dB (mean deviation 1.875) whilst Table 3 shows the results taken from Fig 6 over the 36STC contour showing a total deviation of 25dB (mean deviation 1.563). Thus the sound insulation value between Units #2 and #1 just about scrapes home at 32STC (or 32dB Rw) and between Units #2 and #3, a more comfortable 36STC, the improved performance in the latter instance being probably due to the partitioned roof void between these particular Units. It can be seen that these figures are very close to the simple A-weighted SPL differences, fall well short of the calculated 42STC value, and are nothing short of a disaster in comparison to the published specifications.

By way of verification the tests were re-run with very similar results and were then repeated using a swept sinewave signal with a 1/3rd octave warble to avoid the effects of standing waves and phase cancellations. This produced still lower transmission loss figures as shown in Fig 6.

CONCLUSIONS

Clearly the results suggest that the assembled partition, as the original object of the work herein described, is not behaving as a coherent panel in practice and, based on the differences in the results obtained between Units #2 and #1 where there is no void closure above the track, and those obtained between Units #2 and #3 where the void is closed off, flanking transmission would appear to be a significant factor.

Although it is clear that the particular proprietary partition system tested does not, and is not likely to, comply with the manufacturer's published specification, there are a number of other issues arising from this study, many of which question the value of the single figure rating systems per se.

In the first instance, although the STC rating is a system in wide use by American manufacturers it is not widely known in the UK and it took several enquiries to ascertain its origin. A copy of the ASTM standard was eventually obtained from a colleague within the industry who markets American sourced architectural products in the UK. An architect in normal practice would simply take the published rating figure to mean an average transmission loss value as was the case as described here. Given the deviations permitted within these single figure rating methods this could be far from so and contrary to the stated objectives of the ASTM standard in particular, could produce a wide range of subjective results. It is suggested that it is not reasonable to expect an architect to fathom the mysteries of obscure and involved partition specification practices in order to specify a product!

Let us now consider some of those deviations in terms of the data herein presented.

In the "best fit" exercise in respect of the calculated TL values as shown in Table 1 it can be seen that the maximum deviations occur over the low-mid frequency band with quite significant levels of short-fall over the all-important two octaves between 250Hz and 1KHz, to provide a total deviation just 0.1dB inside the criteria value. At both extremes the TL values correlate well.

Now consider the situation as illustrated by Table 2. This again is a close shave fit into the 30STC contour, but in this instance the best correlation is over the low and mid frequencies with maximum deviation at the high frequency end to produce what is surely a far more useful transmission loss characteristic for most normal applications.

Finally, if we now take Table 3 we find a situation where the partition significantly out-performs the 36STC contour over the low frequency bands, deviates quite dramatically over the mid band and falls more or less into line at the high frequency bands. Here the improved low frequency performance would be a significant design feature for many applications but goes unrecorded by the STC rating system.

SINGLE FIGURE TRANSMISSION LOSS RATINGS FOR
DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

It is therefore possible - and even likely - to find significant spectral and therefore subjective loudness differences between two partition systems of the same STC or Rw rating. Even if the published ratings were reliable it is suggested that this is a most unsatisfactory, even misleading way in which to specify product intended to provide a quantifiable noise related function. Certainly, we as a practice would not begin to consider accepting a maximum deviation of the order of 8dB below our design target. Nor would we accept a total deviation of 32dB if all the deviations occurred over a critical band of frequencies as is the case in Table 1.

Given that partition systems of normal constructional forms invariably perform better at high frequencies than they do at low it seems that these single figure rating systems are the ideal get-out for the partition manufacturers, as provided the contours line up fairly well above, say, 1KHz - which is likely, the bit which matters can deviate considerably below the rating curve, yet still come within the specified data. Hirschorn (5) however, working with partition systems which closely fit the low and mid frequency part of the STC or Rw contours, finds that as a consequence the high frequency performance is orders of magnitude better than the reference contour, yet qualifies for the same relatively low STC or Rw rating as would an inferior product. He concludes that:-

"...a single number STC rating is not necessarily a good decription of performance."

Mr Hirschorn is clearly a master of understatement and his view is here fully endorsed.

References
(1) ASTM E413-73 "Standard Classification for Determination of Sound Transmission Class" (Reapproved 1980), American Society for Testing and Materials.

