聲學測試服務有限公司
Acoustic Testing Services Limited
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Assessment Report for Sound Transmission Loss of Single-leaf Acoustic Door

REPORT REFERENCE NUMBER:	ATS17-009-RP001
DATE OF REPORT:	09th June 2017
REPORT FOR:	Faith Mark Consultants Limited G/F., 120 Camp Street, Sham Shui Po, Kowloon
ATTENTION:	Mr. H. F. CHAN

Assessed & Issued by

Ir Dr. Fan CHONG
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1. Introduction

This report presents an appraisal for the sound insulation performance of one modified single-leaf acoustic door, based on the tested data of a tested ***Acoustic Timber Door*** which has been tested by Acoustic Testing Services Limited in April 2017, refer to Test Report ATS16-095-RP001 as given in Appendix B.

The tested ***Acoustic Timber Door*** has been proved achieving the acoustic rating of *STC* 41 according to ASTM E90-09 and ASTM E413-10. And the predicted performance of the modified single-leaf acoustic door is also checked with the requirement of ASTM E90 with ASTM E413 for ***STC*** rating.

2. Background Information

2.1 STC Rating

The sound transmission loss of a doorset is a measure of the airborne sound insulation it provides. It is a measure of the ratio of the sound energy W_1 striking the doorset relative to the energy W_2 which is transmitted through the doorset.

This quantity is denoted by R and is expressed in decibels as follows,

$$R = 10 \lg \frac{W_1}{W_2} \qquad (1)$$

The sound transmission loss of a doorset varies with frequency, usually increasing as the frequency increases.

Although sound insulation varies with frequency and is very different for different types of doors, it is convenient to compares the effectiveness of two doors using a method of rating sound insulation that can be represented by a single number. In North America, the most commonly used single-number rating of sound insulation is called the "Sound Transmission Class (*STC*)". The higher the *STC* rating a door achieved, the better the sound insulation provided by the door.

In this report, *STC* will be used to present the sound insulation performance of doors. Values of the weighted sound transmission class, *STC*, are determined from the measured sound transmission loss, *TL*.

2.2 It is assumed that the assessed doors will be tightly sealed around the entire door perimeters. The sound reduction index on the weight per unit area of the door is in terms of Mass Law. It is assumed there is a 6dB increase in sound reduction index for each doubling of superficial weight of the door leaves.

2.3 Sound Insulation

The improvement of sound insulation performance for a common building element can be achieved by increase the mass per area of the element.

Building element consisting of a single homogeneous panel can be modeled quite well by the mass law up to the critical frequency. The mass law predicts the sound insulation (or sound transmission loss) from the surface mass of the building element and the frequency. If the surface mass is in kg/m^2 and the frequency in Hz, then the sound transmission loss *TL* is given in

$$TL = 20\lg(f * m) - 47 \qquad (2)$$

where, *m* is the surface mass of the single homogeneous panel.

A simple explanation of the mass law is that the motion of the panel is controlled by its inertia, the panel behaving as a limp mass, and the displacement or velocity of the panel reduces as the mass of the panel is increased or as the vibration frequency increases. The mass law is a good approximation for the great majority of materials at low and mid frequencies.

For double-leaf building elements, the sound transmission loss *TL* based on mass law is given in

$$TL = 16\lg[(m_1 + m_2) \times f] - 30 + \Delta TL \qquad (3)$$

where, m_1 and m_2 are surface mass of two leaves; ΔTL is the additional sound reduction of the cavity between of two leaves.

2.4 Supporting Data

"Test Report ATS16-095-RP001 by Acoustic Testing Services Limited"

The ***Acoustic Timber Door*** was tested according to ASTM E90-09 with ASTM E413-10 by Acoustic Testing Services Limited in April 2017. The ***Acoustic Timber Door*** can achieve sound insulation performance of *STC* 41 under the laboratory testing. The details of the laboratory sound transmission loss measurement for the captioned acoustic door are given in the Test Report ***ATS16-095-RP001*** as attached.

