

Memo

To: Manchester City Council
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Date: 23-7-2018 (update 23-11-2021)
Project: Factory –acoustic performance specifications Mechanical Services
Reference: ASITE MF-LAV-XX-XX-RP-YA-01-0016 – revision C08 (LA.170505.M09)
Issued for Construction

This document deals with the acoustic performance specification of Factory's mechanical services.

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1 Interior admissible noise levels

Noise from service equipment in noise-sensitive areas of the building and towards noise-sensitive buildings around the Factory should be sufficiently reduced. Table 1 shows the admissible noise levels due to building services per space.

Table 1: Admissible noise levels due to building services

Explanation	Criteria for path
Theatre seated	See occupancy scenario's annex E
Theatre standing	See occupancy scenario's annex E
Warehouse	See occupancy scenario's annex E
Theatre + warehouse stage	See occupancy scenario's annex E
Control room level 2	NR25
Control room level 5 (recording/editing)	NR25
Control room level 5 (spot light)	NR45
Green room	NR35
Meeting rooms L5	NR35
Meeting rooms L6	NR30
Cellular offices	NR35
Open plan offices	NR40
Foyers	NR40
Retail units, shops, cafes	NR40
Toilets	NR40
Cloakrooms	NR40
Dressing rooms	NR40
Crew rooms	NR40
Workshops	NR45
Equipment rooms	NR45
Kitchen	NR45
Truck lift	NR45
Chiller room south tower L6	NR 84 {86 dB(A)}
(Indoor) plant room	NR70
Electrical room / equipment room	NR60
Grid lobby*	NR54

* with a grid access door ($R_{\text{Atr}} = 25$ dB), see section 7

2 Environmental noise

2.1 Criteria

A key element of the design is to control noise breakout from Factory to its surroundings, in particular the nearby residential areas. The nearest proposed residential building is less than 9m from the venue's facade. The following criteria have therefore been set for amplified music in Factory in the previous stages of the project, by Arup and Sandy Brown consultants in conjunction with the MCC Environmental Protection Department:

- For residential apartment buildings and hotels, the maximally allowed sound levels inside due to amplified music in Factory are 47 dB for the 63 Hz octave band, 41 dB for the 125 Hz octave band.
- An attenuation of 5dB through an open window at these low frequencies has been assumed by Arup. Which results in the criteria on the facades that the maximally allowed sound level from event noise on the façade of residential apartment buildings and hotels is:
 - 52 dB L_{eq} for the 63 Hz octave band

- 46 dB L_{eq} for the 125 Hz octave band
- In addition to the criteria for music noise, the following criteria are set for mechanical services noise. These plant noise emission criteria apply to noise sensitive buildings in general, so not only residential apartment buildings and hotels, but also offices for example. The maximally allowed noise level at 1 meter from the façade of noise sensitive buildings due to external plant noise emission by Factory is:
 - 50 dB L_{Aeq} during daytime (07.00-23.00h)
 - 43 dB L_{Aeq} during night-time (23.00-07.00h)

2.2 Normal operation

The emitted noise from the Factory during normal operation contains:

- Music noise transmitted through the structures;
- Music noise transmitted through the air supply and return ducts;
- Mechanical noise:
 - AHU noise emitted through façade grills
 - Noise in MEP rooms transmitted through the façade
 - Dry air cooler noise (four units each with SWL 71 dB)
 - Chiller noise (three units each with SWL 95 dB) transmitted through the structure

The maximum allowed sound power levels of the intake and exhaust openings of the AHU's are given in annex B. Sound attenuators at the intake and exhaust openings of the AHU's need to mitigate the noise. The minimum required insertion loss of these attenuators is shown in table 5 in annex A and the positions in the isometric views in annex A.

Large façade plenum boxes for combined air exhaust and intake require sound proofing ($R_{Atr,63-4k} \geq 47\text{dB}$). A typical build-up is:

- Steel sheet of plenum box
- 1 layer of gypsum board
- 100 mm studs with 80 mm mineral wool in between
- Multiple layers of gypsum board.

The connecting joint between the faced and the plenum box needs to be flexible.

The chillers are placed in the chiller room. In order to limit the noise level in the chiller room down to $L_{pA} = 86\text{ dB}$, a sound absorbing finish is required on the ceiling and one wall. The required sound absorption coefficient is $\alpha_w = 0.75$.

2.3 Emergency situations

In case of emergency situations the emergency generator and the smoke exhaust fans can run. No requirements are set for these situation. Noise levels due to emergency situations are presented in appendix 9.4 of the EIS.

3 HVAC noise control

Main noise sources of HVAC noise are:

- The ventilators in air handling units, VAV boxes and fan coil units.
- Air flow noise caused by the duct system and grills

In order to reduce air flow noise the maximum air speed in the low-pressure ventilation systems needs to be limited. This depends on the admissible background noise level in the room (see Table 1). Table 2 provides required maximum air velocities in different types of ducts with respect to noise criterion.

Table 2: Recommended maximum air speed in low-pressure ventilation-systems

NR in room [dB]	15	20	25	30	35	40
in shafts and other main ducts [m/s]	4,0	4,5	5,0	6,5	7,5	9,0
in branches [m/s]	2,5	3,5	4,5	5,5	6,0	7,0
in last duct to room [m/s]	1,5	2,0	2,5	3,25	4,0	5,0

Noise generated by the HVAC system need to be reduced in order to meet the requirements as mentioned in chapter 1 and 2. Cross talk between rooms via ducts is to be prevented. Therefore, sound attenuators and acoustic insulation are to be applied in locations pointed out in annex A. Annex B contains an overview of the AHU acoustic specifications taken into account.

3.1 Grills & diffusers

Schedule ref: MF-BDP-ZZ-ZZ-SH-M-68-0030 Rev. C10

3.1.1 Theatre air grills and diffusers

For the final choice of air diffusers the total sound power level (mechanical noise plus air flow noise diffusers) may not exceed the NR criterion in order to achieve NR27 and a sound pressure level ≤ 29 dB(A).

Table 3: Max sound power level SWL per diffuser/grill [dB(A)]

	SWL per diffuser/grill [dB(A)]
centre of balcony (8 diffusers)	≤ 35
front of stalls (12 diffusers)	≤ 38
back of stalls (15 line diffusers length 1,37m)	≤ 28
extract grills (14 ceiling grills)	≤ 28
Balcony floor grills (north and south wing)	≤ 15

3.1.2 Warehouse air grills and diffusers

The air flow noise from the air diffusers and grills must be limited, in order to achieve certain maximum noise level. For the Warehouse diffuser type HALTON TSA-630 (C) will be used. The north Warehouse has 4 banks with 7 diffusers and the south Warehouse 6 banks with 7 diffusers.

Table 4: theater and Warehouse air volumes

Warehous occupancy scenario	Maximum assumed flow rate [l/s]			
	Warehouse north/south divided		Warehouse south open to theatre	Undivided Warehouse
	maximum seated (900 north, 1500 south)	maximum standing (1190 north, 2933 south)	1519 seated	Up to 5000 standing
Cooling mode	571	714	571	714
Heating mode	553	553	553	553
Pre-heat mode (prior to event)	1105	1105	1105	1105

With a 3D acoustic model (CATT-Acoustic ©) the noise levels are predicted for the south Warehouse as stage area for the theatre. The sound power levels of air flow of air diffusers and air extract grills in the theatre and south Warehouse are taken into account and also the mechanical noise. In annex G the results are shown.

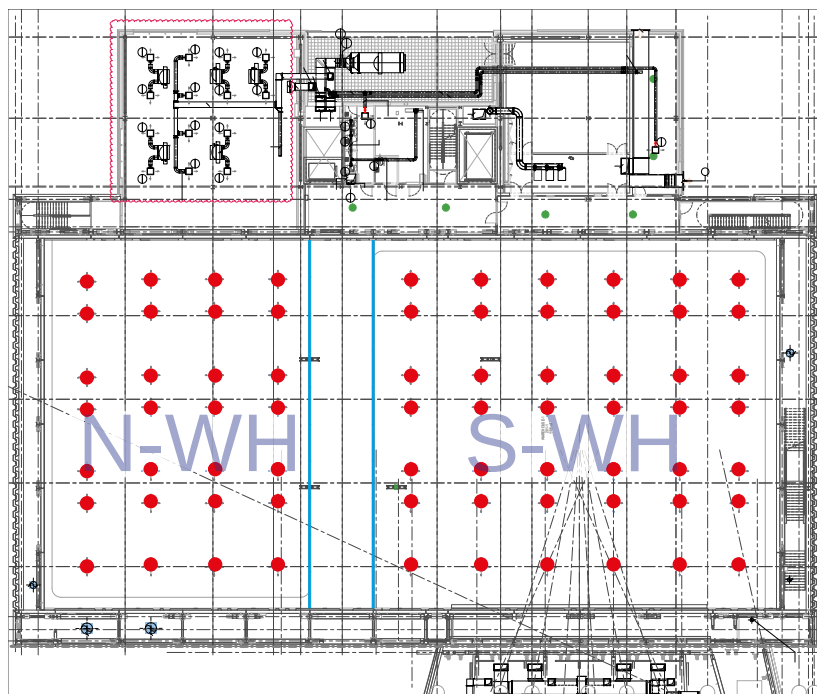


Figure 1: air diffuser layout in the north and south Warehouse

Table 5: HALTON TSA-630 (C) sound power level per diffuser

Air volume	63	125	250	500	1k	2k	4k	8k	dB(A)
1105 l/s	42	45	48	48	53	46	25	12	55
715 l/s	30	33	36	36	41	34	13	6	43
571 l/s	25	28	31	31	36	29	8	4	38

3.2 Sound attenuators

The insertion loss of the sound attenuators are specified in document MF-BDP-ZZ-ZZ-SH-M-68-0028 Rev. C12.