(2) BS5821:Part 1:1984 "British Standard Methods for Rating the Sound Insulation in Buildings and of Building Elements - Part 1. Method for Rating the Airborne Sound Insulation in Buildings and of Interior Building Elements", BSI, London.

(3) ISO717/1-1982 "Acoustics - Rating of Sound Insulation in Buildings and of Building Elements - Part 1: Airborne Sound Insulation in Buildings and of Interior Building Elements".

(4) Project File CF3301, The Sound Practice, Rugby, 1987

(5) Hirschorn M, "IAC Noise Control Handbook", The Industrial Acoustics Company, New York, 1982

1/3rd Oct Ctr Frq	125	160	200	250	315	400	500	630	800	1K	1.25K	1.6K	2K	2.5K	3.15K	4K
Calc TL	25.3	27.5	29.4	31.3	33.3	35.4	37.4	39.4	41.4	43.4	45.3	47.5	49.4	51.3	53.3	55.4
42STC	26.0	29.0	32.0	35.0	38.0	41.0	42.0	43.0	44.0	45.0	46.0	46.0	46.0	46.0	46.0	46.0
Deviation	0.7	1.5	2.6	3.7	4.7	5.6	4.6	3.6	2.6	1.6	0.7	-	-	-	-	-

total deviation = 31.9dB

Table 1: Calculated TL Values Vs 42STC Reference Curve

1/3rd Oct Ctr Frq	125	160	200	250	315	400	500	630	800	1K	1.25K	1.6K	2K	2.5K	3.15K	4K
Meas TL	20	17	20	22	24	32	32	29	35	32	32	32	35	35	32	38
32STC	15	18	21	24	27	30	31	32	33	34	35	35	35	35	35	35
Deviation	-	1	1	2	3	0	0	3	0	2	3	3	3	3	3	3

total deviation = 30dB

Table 2: Measured TL Values between Conference Units #2 and #1
US 32STC Reference Curve

1/3rd Oct Ctr Frq	125	160	200	250	315	400	500	630	800	1K	1.25K	1.6K	2K	2.5K	3.15K	4K
Meas TL	23	29	29	35	29	32	35	32	36	39	32	35	38	41	38	41
36STC	20	23	26	29	32	35	36	37	38	39	40	40	40	40	40	40
Deviation	0	0	0	0	3	3	1	5	2	0	2	5	2	0	2	0

total deviation = 25dB

Table 3: Measured TL Values between Conference Units #2 and #3
US 36STC Reference Curve