The overall size of the ***Acoustic Timber Door***, with door frame, is 1870mm wide by 2338mm high. And the overall size of each door leaf is 900mm wide by 2300mm high by 60mm thick. A 40.5mm thick glazing vision port with vision dimension 355mm wide by 655mm high, consisted of a laminated glass (6mm clear glass + 1.52mm PVB + 6mm clear glass) and 8mm clear glass with 19mm

airspace between panes, was incorporated to one of the door leaf. Door leaf core information is shown as follows,

Door Leaf Core	
Material:	51mm thick 650kg/m^3 Hardwood Stile
	2.5mm thick Plywood both sides
	2mm thick Steel Plate both side
	60kg/m^3 rockwool infilled in the cavity

Weather strip Typed Lorient JS1212 Batwing smoke seal & Raven RP10Si perimeter seal fitted to head and jambs of door frames were concealed by frame covers, Raven RP70Si door bottom drop seal was applied to the bottom of the door leaf, Raven RP117Si Threshold was applied to the bottom of doorset and Raven RP16Si Meeting Stile Seal was applied at the meeting stile of the door leaves to achieve the acoustic performance of *STC* 41. Details of the tested ***Acoustic Timber Door*** are given in Appendix B.

3. Required Variations and Modifications to Tested Doorset

The requirement for this assessment is for the following variations and modifications to the tested ***Acoustic Timber Door***,

a) The overall size of the door with door frame is modified from 1870mm wide by 2338mm high with double leaves to *966mm wide by 2338mm high with single leaf*, with other detailed configuration of the doorset comprising door frame and other weather strips are remained.

b) *Two layers of Minimum 6mm thick MDF/Fireboard* with minimum density 700kg/m^3 will be incorporated into the door leaf additionally. The total thickness of door leaf is remaining unchanged as 60mm.

c) Vision panel will be changed to double laminated glasses configuration as *"6mm clear glass+1.52mm PVB+6mm clear glass + 19mm Air Space + 6mm clear glass+1.52mm PVB+6mm clear glass"*. The height and width of vision panel are remaining unchanged.

Details of modified single-leaf acoustic door shall refer to Appendix C.

4. Technical Assessment

4.1 In general, the degradation of sound insulation performance between the door-leaf panel and doorset is due to the leakage of air through gaps between the door leaf and its frame. It is clear to know that the acoustic performance of high performance door is nearly always governed by the door seals. Even a slight air gap will render the door acoustically ineffective. Appendix A gives a reference

curve showing the relationship between and sound transmission loss and sound leakage.

4.2 Moreover, most of the double-leaf acoustic doors normally have a sound insulation weak point at the middle of the doorset. The meeting stile is the dominant sound leak area for double-leaf acoustic door which is seldom found in a single-leaf acoustic door.

In this assessment, the overall dimension of the modified single-leaf acoustic door is 966mm wide by 2338mm high which is smaller than the tested ***Acoustic Timber Door***.

Based on the above-mentioned information, for the modified single-leaf acoustic door, the perimeter of door leaf is decreased by 40% due to the alternation of the door overall dimension and without meeting stile of double door leaves, which will lead to the reduced sound leakage through the gaps between the door leaf and door frames and result in the improvement of sound insulation performance of the modified single-leaf acoustic door.

Two layers of minimum 6mm thick MDF/Fireboard with minimum density 700kg/m^3 are incorporated into the door leaf. For the modified single-leaf acoustic door, the door leaf can be regarded as a double-layer construction, with the aid of the computer simulation and the Mass Law, the sound insulation performance of the door leaf panel (except vision panel) can be obtained as *STC 50.*

The sound insulation performance of the vision panel with configuration as *"6mm clear glass+1.52mm PVB+6mm clear glass + 19mm Air Space + 6mm clear glass+1.52mm PVB+6mm clear glass"* can be expected as *STC 46.* Thus, the overall sound insulation of the door leaf can be obtained as *STC* 49.