4 Duct, pipe and cable penetrations

Silencers preferably should be inserted as close as possible to the penetration of room dividing walls and external building elements to minimize noise transmission between the silencer and partition.

For all types of walls, service penetrations shall be sealed with resilient caulk.

Pipes, ducts, and conduits penetrating walls, ceilings, or floors of mechanical rooms should be acoustically treated. Typically, a 10-15 mm gap around the penetrating element is filled with an appropriate material such as mineral wool insulation. The penetration is then sealed with resilient caulk.

Ducts passing a double acoustically separated wall require a flexible connection and all locations pointed out in annex A. Sleeves used in double acoustically separated wall are only rigidly fix to one of the walls. The connection to the other wall must be flexible in order not to shorten the walls. Rigid contact between ducts, pipes and cable (trays) with a sleeve is not permitted.

Caulk used for acoustic sealing must be non-hardening and if required fire resistant. The depth of the caulk seal must be at least equal to the width of the gap.

- Application of the plasterboard on the metal studs after the ducts/pipes are installed, leaving a 10-20 mm gap, to be sealed with resilient (fire resistant) caulk. Oversized penetration must be acoustically closed:

- Metal stud walls:
Plasterboard on both sides (same thickness and amount as in the wall), leaving a gap of 10-20 mm, to be sealed with resilient (fire resistant) sealant. The space between the duct/pipe and the wall filled with mineral wool, weight $\geq 50 \text{ kg/m}^3$.
- Brick or concrete walls:
 - Cement grout down to a 10-40 mm. This reduced gap can be treated as described at the first two bullet points.
 - 3 layers of plasterboard on both sides, leaving a gap of 10-20 mm, to be sealed with resilient (fire resistant) caulk. The space between the duct/pipe and the wall filled with mineral wool, weight $\geq 50 \text{ kg/m}^3$.
- Gaps with a width of 40 mm or less can be closed with L-shape steel duct flange, at least 2 mm thick in case sound insulation requirement of $R_{\text{Atr}} = 40 \text{ dB}$ or higher, 1 mm in case of lower sound insulation requirement.

Coordinated with fire safety requirements is required.

Details can be found in annex C and in drawing series MF-OMA-XX-XX-DR-A-52.

5 Acoustic insulation treatments

5.1 Ducts

Pictures in Annex A show the location of required acoustic duct insulation, including a description of the build-up.

5.2 Rain water and drainage pipes

Rain water and drainage pipes without sound proofing are not permitted to run through rooms with a noise requirement of NR40 or lower. No drainage pipes are allowed to run through rooms with NR30 or lower.

Drainage pipe soundproofing can be achieved by:

- Wrapping the pipes with adhesive noise blocking materials (a thick foil in combination with a sound absorbing foam);
- Enclosing the pipes with panels (gypsum board) and filling the cavities around the pipes with mineral wool.

A combination of both is possible for higher noise reductions.

The pictures in annex D show locations of required (drain) pipe sound proofing with some examples of sound proofing materials.

All drainage pipework required rubber sleeved braces. This concerns all above ground siphonic and traditional rainwater drainage. Condensate drainage do not require special bracing.

6 AV mounts

6.1 Pipework

6.1.1 Theater plant room

Pipework with running and/or pressurized fluid suspended from or mounted to sensitive floor slab (marked red in figure 2, 3 and 4) require acoustic hangers or acoustic bearings with a minimum static deflection of 2.0 mm

- Hangers: Christie & Grey type RH
- Bearings: Farrat AVM-DS-VR

Pipework fitted in a skid:

- can be mounted to the skids with hangers and bearings as mentioned above. In this case the skid itself doesn't require an acoustic bearing on the floor;
- or the pipework is mounted to the skid with a non-flexible coupling. In this case the skid requires acoustic bearings with pads type Farrat type AVM-DS-VR27, thickness 12.5 mm. The pad amount, type and size depends on the load. The required deflection is at least 1 mm (natural frequency 14Hz). The pad load stress should be about 0.072 MPa.

No pipework mounting allowed to the partition wall between plantroom and theatre (green in figure 4)

Pipe mounting to toilet blockwork wall (blue in figure 4) allowed with sleeved braces.

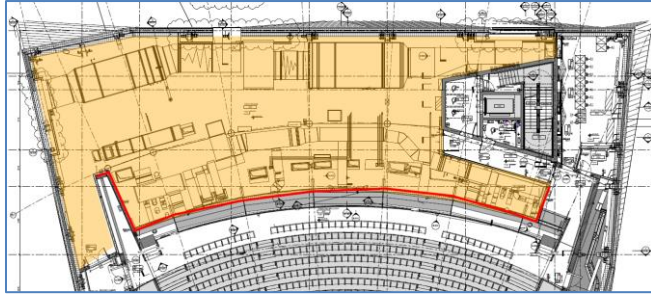


Figure 2

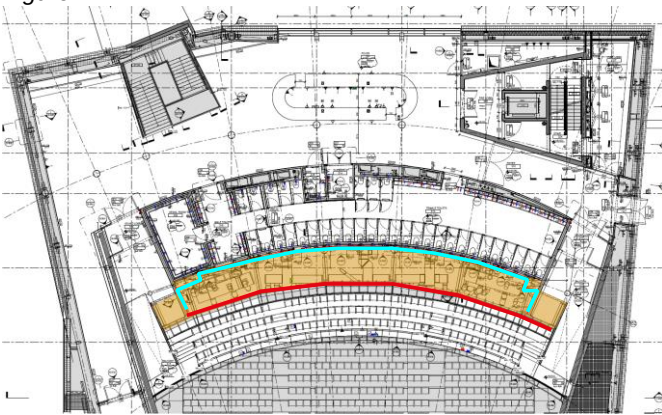


Figure 3

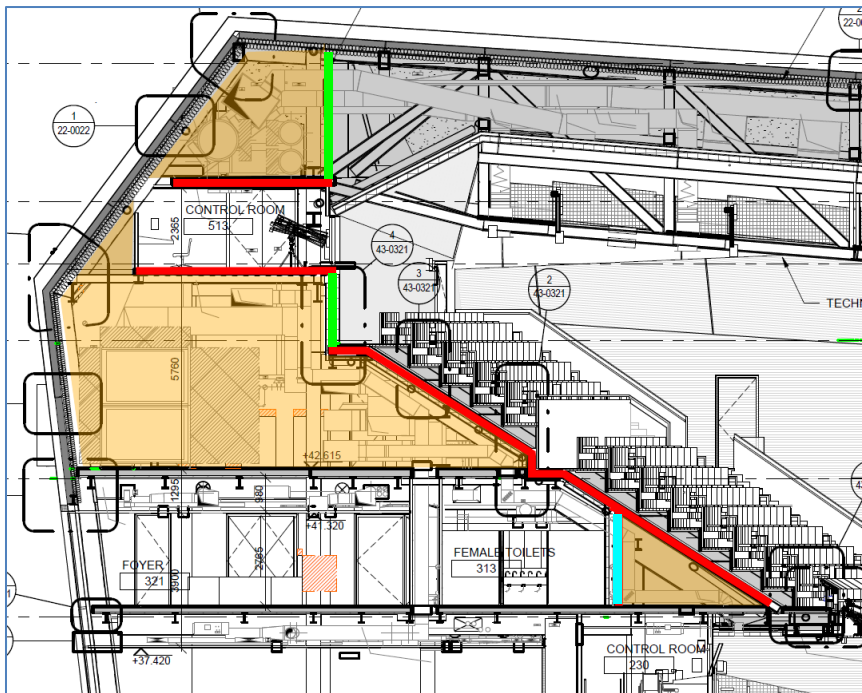


Figure 4

6.1.2 WH foyer soffit floor

Pipework with running and/or pressurized fluid suspended from WH foyer soffit floor (figure 5) require acoustic hangers with a minimum static deflection of 2.0 mm:

