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DUCTED SILENCER TEST FACILITY WITH ADJUSTABLE TEST DUCT IN CHINA ACADEMY OF BUILDING RESEARCH

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In laboratory measurements for ducted silencers of different size or shape, transitions are needed to connect mismatching cross sections of test silencers and test duct, which may lead to unexpected deviations in test results and limit the dimension of test objects. To minimize the interference caused by the insertion of transitions, China Academy of Building Research established a ducted silencer test facility with adjustable test duct in 2016. The ductwork is constructed of a steel platform and compound metal modules. By changing the configuration of the modules, the cross section of test duct can vary from 500mm×400mm to 1000mm×1400mm, 12 sets in total. Silencers of the same size and shape can be installed directly, while other test objects can be connected to the test duct through transition as usual, which can minimize the cross section changes.
Keywords: ducted silencer, adjustable test duct, insertion loss, pressure loss, flow noise

1. Introduction

In laboratory measurements for ducted silencers of different size or shape, it is common that transitions are needed to connect mismatching cross sections of test silencers and test ducts. However, the existence of transitions may lead to unexpected deviations in test results and limit the dimension of test objects. To minimize the interference caused by the insertion of transitions, China Academy of Building Research established a ducted silencer test facility with adjustable test duct in 2016. The acoustic and aerodynamic performance of silencers and air-terminal units, including insertion loss, flow noise and total pressure loss, can be achieved through this facility in compliance with ISO 7235:2003.

2. Facility Set-up

The test facility mainly consists of source chamber, adjustable ductwork, reverberation room, fan chamber and system silencers. The intake and outlet for airflow are arranged independently beside the reverberation room since the flow path is of acyclic organization.

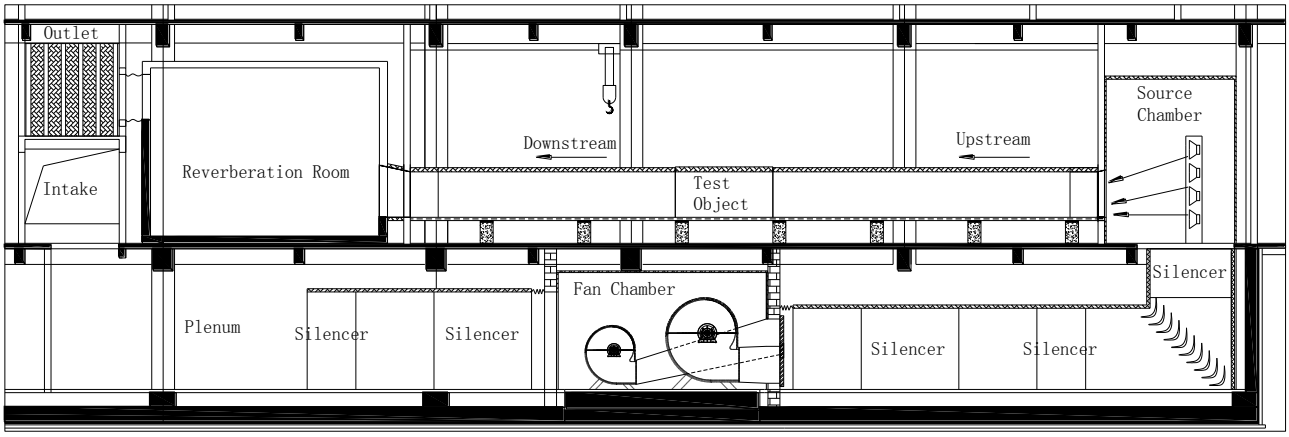

Figure 1: Profile of the test facility

2.1 Sound-source and Receiving-side Equipment

For acoustic testing, the sound field is excited by a pair of loudspeakers in the source chamber with a peak power rating up to 3200W. The sound travels through the test object and radiates into the reverberation room with a volume of 241m^3, inside which the sound level is measured by a rotary microphone.