Therefore, it can be concluded that, the modified single-leaf acoustic door, with modifications and variation as per Section 3, can achieve the sound insulation rating as *STC 45*, to our best knowledge.

5. Conclusions

5.1 It is our opinion that the above-mentioned modified single-leaf acoustic door (966mm wide by 2300mm high), modified from the tested ***Acoustic Timber Door***, can achieve the sound insulation rating as *STC* 45.

5.2 Change of material for skins of door leaf and door frame to stainless steel, with no change of the thickness, will NOT affect the sound insulation performance of the assessed door.

Change of height and width of the door frame and door leaves (but not the thickness) by a few percent (says less than 10%), with the seal conditions

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between the door frame and the door leaves being kept the same, will NOT affect the sound insulation performance of the assessed door.

Change of ironmongery, with similar size and function as assessment but with different name and brand and with no changes of the original constructions, it will hardly have any effects on the sound insulation performance of the assessed door.

Application of additional features and finishes (like moulding, wall paper, plastic laminate sheet, metal sheet on the assessed door.), with no changes of the original constructions of the assessed door (including on replacement of material to its original construction), it will not have any significant effect on the sound insulation performance of the assessed door.

Moreover, the width of fire seal, if any, subjected to different fire rating requirement, will not affect the sound insulation performance of the assessed door.

5.3 Alternative Door Seals

Additional to the above assessment, some acoustic door seals with similar performance as the applied door seals can be replaced by alternatives, which will NOT degrade the overall performance of the assessed acoustic door.

5.4 This assessment is based on the acoustic theory, engineering experience and information provided by **Faith Mark Consultants Limited**. Any changes in the configuration of the doors, excluding the above mentioned changes, under assessment will invalidate this assessment report.

The predicted ratings are for indicative only, actual performance of the assessed door in accordance to ASTM E90 with ASTM E413 shall be verified by a laboratory test.

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Appendix List

Appendix A	Reference Data
Appendix B	Test Report ATS16-095-RP001
Appendix C	Details of modified single-leaf acoustic door

Appendix A

Reference Data

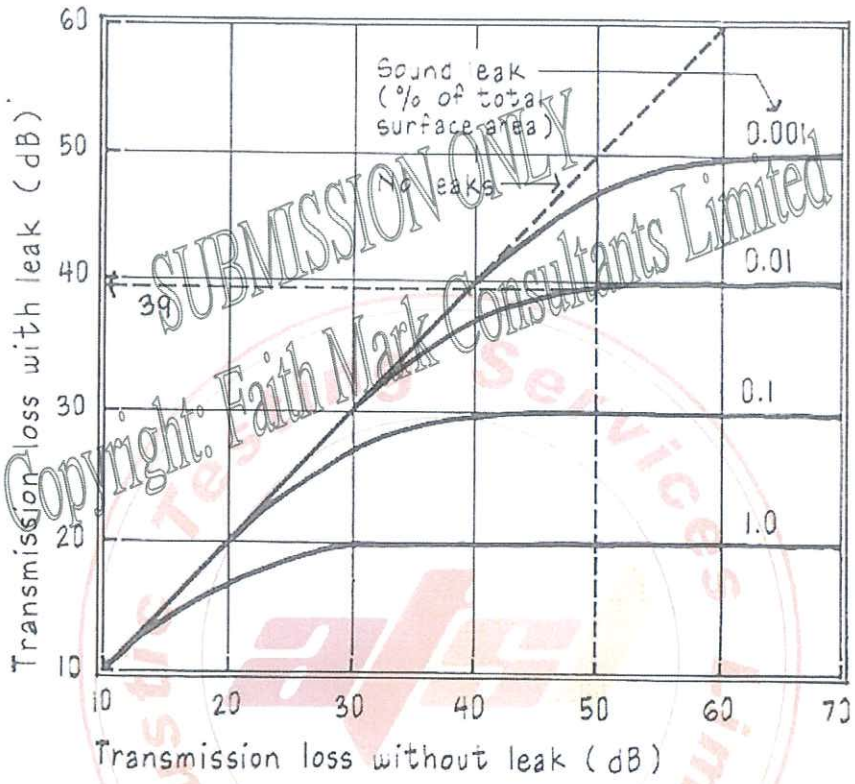

Figure 1 The degradation of Transmission Loss with / without sound leak.