- Acoustic hangers Christie & Grey type RH

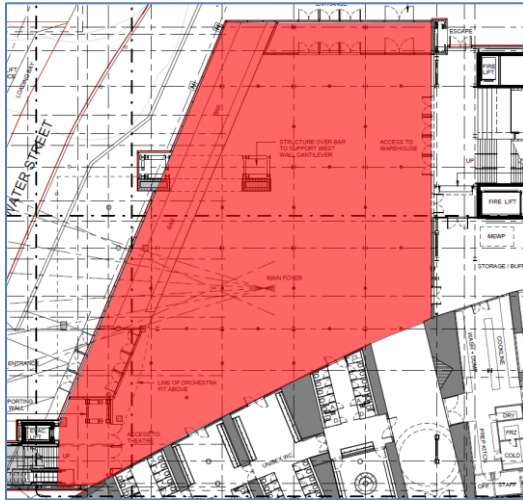


Figure 5: Wh foyer soffit floor

6.1.3 Tower plantrooms L6 (chiller room), L7 north tower

Pipework with running and/or pressurized fluid suspended from or mounted to sensitive floor slab requires acoustic hangers or acoustic bearings with a minimum static deflection of 1.0 mm

- Hangers: Christie & Grey type RH
- Bearings: Farrat AVM-DS-VR

Pipework fitted in a skid:

- can be mounted to the skids with hangers and bearings as mentioned above. In this case the skid itself doesn't require an acoustic bearing on the floor;
- or the pipework is mounted to the skid with a non-flexible coupling. In this case the skid requires acoustic bearings with pads type Farrat type AVM-DS-VR27, thickness 12.5 mm. The pad amount, type and size depends on the load. The required deflection is at least 1 mm (natural frequency 14Hz). The pad load stress should be about 0.072 MPa.
- **Skids in plantroom north tower L7 do not require acoustic bearings.**

Chilled water pipework is mounted on wooden blocks.

6.1.4 Tower roof plant areas L6, L7 south tower, L8 north tower

Pipework with running and/or pressurized fluid mounted on the floating slabs do not require acoustic bearings. Connections to steel structure require rubber sleeved braces.

6.1.5 Tower plant area L3

Pipework with running and/or pressurized fluid mounted on the floating slabs do not require acoustic bearings. Pipework directly suspended from the soffit (structural) floor requires acoustic hangers with a minimum static deflection of 1.0 mm

- Hangers: Christie & Grey type RH

For support of ducts and pipes hang structures are connected to the soffit floor with acoustic bearings (Farrat). Pipework can be fitted to these hang structures with non-flexible couplings.

6.1.6 Outside plant rooms

Pipework with running and/or pressurized fluid in other spaces than plant rooms are supported with rubber sleeved braces.

6.1.7 Facades and roofs

It's not allowed to connect or hang pipework to flexible mounted façade and roof elements.

6.2 Electrical Connections

Isolated equipment should not be shorted by cable trays or gutters, which are rigidly connected to the structure.

6.3 Air handling units

Fans in all AHU's are equipped with resilient mounts in the units.

6.3.1 AHU bearings

The AHU's on floating roof slab do not require AV bearings. The vibration isolation will be provided by the flexible bearings underneath the floating concrete slab. Design of these bearings is part of the building envelop design. The AHU's on indoor floor slabs are supported by rubber pads with a deflection as described annex I. The theatre AHU on level 5 is supported on a steel structure and requires spring bearings as specified in annex I.

6.3.2 AHU Pipework

Pipework to each AHU shall be independently supported and designed to prevent shearing forces transmitted to the unit. Pipework inside the plant rooms require AV mounts. See also section 6.1

6.4 Ductwork

6.4.1 Flexible duct connections

All ductwork connections to fans and air handling units should be flexible and at least 75mm long. The sound barrier mat density is at least 5 kg/m². These connections should be straight but not rigid, with no offset, in order to prevent turbulence.

Flexible duct connections are required:

- At fans and air handling units
- In enclosed plant rooms at the structural penetration of the plant room walls, floors and ceiling
- At air intake and exhaust grills in flexible mounted façade and roof elements. The grills can be fixed in these façade and roof elements
- At locations indicated in annex A.

6.4.2 Duct supports and hangers

Ductwork in the theatre plantroom is supported by spring or rubber hangers with a minimum static deflection of 4 mm. Outside the plantrooms ductwork requires supports to sensitive structures using neoprene mounts/hangers, providing a minimum deflection of 2 mm. Sensitive structures are:

- The theatre balcony floor (see figure 2)
- The theatre CLT walls and ceilings
- The Warehouse concrete ceiling

It's not permitted to connect or hang ducts from

- Flexible mounted façade elements
- Flexible mounted roof elements

Ducts can be hanged from sound insulating resilient ceilings but at the room partition penetration a resilient duct connection is required:

- opera XL
- Theatre plantroom underneath the balcony floor
- Theatre control room L2M

In the GF foyer the ducts and FCU's are hanged from the sound insulating ceiling. The ducts can be hanged with normal mounts but are flexible connected to the FCU's.

6.5 Emergency generator

Reference: MF-CHT-XX-XXTS-E-01-0002 Rev V02

The emergency generator engine is fitted on a main frame with AV-mounts. The AV-mount specifications provide static stiffness. Dynamic stiffness specification to be provided by the supplier.

The specs are shown in annex O.

7 Fan Coil Units

Acoustic hangers are used for FCU mounted to or hanged from the concrete ceiling floor. In situations the FCU is positioned underneath a sound insulating resilient suspended ceiling, the FCU is hang from the sound insulating ceiling structures.

Ducts are flexible connected to the FCU and can be hanged from the ceiling with normal mounts, but are flexible connected to the FCU.

In de AV Rack room next to the theater grid lobby @L5 2 no FCU's will be installed. The FCU's are not to be mounted to the CLT wall.

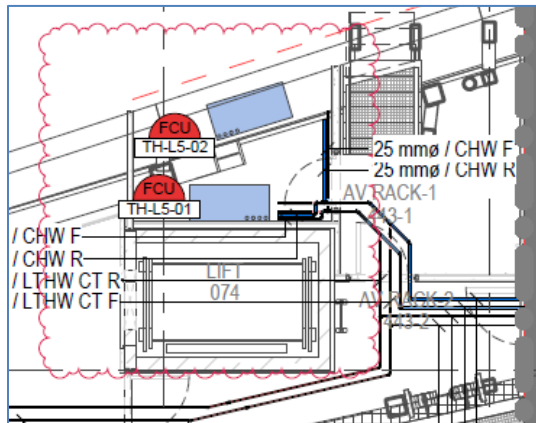


Figure 6: Theater grid lobby @L5

8 Chillers & Dry Coolers

8.1 Chillers

On level 6 in the south tower three chillers are placed (MF-BDP-ZZ-ZZ-SH-M-68-0013 Rev. C02).

CHT has submitted technical information of the chillers and the AV-mounts. This information is shown in annex M.

In order to reduce sound radiation of the floor to the office space below the maximum vibration velocity level of the floor (one chiller running) should not be higher than:

Freq. [Hz]	31,5	63	125	250	500	1k	2k	4k	8k
L _v [dB]	43	42	35	29	24	22	20	18	16

In which the vibration velocity level:

$$L_v = 10 \log_{10} (v^2 / v_{ref}^2) \quad v_{ref} = 5E-8 \text{ m/s} \quad [\text{dB}]$$

Regarding the vibration characteristics the manufacturer of the Turbocor compressors inside the chillers states following;

Turbocor® don't publish any information relating to vibration from the TT compressor ranges. This is because it is slightly meaningless because the compressor is mounted in a system which impacts the vibration levels measured on the compressor. Our Turbocor compressors don't generate any vibration because there is no mechanical contact between the moving parts and the static parts due to the magnetic field. As for the gas flow, it is continuous without pulsation so the gas doesn't generate vibration either. When applied in a water cooled chiller the vibration produced by the combined components makes the chiller virtually vibration free and can only be affected by external hydraulic water circuit influences which if designed correctly again should be virtually none existent. It is apparent and true in our own experience that the use of external AVs at the base of the chiller with Turbocor, are purely a double vibration safety measure and not normally required.

Chiller pipes do not require rubber sleeved braces.

8.2 Dry coolers

On the roof of the north towers four dry coolers will be placed (MF-BDP-ZZ-ZZ-SH-M-68-0012 rev. C04). Each dry cooler has a sound power level SWL = 71 dB(A).

The dry coolers are placed on a floating concrete slab and therefore don't require AV-mounts. Technical specifications are shown in annex N.