SINGLE FIGURE TRANSMISSION LOSS RATINGS FOR
DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

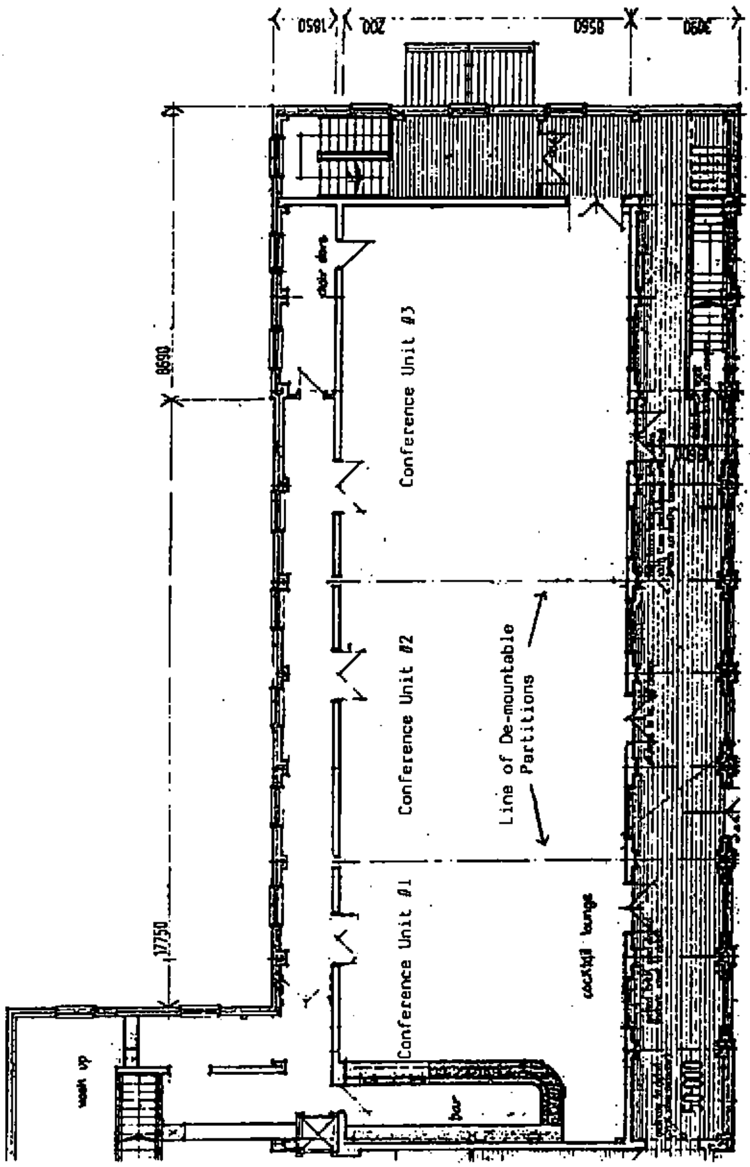

Fig 1 Plan Layout of Conference Suite

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DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

