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A NEW FACILITY FOR TESTING DUCTED SOUND ATTENUATORS UNDER THE INFLUENCE OF FLOW

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INTRODUCTION

Following the completion of its new buildings on the University campus in Stuttgart, the Fraunhofer-Institut für Bauphysik has a number of novel experimental facilities to offer both as research and development aids and for product testing. The test facility for ducted silencers is one of these. Designed and built by Turbo-Lufttechnik GmbH of Zweibrücken, it is the largest test rig in the Institute, occupying a volume of over 2000 m^3.

PROCEDURES FOR TESTING DUCTED SILENCERS

A silencer's performance can be assessed by means of the two test procedures set out in the draft Standards ISO 7235 [1] and DIN 45 647. In the Direct Method, said to yield a silencer's transmission loss, the silencer is fitted in a test duct, a sound field generated to one side of it and the space- and time-averaged sound pressure levels on either side compared (Fig. 1). The Substitution Method, which yields the insertion loss, compares for a given incident sound field the noise level on the silencer's receiver side with the level measured in the same part of the duct when the silencer is replaced by a rigid substitution element (Fig. 2).

The Direct Method is the simpler of the two. Strictly though, it yields a silencer's transmission loss (defined as the ratio of the incident sound power to the transmitted sound power) only when the waves reflected from the silencer are weak compared with those incident upon it. That is because the source side microphone senses both incident and reflected waves and simple analysis procedures cannot discriminate

between them. This method has a further weakness however. Direct Method sound level measurements must be carried out in the duct. That may be difficult if there is a steady flow, for then background flow noise may mask the acoustic signal.
The Substitution Method has the edge because it offers the possibility of carrying out measurements in reverberation chambers connected to the duct, as well as in the duct itself (Fig. 2b). Microphones fitted in reverberation chambers can be positioned away from regions of high local flow velocity. Further, if a reverberation chamber is provided on the source side (Fig. 3), measuring the sound level there provides a check that the rate of acoustic power flow toward the silencer is the same in the two comparative tests that the Substitution Method calls for.

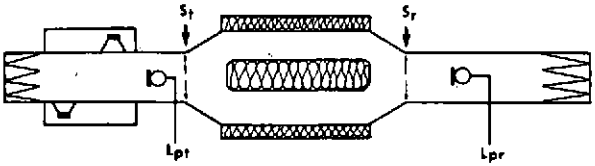
THE STUTTGART TEST FACILITY

The test silencer is inserted in a 12 m long test section 6 connected to reverberation chambers 1, 9 at each end. Air is driven through the test section (at maximum velocities of over 50 m/s) by means of a two-stage axial flow fan 12, which can be run in either direction. The facility is normally run in the closed circuit mode of operation but it can also be driven open-circuit by opening the ports numbered 10 in Fig. 3.
Careful design ensures that negligible fan-induced noise reaches the reverberation chambers, especially the receiver room, whose tolerable background noise threshold is lowest. The fan is double-mounted on a massive concrete foundation, extensive decoupling treatment interrupts the sound transmission paths within the facility's structural shell and sound-absorbent baffles that extend 9 m into the air passage upstream of the fan and 6 m downstream are fitted. The success of these measures may be judged by the fact that at a volumetric flow rate of 20 m^3/s, the fan-induced noise levels in the transmission and receiver rooms are only 35 dB(A) and 29 dB(A) respectively.

CONCLUSION

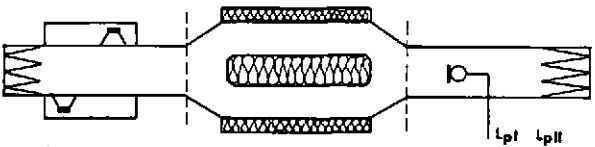
The new test facility allows the precision measurement of a silencer's insertion loss, transmission loss, self noise and pressure loss, parameters that are of key importance in applications.
The facility is large enough to allow the full-scale testing of most air-conditioning equipment as well as silencers for industrial applications under realistic operating conditions. It is equally well suited to the study of fundamental problems of flow-acoustic interaction, however, many of which remain poorly understood.

[1] Measurement procedures for ducted silencers. ISO/DIS 7235

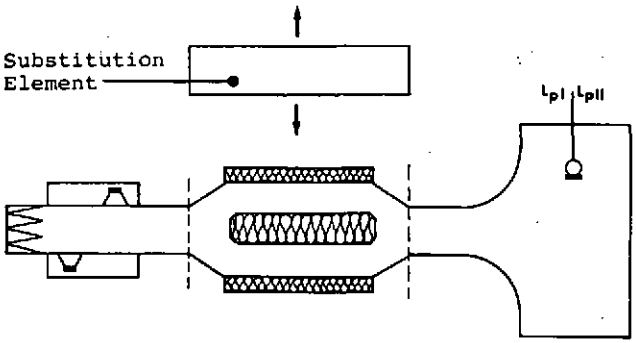


$$\text{Transmission Loss} = \overline{L}_{pt} - \overline{L}_{pr} + 10 \lg \frac{S_t}{S_r}$$

Fig. 1: The Direct Method



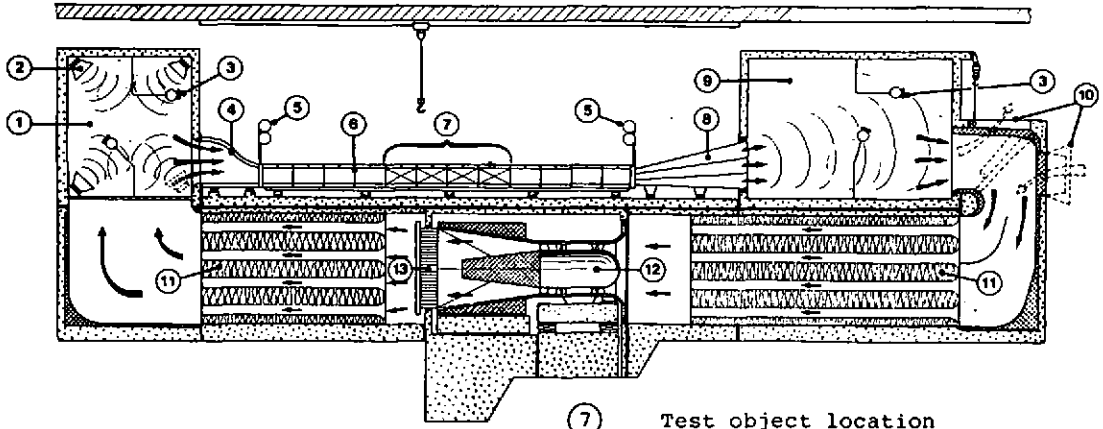
(a) In-duct measurements



(b) Reverberation chamber measurements

$$\text{Insertion Loss} = \overline{L}_{pI} - \overline{L}_{pII}$$

Fig. 2: The Substitution Method



1. Transmission room
2. Loudspeakers
3. Rotating microphone
4. Contraction
5. Static and dynamic pressure measurement stations
6. Test section
7. Test object location (duct width variable)
8. Diffusor
9. Receiver room
10. Ports for open-cicuit operation
11. Sound-absorbent baffles
12. Fan
13. Air cooler

Fig.3 : The Silencer Test Facility