Dry coolers pipes do not require rubber sleeved braces. However they need to be installed such that they don't create an acoustic shortcut between the floating roof floor and structural roof floor.

9 Humidifier

MF-BDP-ZZ-ZZ-SH-P-11-0004

The maximum allowed sound power level of the humidifier In the MEP room at theater L1, including its contactors, is $SWL \leq 60$ dB(A).

10 Pump products – Public health

Schedule reference: MF-BDP-ZZ-ZZ-SH-P-11-0004 C.05

The pumps are provided with AV mount according annex I.

Annex A: locations of acoustic duct isolation

Sound insertion loss [dB]

A1 AHU-TH-L4-01 THEATRE TOILETS (AHU2)

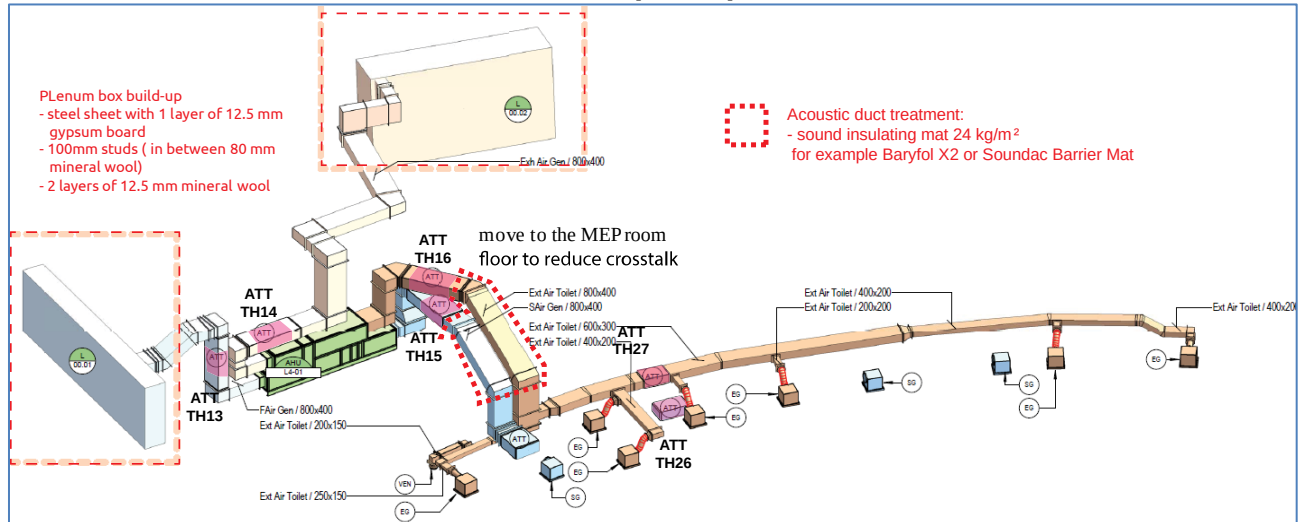


Figure 7: Acoustic duct enclosure and plenum box build-up

Acoustic hangers to be applied to all ducts hanging from the balcony floor.

A2 AHU-TH-L4-02 AUDITORIUM BALCONY (AHU3) AHU-TH-L4-03, Theatre Auditorium stalls (AHU4)

Drawings:

- MF-CHT-TH-L6-DR-M-57-0160_Theatre Sixth Floor Ventilation Layout (Sheet 1 of 2)_Ver2_C01
- MF-CHT-TH-L6-DR-M-57-0161_Theatre Sixth Floor Ventilation Layout (Sheet 2 of 2)_Ver2_C01

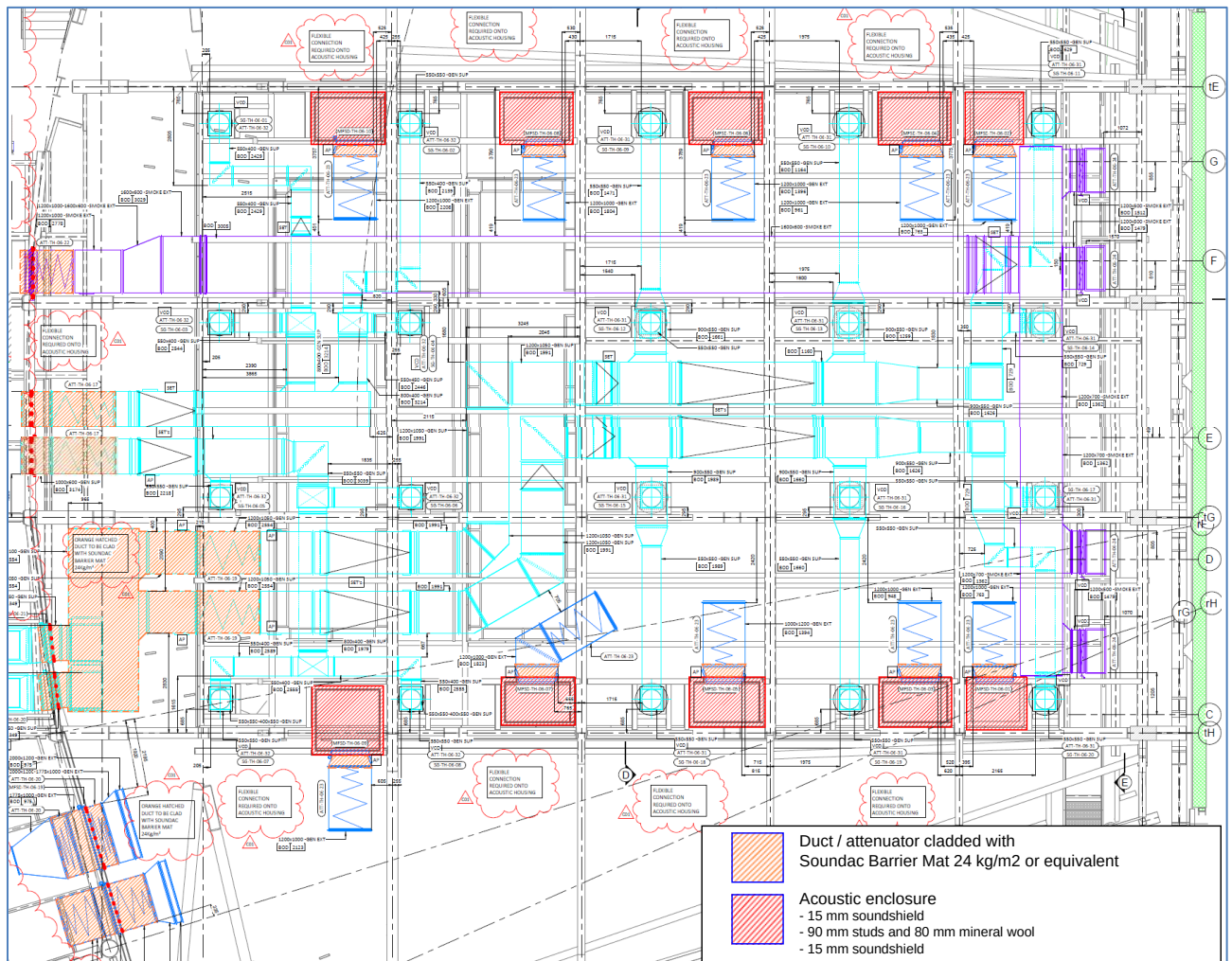


Figure 8: Acoustic duct enclosure and flexible duct joints

A3 AHU-TH-L5-01 THEATRE AUDITORIUM REAR (AHU5)

Drawing MF-BDP-TH-L4-DR-M-65-0041:

Acoustic enclosure: sound insulation mat 24 kg/m², for example Baryfol or Soundac IS240HH