2.2 Airflow Supply Equipment

For dynamic testing, the airflow is produced by three centrifugal fans located in the basement. The small one with a power of 37kW works alone, while the other two of 75kW works together, allowing the flow rate of higher than 30m^3/s. The fans are controlled by two variable-frequency drives working from 5Hz to 50Hz, which enables the flow rate to change continuously.

2.3 Vibration and Noise Control of Fans

To insulate the vibration and noise transmitted from the fan chamber to the reverberation room, the fans are mounted on a concrete pedestal weighing more than 50,000kg, which is supported by spring vibration isolators. Besides, additional enclosures are built up to cage the fans and system silencers, improving the airborne insulation of the original walls and ceiling.

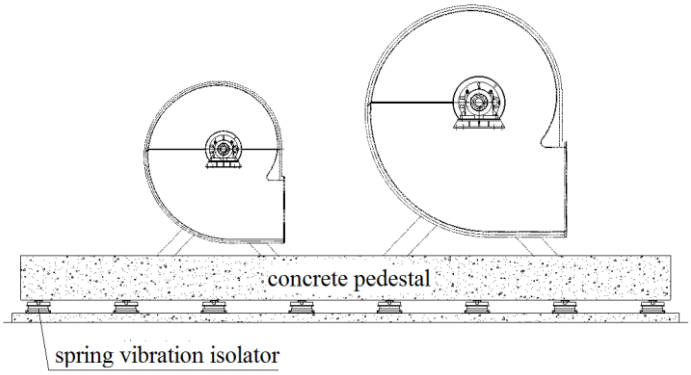

Figure 2: Vibration insulation of fans

To obtain a quiet airflow for the measurement of flow noise, three sections of splitter silencers with a total length of 6m are arranged behind the fans. The first two silencers are used to attenuate the fan noise, while the third one, which is located beneath the steel lattice of the source chamber, is used to reduce the fan noise as well as the regenerated noise of the upstream components.

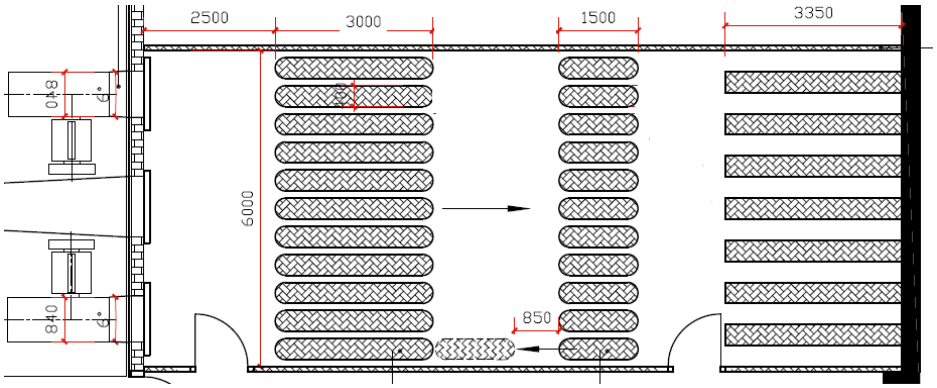

Figure 3: Silencers behind the fans

Another two sections of silencers are arranged in front of the fans, in order to lower the noise of the intake and basement.