Appendix B

Test Report ATS16-095-RP001

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HOKLAS 173 TEST

Test Report for Laboratory Measurement of Sound Transmission Loss

TEST REPORT REFERENCE NUMBER:	ATS16-095-RP001
DATE OF REPORT:	29 May 2017
TESTED FOR:	Faith Mark Consultants Limited G/F., 120 Camp Street, Sham Shui Po, Kowloon, Hong Kong
ATTENTION:	Mr. H. F. CHAN
UNIT UNDER TEST:	Acoustic Timber Door
TEST STANDARD:	ASTM E90 – 09
TESTED AT:	Unit E, 2/F., Century Industrial Centre, 33-35 Au Pui Wan Street, Fo Tan, Shatin, New Territories, Hong Kong.

Approved by: _____
Ir Dr. Fan CHONG / Managing Director
CEng, RPE, MHKIE, FIMechE, FIOA,
MHKIOA, MCIBSE, MASHRAE, MHKIQEP

HKAS has accredited Accustic Testing Services Limited (Reg. No. HOKLAS 173) under HOKLAS for specific laboratory activities as listed in the HOKLAS directory of accredited laboratories.

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1. METHOD OF TEST

The test was conducted in accordance with ASTM E90 – 09 "Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements" in the reverberation rooms of Acoustic Testing Services Limited. The single number rating of airborne Sound Transmission Loss is given as Sound Transmission Class (STC) by evaluation in accordance with ASTM E413 – 10 "Classification for Rating Sound Insulation".

2. INSTRUMENTATION

Description:	Serial Number:
Bruel & Kjaer Type 3560-B Real Time Frequency Analyzer	2454296
Ultragraph Pro Equalizer	N0517513166
STK V-6 Amplifier	C04OM013
Bruel & Kjaer Type 4292 OmniPower Sound Source	021005
Bruel & Kjaer Type 4292-L OmniPower Sound Source	005007
Bruel & Kjaer Type 4942 Random Incident ½" Microphone (Source Room)	2497997
Bruel & Kjaer Type 4942 Random Incident ½" Microphone (Receiving Room)	2497998
Bruel & Kjaer Type 4231 Sound Level Calibrator	2478237

The measuring equipment has been calibrated by an external recognized accredited laboratory, and is in current calibration.

3. PRINCIPLE OF TEST

The Sound Transmission Loss of a partition is usually measured in a laboratory by placing the element in an opening between two adjacent reverberant rooms designed for such tests. Noise is introduced into one of the rooms, referred to as the source room, and part of the sound energy is transmitted through the test element into the second room, referred to as the receiving room. The resulting mean space-average sound pressure levels in the source room and the receiving room are L_1 and L_2, respectively.

The Sound Transmission Loss is given by

$$TL = L_1 - L_2 + 10\lg(S/A) \quad \ldots(1)$$

where,

L_1 is the average sound pressure level in the source room, in dB;
L_2 is the average sound pressure level in the receiving room, in dB;
S is the area of the test specimen, in m²;
A is the equivalent absorption area in the receiving room, in metres sabins.

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$$A = (0.9210Vd / c) \quad \ldots(2)$$

where,

V is the receiving room volume, in m^3;
d is the rate of decay of sound pressure level in receiving room, dB/s;
c is the speed of sound in the medium, m/s.

The speed of sound changes with temperature and shall be calculated for the conditions existing at the time of test from the equation:

$$c = 20.047\sqrt{273.15 + t} \quad \ldots(3)$$

where,

t is the receiving room temperature, measured to nearest degree Celsius.