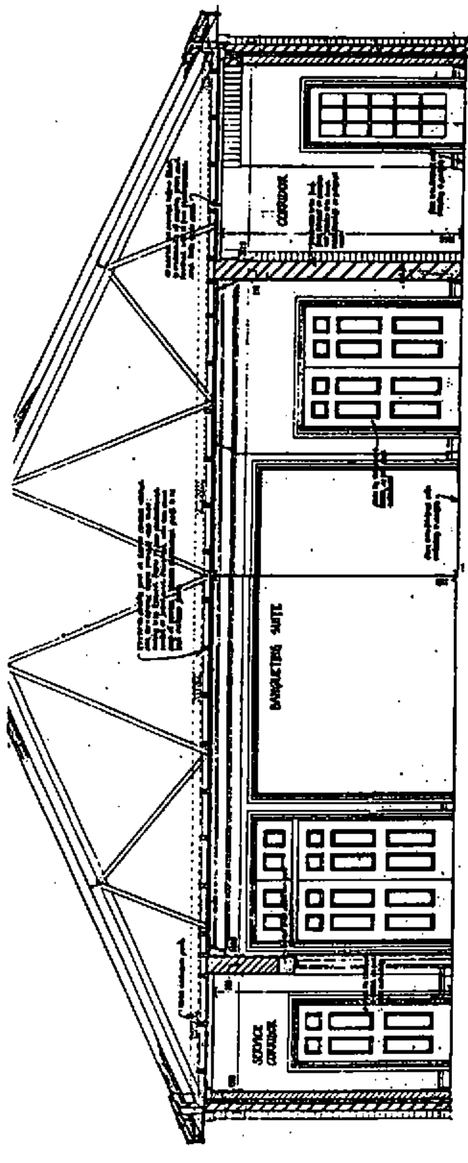

Fig 2 Section thru Conference Suite

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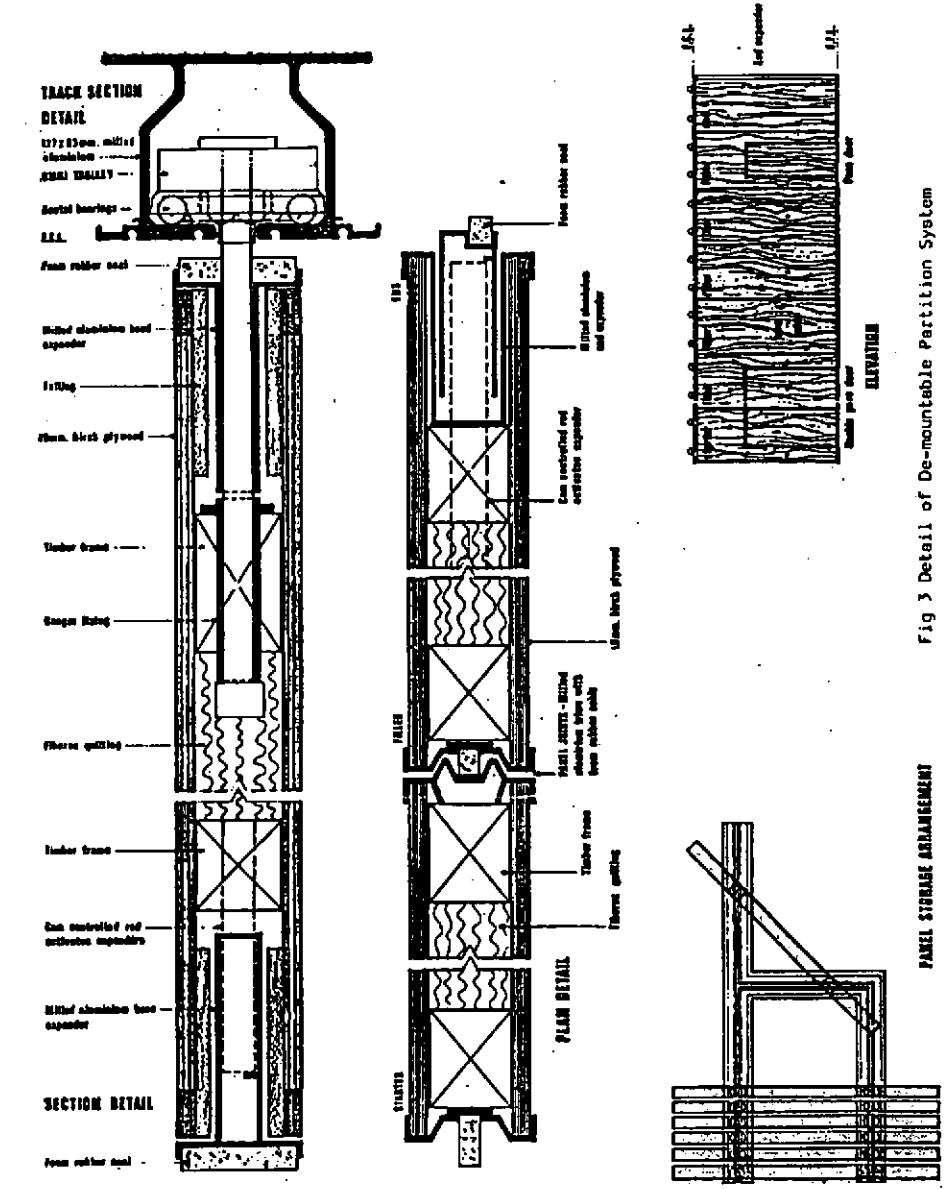

Fig 3 Detail of De-mountable Partition System

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DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?

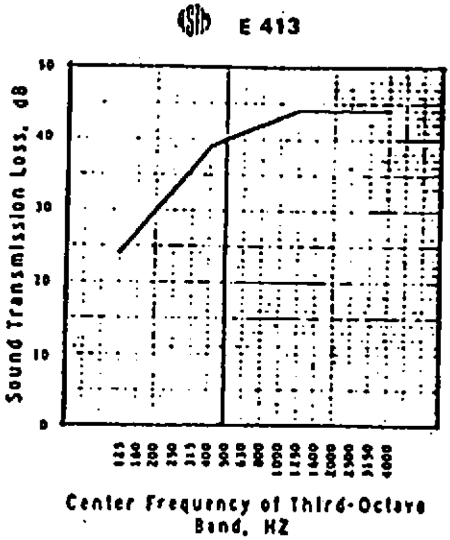

Fig 4 Typical STC Contour (STC-40).