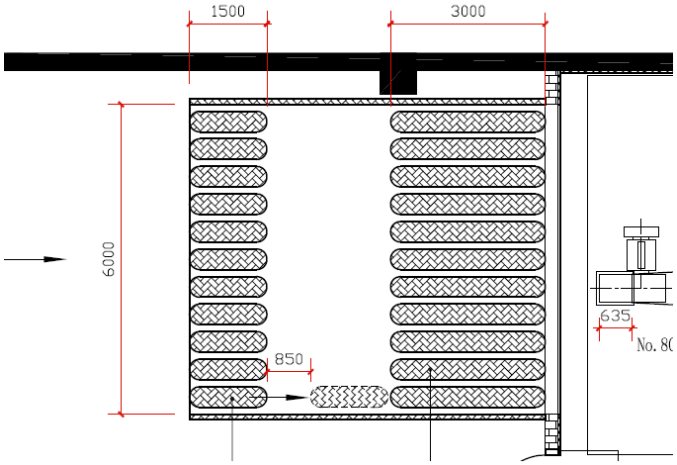

Figure 4: Silencers in front of the fans

Figure 5: Photograph of the fan silencer

3. Adjustable Test Duct

The whole test duct can be divided into three parts: the shrinking inlet, the straight duct and the expanding outlet. The enclosed angles of the walls for the inlet and outlet do not exceed 15 °in compliance with ISO 7235:2003. The overall length of the ductwork is about 21.1m, and the allowable limit for specimen installation is up to 5.1m.

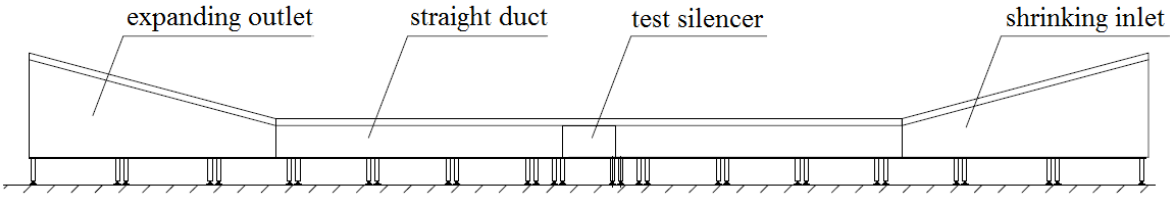

Figure 6: Profile of the test duct

3.1 Steel Platform

The bottom of the test duct is a steel platform consists of 15 units. The middle 5 units with a length of 5.1m are removable for specimen installation. Bolt-holes are reserved for the mounting of duct walls.

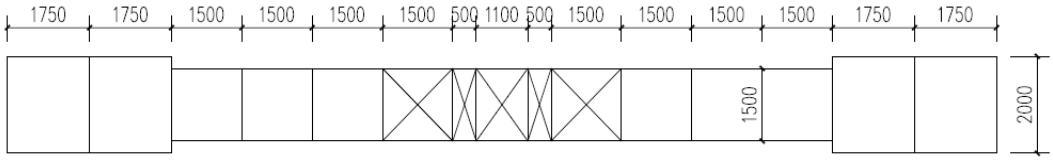

Figure 7: Configuration of the steel platform

3.2 Duct Wall Module

The side walls and the roof of the test duct are composed of compound metal modules of customized size. The thickness of the module is about 45mm with a construction of 2mm steel sheet + 40mm damping material + 3mm steel sheet, providing a sound insulation of higher than 50dB.