The Sound Transmission Class (STC) of test specimen is calculated by comparing the sixteen values of Sound Transmission Loss from 125 Hz to 4000 Hz with a defined reference curve which is incremented until the requirements of ASTM E413 – 10 are met.

STC contour consists of a horizontal segment from 1250 Hz to 4000 Hz, a middle segment increasing by 5 dB from 400 Hz to 1250 Hz and a low frequency segment increasing by 15 dB from 125 Hz to 400 Hz. The STC rating of an element is determined by plotting the 1/3 octave band TL of the element and comparing it with the STC contour. The STC contour is shifted vertically until the TL curve falls mainly below the contour and the following criteria are met:

1. the TL curve is never more than 8 dB below the STC contour in any 1/3 octave bands; and
2. the sum of the deficiencies below the contour over the 16 1/3 octave bands does not exceed 32 dB.

When the STC contour is shifted to meet these criteria, the STC rating is given by the value of the contour at 500 Hz.

The measured sound transmission loss values are obtained from a single direction measurement.

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4. MEASUREMENT PROCEDURES

4.1 Firstly, the background noise level was measured in the receiving room before the sound pressure level measurement.

4.2 Then, sound source was generated in the source room. The sound pressure levels were measured for 15s in the source room and receiving room simultaneously for each measurement. Total 16 measurements of sound pressure level in each room were made.

4.3 After measurements of sound pressure level, the decay rates were measured at total 3 microphone positions with 5 times measurement at each microphone positions in the receiving room.

4.4 Before and after the measurement, the used measurement system was calibrated by sound level calibrator.

5. RESULTS APPLICATION

The results obtained can be used to design building elements with appropriate acoustic properties, to compare the sound insulation properties of building elements and to classify such elements according to their sound insulation capabilities.

The test was performed in laboratory facilities in which transmission of sound through flanking paths is suppressed. Results of measurements shall not be applied directly in the field without accounting for other factors affecting sound insulation, especially flanking transmission and loss factor.

The test results obtained relate only to the Unit Under Test.

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6. DETAILS OF TEST

Date of receipt of Unit Under Test:	30 March 2017
Date of commencement of construction of Unit Under Test:	31 March 2017
Date of test:	03 April 2017
Unit Under Test:	Acoustic Timber Door
Sample I. D.:	ATS16-095-TS001
Dimensions used for calculation:	1860 mm (width) X 2330 mm (height)
Manufacturer:	Faith Mark Consultants Limited
Installed by:	Faith Mark Consultants Limited
Additional Description:	--

The details of the Unit Under Test refer to the drawings given in Appendix 1, if applied. The information of the Unit Under Test is provided by the Client and is not verified by the laboratory.

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7. TEST RESULTS

Source Room:

Temperature:	21	°C
Humidity:	62	%
Volume:	221	m³

Receiving Room:

Temperature:	21	°C
Humidity:	62	%
Volume:	80	m³

Specimen Dimension used for calculation:

Width:	1860	mm
Height:	2330	mm

Sound Transmission Loss (TL):

Freq. (Hz)	1/3 Oct. TL (dB)	1/1 Oct. TL (dB)
100	23	
125	32	27
160	36	
200	35	
250	32	34
315	37	
400	38	
500	39	39
630	40	
800	41	
1000	41	41
1250	40	
1600	41	
2000	44	43
2500	46	
3150	47	
4000	48	48
5000	48	