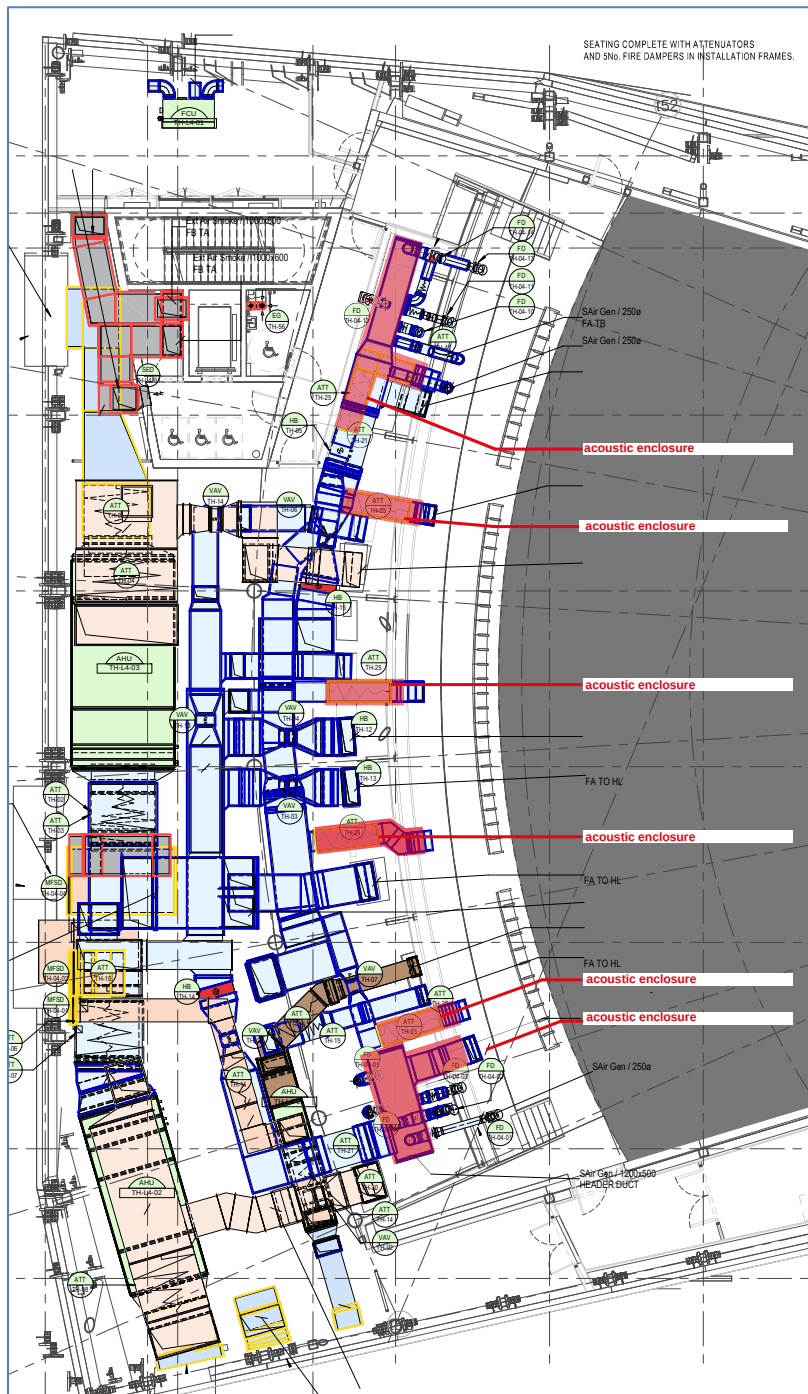


Figure 9: MF-BDP-TH-L4-DR-M-65-0041 acoustic enclosures

A4 AHU-TH-L1-01 ORCHESTRA PIT (AHU1)

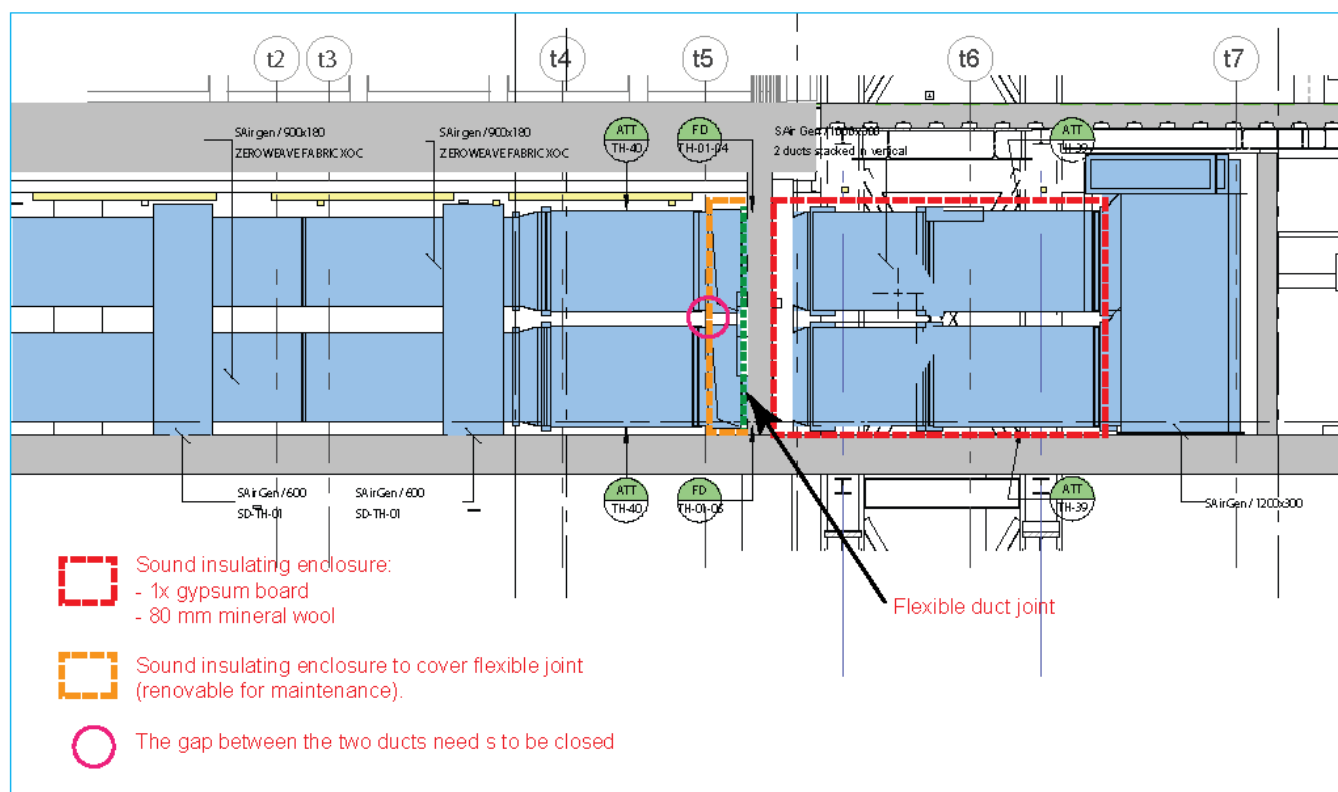


Figure 10: AHU 1: location acoustic enclosure and flexible duct connection

Flexible joint required at orchestra pit wall penetration.

A5 AHU-TOW-L7-01&2 South Warehouse (AHU8 & 9)

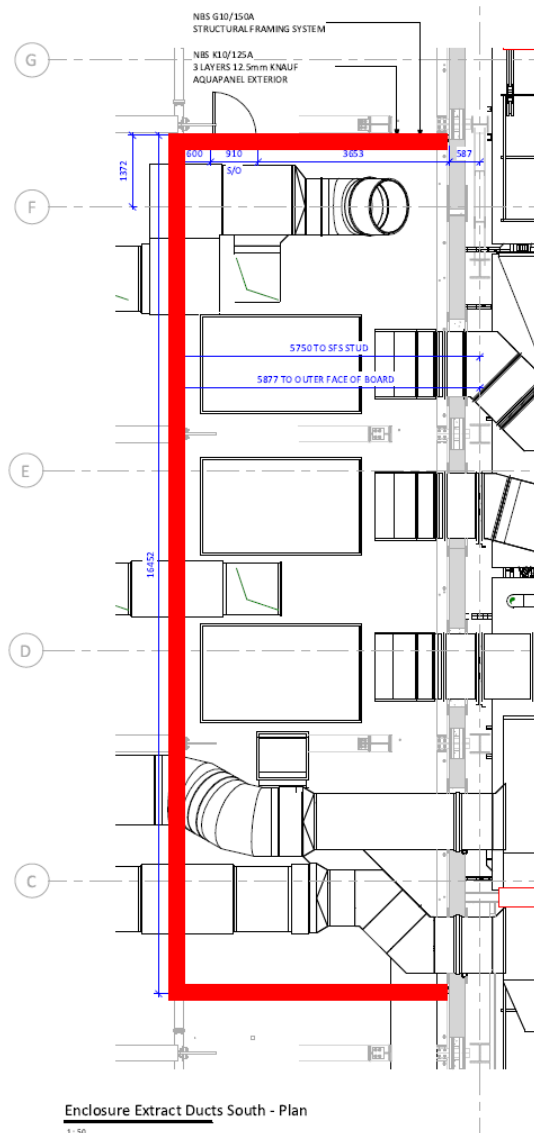


Figure 11: Acoustic duct enclosures AHU8 & 9

According drawings:

MF-RYD-WH-L7-DR-A-40-0010

MF-RYD-WH-L7-DR-A-41-0010

MF-RYD-WH-L7-DR-A-41-0011

MF-RYD-WH-L7-DR-A-41-0013

Resilient joint in supply and return ducts at the penetration of plenum wall on grid line 7.