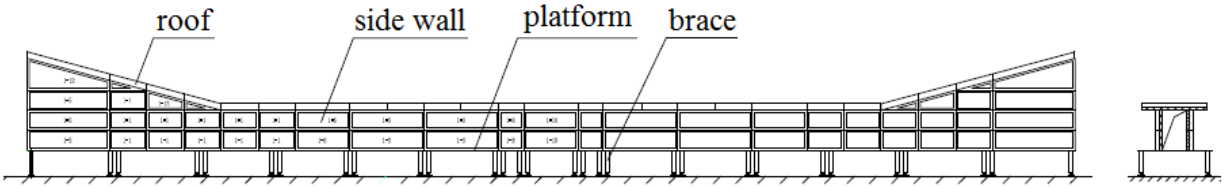

Figure 8: Construction of the test duct

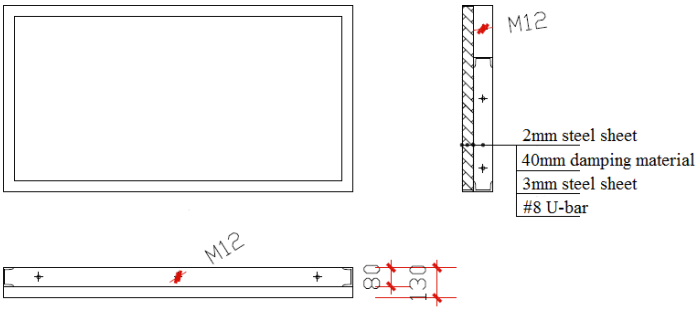

Figure 9: Construction of the duct wall module

Figure 10: Photographs of the test duct

3.3 Variations of Test Duct

By changing the configuration of the modules, the height of the straight duct can vary from 400mm to 1400mm in 200mm-steps, and the width can be modulated to 500mm, 630mm and 1000mm, making a total of 12 sets of test ducts. Silencers of the same size and shape can be mounted directly, while other test objects can be connected to the test duct through transitions as usual, which can minimize the cross section changes.

Table 1: Variations of the test ducts

Height (mm) / Width (mm)	400	600	800	1000	1200	1400
500	500×400	500×600	500×800	——	——	——
630	630×400	630×600	630×800	630×1000	——	——
1000	——	1000×600	1000×800	1000×1000	1000×1200	1000×1400

4. Verification Test

To determine the physical characteristics of the test facility, verification tests have been conducted during the tune-up of the system.

The following data is derived with the test duct of 1000mm×1400mm. The two high-volume fans are running during the dynamic measurements.

4.1 Background Noise of Reverberation Room

The noise level within the reverberation room is measured when the fans are running without airflow in test duct. It is approached by opening the door of source chamber, through which the airflow bypasses the test duct. Test results are shown in Table 2. As a reference, the flow rate in test duct of 1000mm×1400mm is around 15m/s when the VFD is setting at 26Hz.

Table 2: Noise level test results

VFD freq. (Hz)	0	6	12	18	24	30
Noise level (dBA)	20	21	21	22	24	27

4.2 Flow Noise of Test Duct

The flow noise of test duct is shown in Table 3. Testing conditions are the same with the previous subsection, except that the door of source chamber is closed.

Table 3: Flow noise test results

VFD freq. (Hz)	5	10	15	20	25
Flow rate in duct (m/s)	3.0	5.4	8.4	11.1	13.9
Flow noise (dBA)	21	27	41	50	55

4.3 Limiting Insertion Loss

The limiting insertion loss measurement is carried out under the instruction of Annex C specified in ISO 7235:2003. Test results are shown in Table 4.

Table 4: Limiting insertion loss test results

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Limiting insertion loss (dB)	23	41	55	60	64	69	71	67

4.4 End Reflection Coefficient

The end reflection coefficients of the receiver side are measured using the standing wave method in the straight duct. The cut-on frequency for the test duct of 1000mm×1400mm is around 125Hz. Test results are shown in Table 5.

Table 5: End reflection coefficient test results

Frequency (Hz)	50	63	80	100	125
End reflection coefficient	0.4	0.4	0.3	0.4	0.2

5. Conclusion

This article mainly introduces the newly-built test facility for ducted silencers and air-terminal units in CABR. The innovative design of the adjustable test duct can provide the measurements with better flexibility and accuracy. Moreover, fundamental research on the characteristics of silencers can be done based on this facility.

REFERENCES

1 ISO 7235:2003, *Acoustics – Laboratory measurement procedures for ducted silencers and air-terminal units – Insertion loss, flow noise and total pressure loss*.

2 ISO 3741:2010, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation rooms*.

3 ASTM E477-13, *Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers*.

4 China Academy of Building Research, *Handbook of Architectural Acoustics*, China Architecture & Building Press, Beijing (1991).