STC = 41

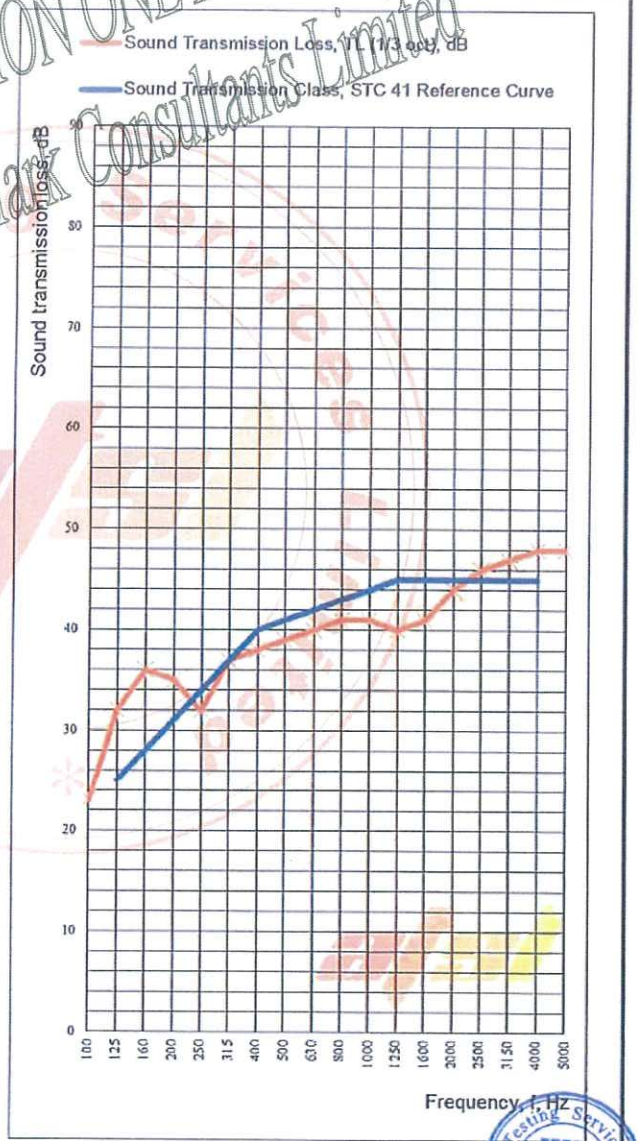

Figure 1. Sound Transmission Loss against Frequency

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APPENDIX LIST

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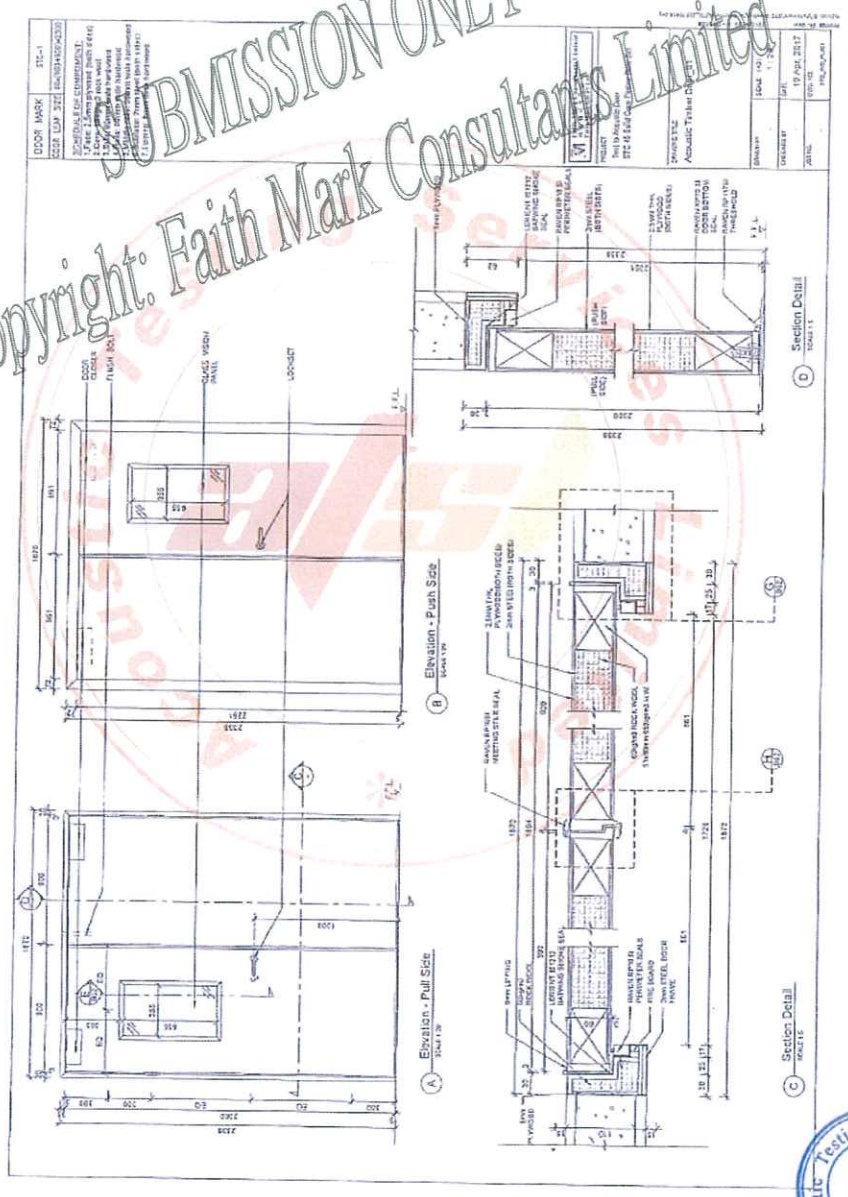
APPENDIX 1