A6 WAREHOUSE AHU WH-03&04 (level 7 north tower)

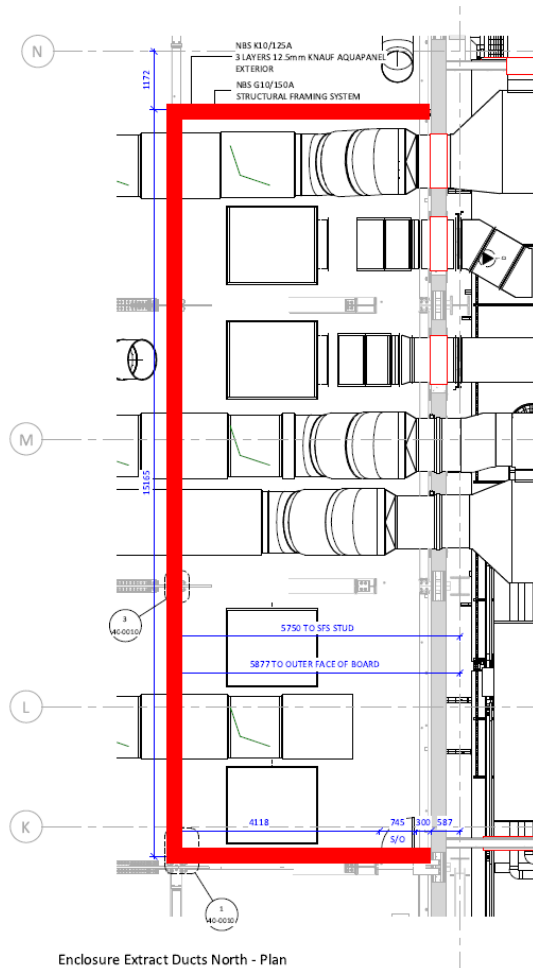


Figure 12: Acoustic ducts enclosure AHU10&11

According drawings:

MF-RYD-WH-L7-DR-A-40-0010
MF-RYD-WH-L7-DR-A-41-0010
MF-RYD-WH-L7-DR-A-41-0011
MF-RYD-WH-L7-DR-A-41-0013

Resilient joint in supply and return ducts at the penetration of plenum wall on grid line 7.

A7 CHILLER/BOILER ROOM (south tower)

The chiller and boiler room are merged to one room. In order to prevent crosstalk through the boiler ventilation air inlet and outlet ducts attenuators will be installed. Also the ducts running through the adjacent crew room require sound proofing. In the figure below the measures are described.

Cross talk from the chiller room via crew room air supply and return duct needs to be reduced by adding duct sound proofing with sound insulating mat (24 kg/m²).

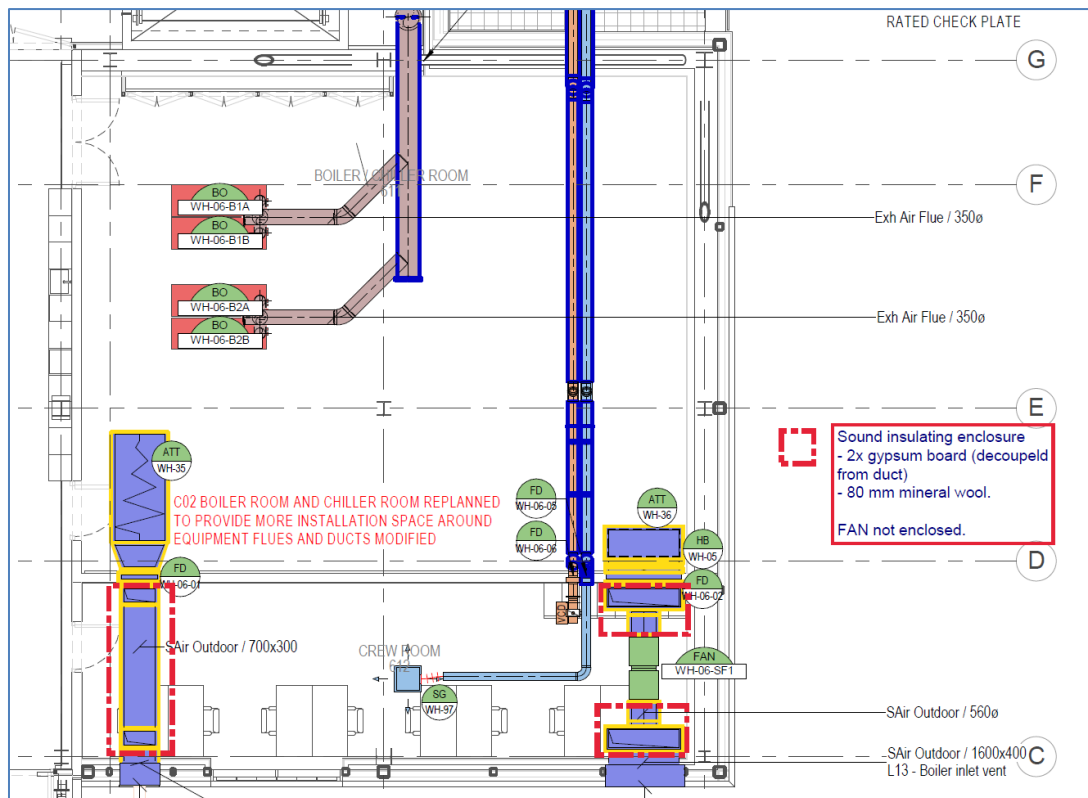


Figure 13: acoustic duct enclosure chiller/boiler room

Annex B: Acoustic specifications AHU's

(reference: MF-CHT-XX-XX-TS-M-01-0001_Technical Submission - Air Handling Units_C07 10-9-2021)

Sound power levels at AHU intake and outlet openings (provided by AirSource on 16-12-2019)

SOUND POWER LEVELS (standard: EN13053 ISO/CD 13347-2)

AHU 1 AHU-TH-L1-01 ORCHESTRA PIT

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	60	65	61	61	58	55	52	49	63
Supply air connection	61	71	64	66	67	64	60	56	71

AHU 2 AHU-TH-L4-01 THEATRE TOILETS

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	64	64	71	71	67	67	63	60	74
Supply air connection	65	66	75	74	77	76	70	66	81
Extract connection	62	62	69	70	66	66	62	59	72
Exhaust connection	63	64	74	73	76	74	69	65	80

AHU 3 AHU-TH-L4-02 AUDITORIUM BALCONY

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	69	83	79	78	80	77	72	70	84
Supply air connection	77	85	83	86	86	80	75	70	89
Extract connection	67	80	76	76	76	73	70	69	80
Exhaust connection	72	81	80	84	82	77	74	68	86

AHU No. 4; AHU-TH-L4-03, Theatre Auditorium stalls

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	76	86	80	77	75	72	69	70	81
Supply air connection	79	89	84	85	83	80	77	72	88
Extract connection	80	85	80	77	74	71	68	69	80
Exhaust connection	82	89	83	85	82	78	74	71	87

AHU 5 AHU-TH-L5-01 THEATRE AUDITORIUM REAR

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	66	77	73	72	73	70	64	62	77
Supply air connection	72	79	78	82	81	74	68	63	84
Extract connection	63	72	70	71	69	66	61	60	74
Exhaust connection	68	75	74	80	76	71	65	61	81

AHU No. 6; AHU-TOW-L3-01, Level 04 down

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	72	82	87	80	81	80	80	79	87
Supply air connection	77	82	88	89	88	84	84	79	93
Extract connection	74	78	87	80	76	74	74	81	85
Exhaust connection	78	81	92	87	86	80	79	82	91

AHU No. 07 - AHU-TOW-L6-01

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	64	79	75	75	75	72	70	69	80
Supply air connection	71	80	79	83	82	77	74	69	86
Extract connection	66	76	74	74	72	70	68	67	78
Exhaust connection	69	78	78	81	79	74	72	68	83

AHU No. 08; AHU-TOW-L7-01 South Warehouse

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	80	102	89	82	81	78	75	73	89
Supply air connection	85	104	91	90	88	86	81	76	94
Extract connection	77	95	85	80	78	74	72	70	85
Exhaust connection	81	97	86	87	85	81	78	72	90

AHU No. 09; AHU-TOW-L7-02, South Warehouse

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	80	88	82	78	76	73	70	72	82
Supply air connection	82	92	86	87	84	82	78	74	89
Extract connection	84	85	82	78	75	72	69	71	81
Exhaust connection	85	89	85	86	83	79	76	73	88

AHU No. 10; AHU-TOW-L7-03, North Warehouse

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	77	89	84	85	85	83	76	77	89
Supply air connection	82	91	92	94	92	89	79	78	96
Extract connection	84	85	82	78	75	72	69	71	81
Exhaust connection	85	89	85	86	83	79	76	73	88