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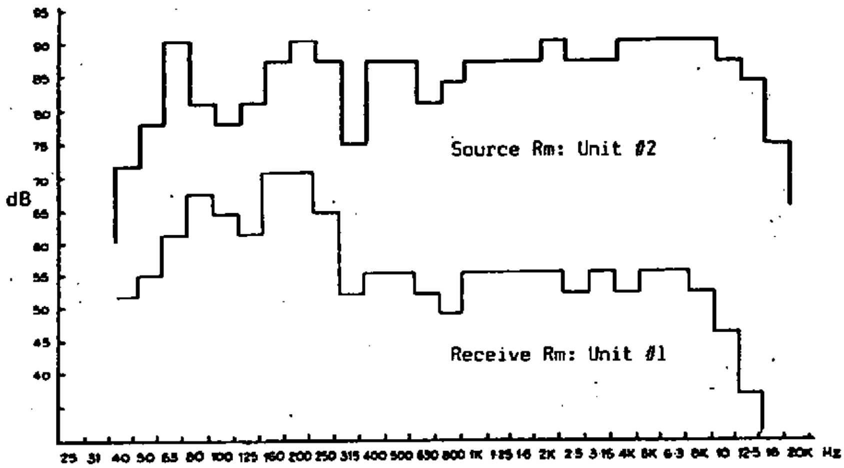
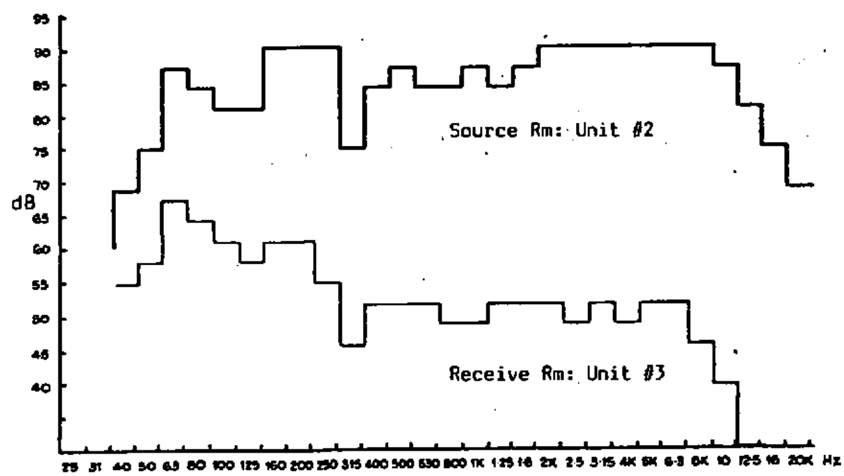
DE-MOUNTABLE ROOM PARTITIONS - ARE THEY WORKABLE?



TL	-	-	20	22	29	14	13	20	17	20	22	24	32	32	29	35	32	32	32	35	35	32	38	35	35	38	41	38	-	-

Fig 5 Transmission loss between Conference Units #2 and #1



TL	-	-	15	18	20	20	20	23	29	29	35	29	32	35	32	36	39	32	35	38	41	38	41	38	38	45	47	51	-	-

Fig 6 Transmission loss between Conference Units #2 and #3

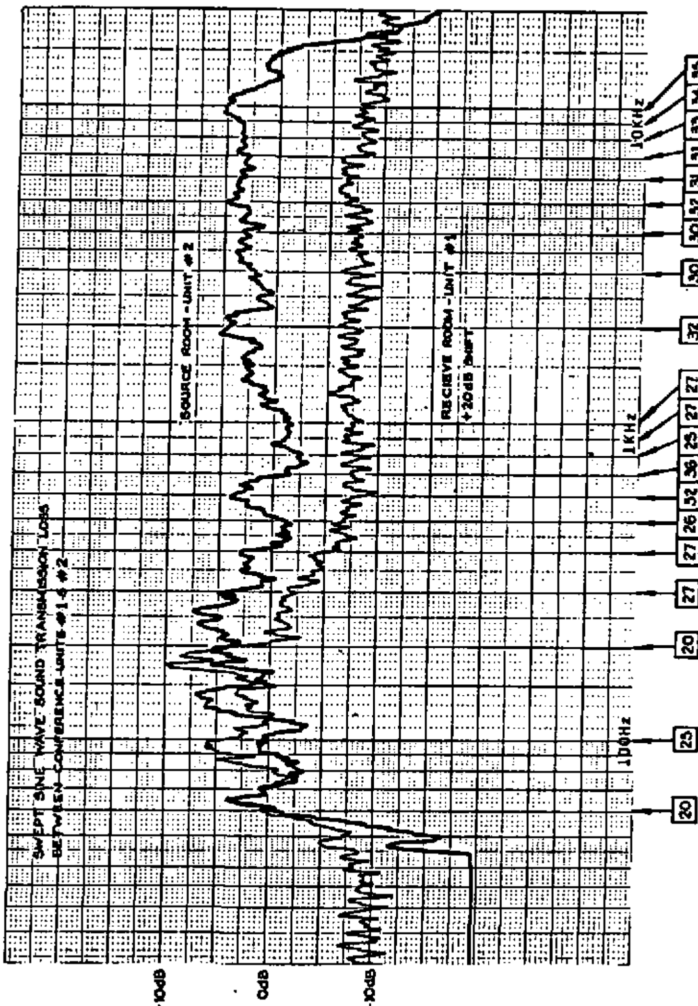


Fig 7 Swept sinewave TL between Conference Units #2 and #1