Details of Unit Under Test



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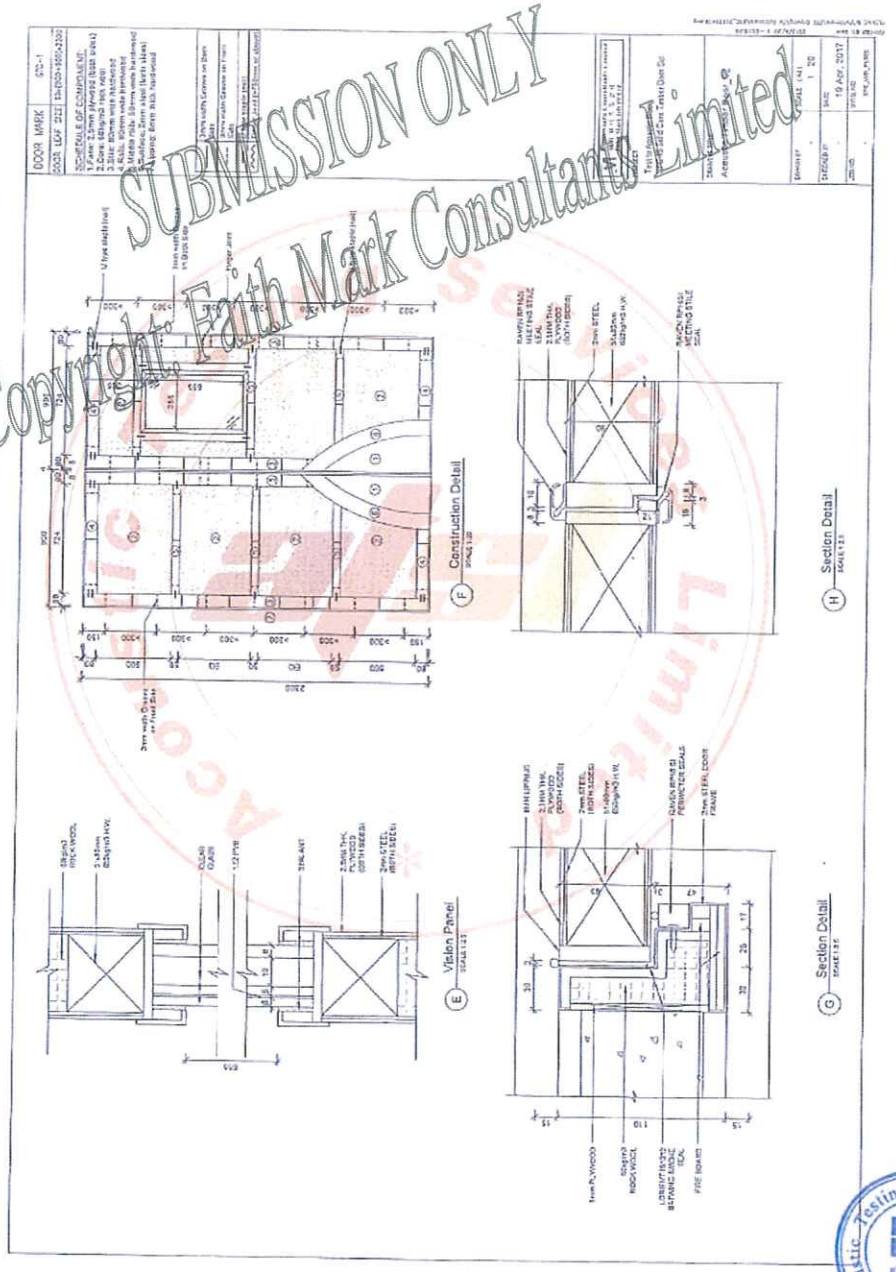