AHU No. 11; AHU-TOW-L7-04

	Lw per octave band (dB)								LwA
Octave band (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
Fresh air connection	77	89	84	85	85	83	76	77	89
Supply air connection	82	91	92	94	92	89	79	78	96
Extract connection	84	85	82	78	75	72	69	71	81
Exhaust connection	85	89	85	86	83	79	76	73	88

AHU noise breakout, measured at 5 m distance (Q5857-13-T.S. CHT, date 6-5-2020)

	LpA,5m [dB]
AHU 01 AHU-TH-L1-01 Orchestra Pit	37
AHU 02 AHU-TH-L4-01 Theatre toilets	44
AHU 03 AHU-TH-L4-02 Theatre Auditorium Balcony	51
AHU 04 AHU-TH-L4-03 Theatre Auditorium Stalls	56
AHU 05 AHU-TH-L5-01 Theatre Auditorium Rear	46
AHU 06 AHU-TOW-L3-01 Level 04 Down	56
AHU 07 AHU-TOW-L6-01 Office and Crew rooms	47
AHU 08 & 09 South warehouse	64
AHU 10 North warehouses	59
AHU 11 North warehouses	58

Annex C: penetrations details

General points of attention:

- All ducting, piping, cabling may not make direct contact with the partition.
- All penetration opening to be sealed according detail examples or according approved fire stopping details
- Gypsum board applied on the outside of solid walls or metal stud walls to reduce the penetration opening require an overlap with the wall of at least 150 mm.
- Sealant should be non-hardening and fulfil fire safety requirements.
The sealant depth must be the same as the width of the sealed gap.
- Attenuators must be positioned as close as possible to the partition wall
- Flexible duct connections, see section 6.4.1
- Alternative details for fire stopping to be reviewed by acoustic consultant.

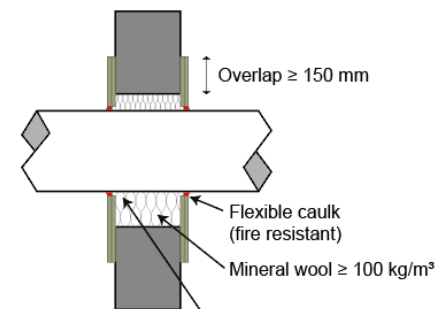
In firerated partitions Rockwool Firepro® will be used. Oversized penetration opening will be closed with double Firepro 60 or 50 mm ablative batts. In order not to affect the required sound insulation of partitions this can be done under following conditions:

- For partitions with acoustic requirement $RA < 40 \text{ dB}$ and $RA_{tr} < 35 \text{ dB}$ double Firepro 50 mm ablative coated batts is sufficient.
- For partitions with acoustic requirement $RA \geq 40 \text{ dB}$ and $RA_{tr} \geq 35 \text{ dB}$ in both fire rated and none fire rated walls additional board required to close up the gap to 10 to 25 mm. The gap needs to be sealed with (fire resistant) resilient caulk.

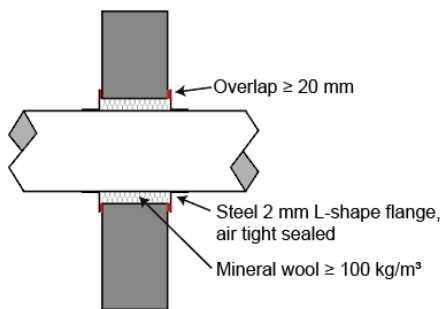
Next pages show examples of acoustic closure of penetration openings.
Also details can be found in drawing series MF-OMA-XX-XX-DR-A-52.

C.1 Solid walls (block work, concrete, CLT)

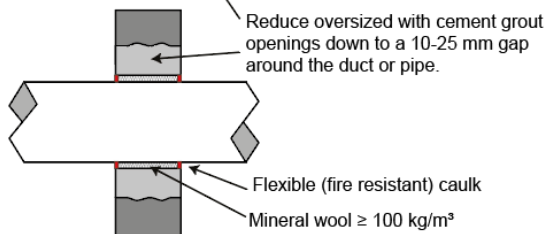
Gaps between duct and wall > 25 mm



Gaps between duct and wall ≤ 25 mm

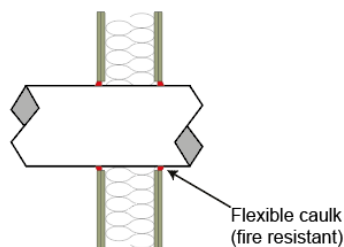


Gaps 10-25 mm

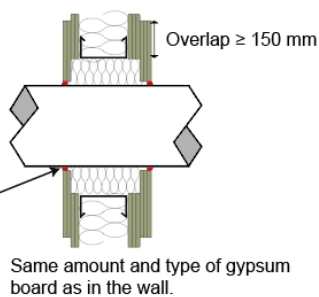


C.2 Single stud gypsum board walls

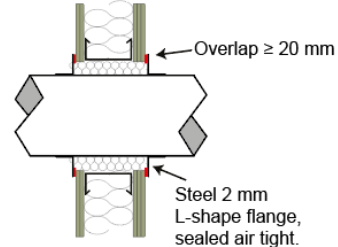
Gap between duct and wall 10-25 mm



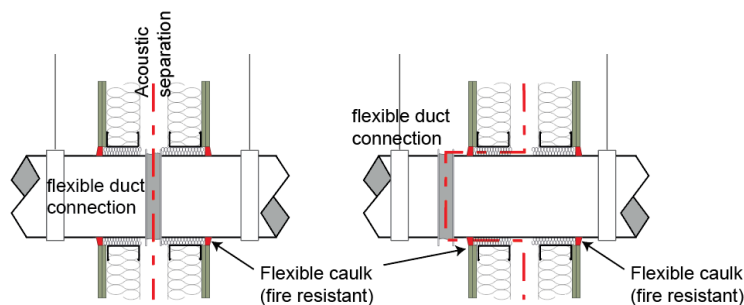
Gap between duct and wall > 25 mm



Gap between duct and wall ≤ 40 mm



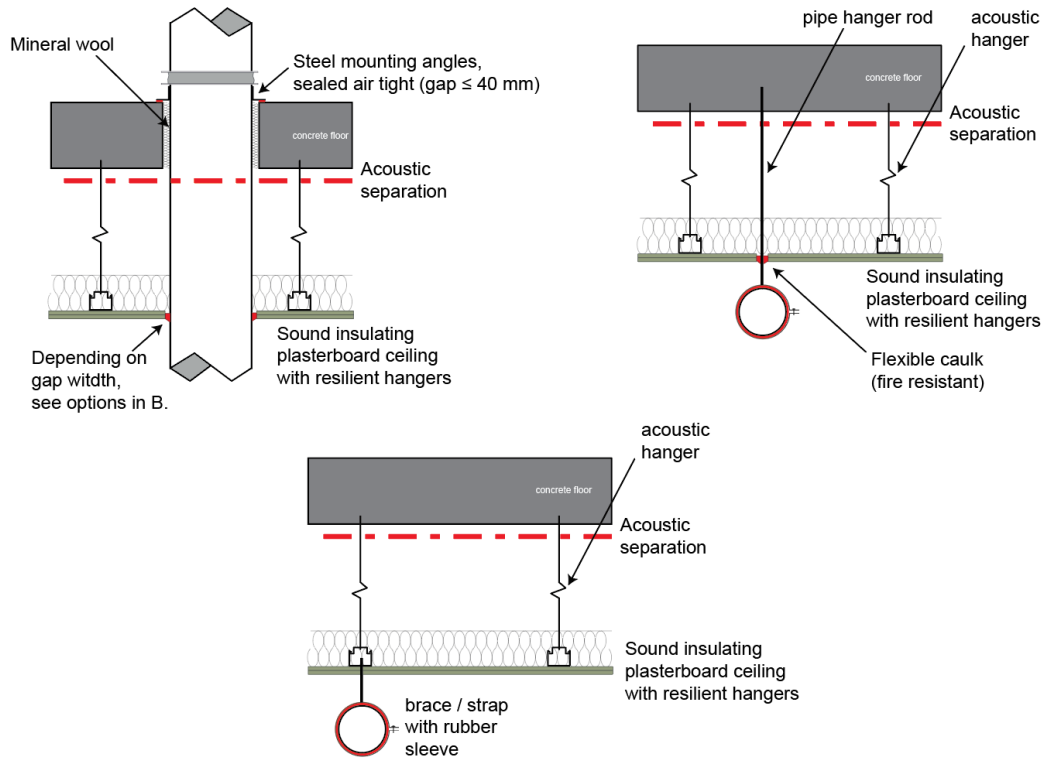
C.3 Double walls with acoustic separation



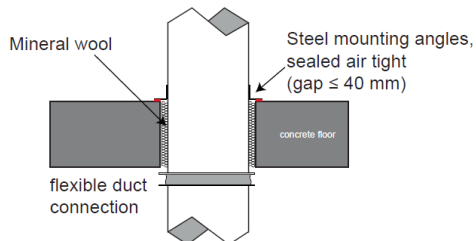
The sealing of gaps smaller than 40 mm also can be carried out as indicated in B.