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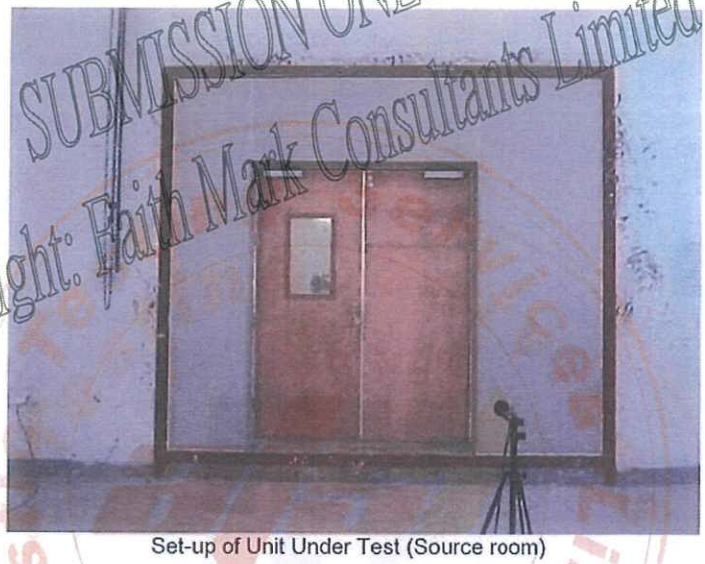
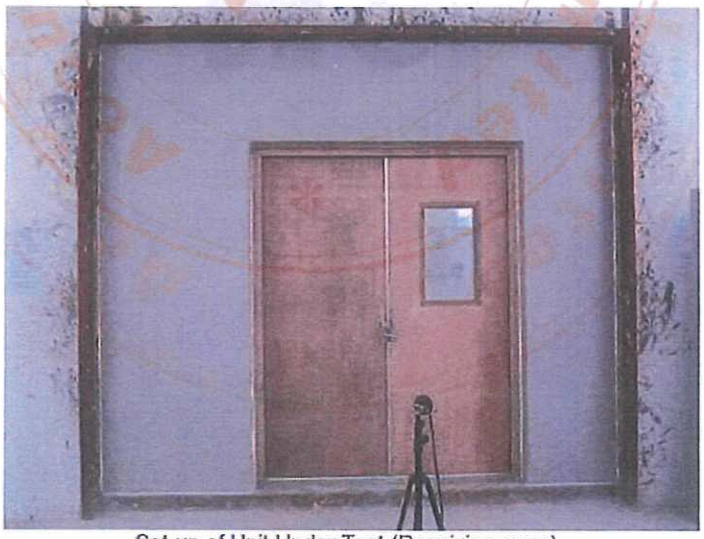
APPENDIX 2

Photographic Records



Set-up of Unit Under Test (Source room)



Set-up of Unit Under Test (Receiving room)

End of Report

Appendix C

Details of modified single-leaf acoustic door