Flexible duct connections:
see chapter 6.4.1

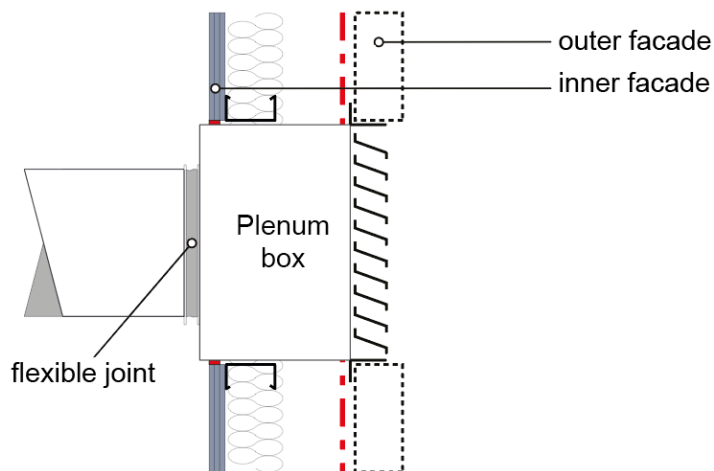
C.4 Floors with flexible hanged plasterboard ceilings



C.5 Plant room floor

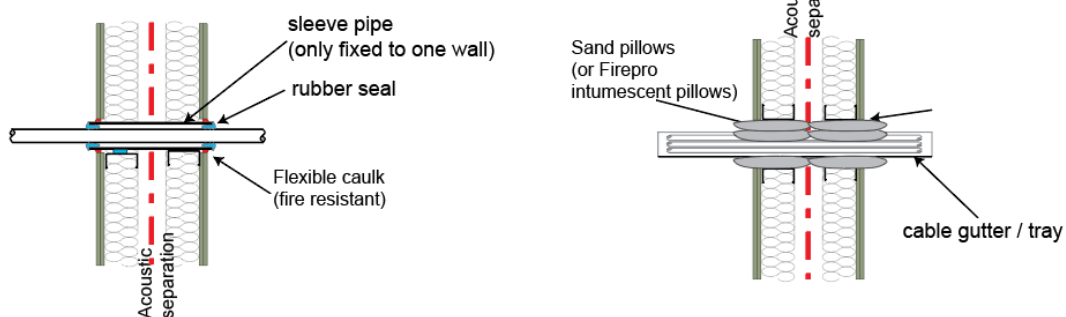


C.6 Facade grills



C.7 Pipe and cable penetrations

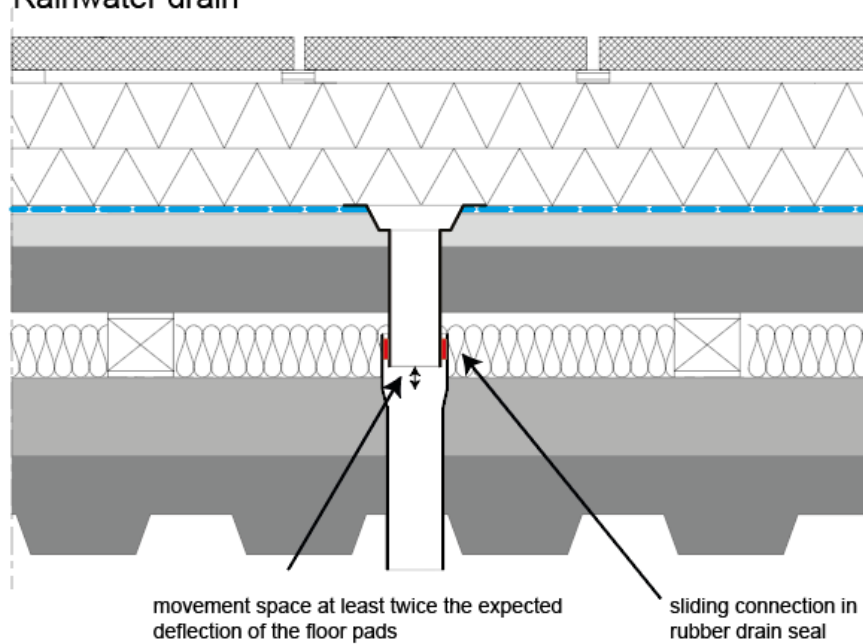
For penetrations for pipes and same solutions as for ducts can be used.
For exchangeable cables following solutions can be used in double walls.



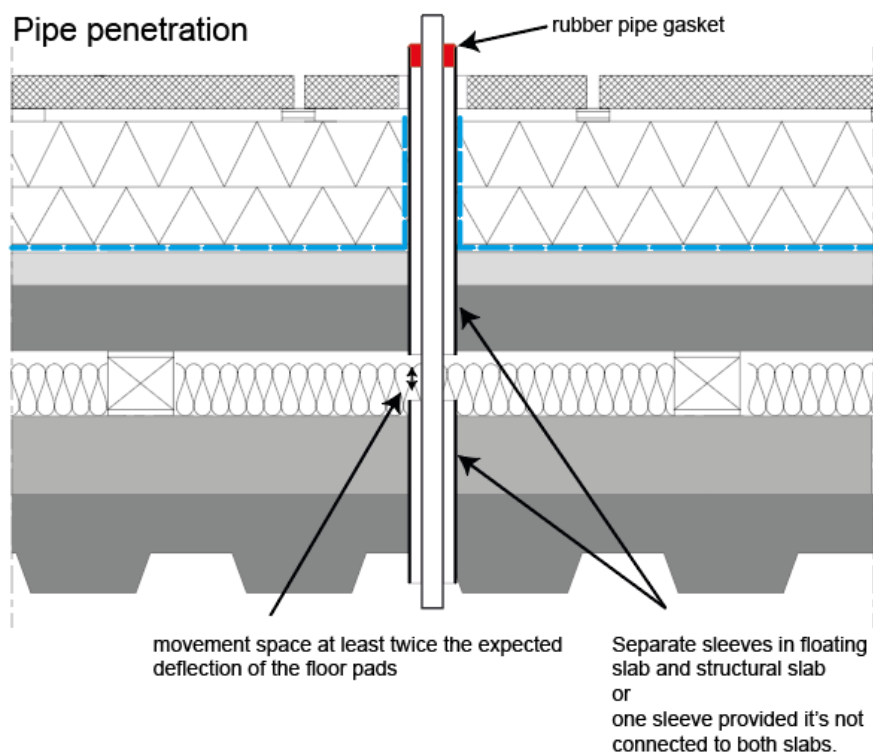
In some cases special sound insulating cable passes are applied.

C.8 Floating floor penetrations

Rainwater drain

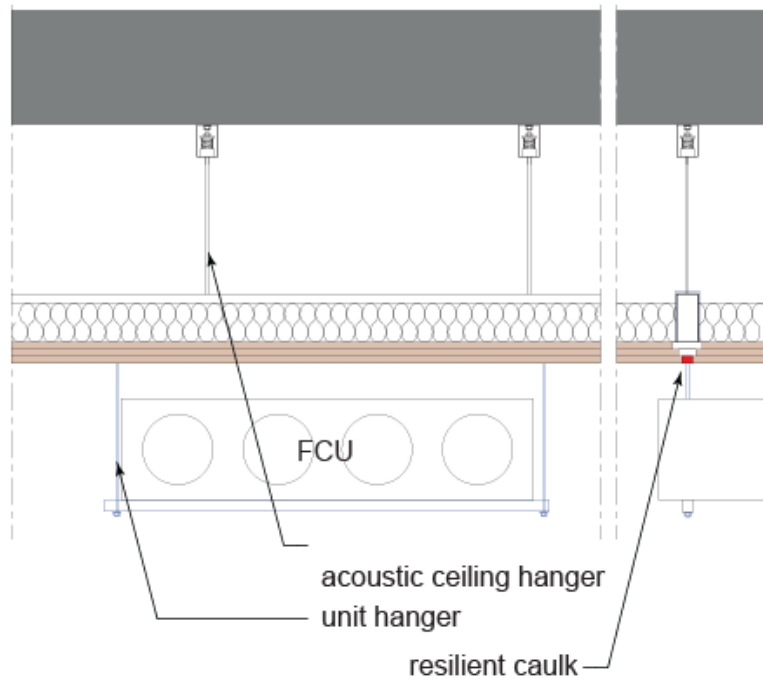


Pipe penetration

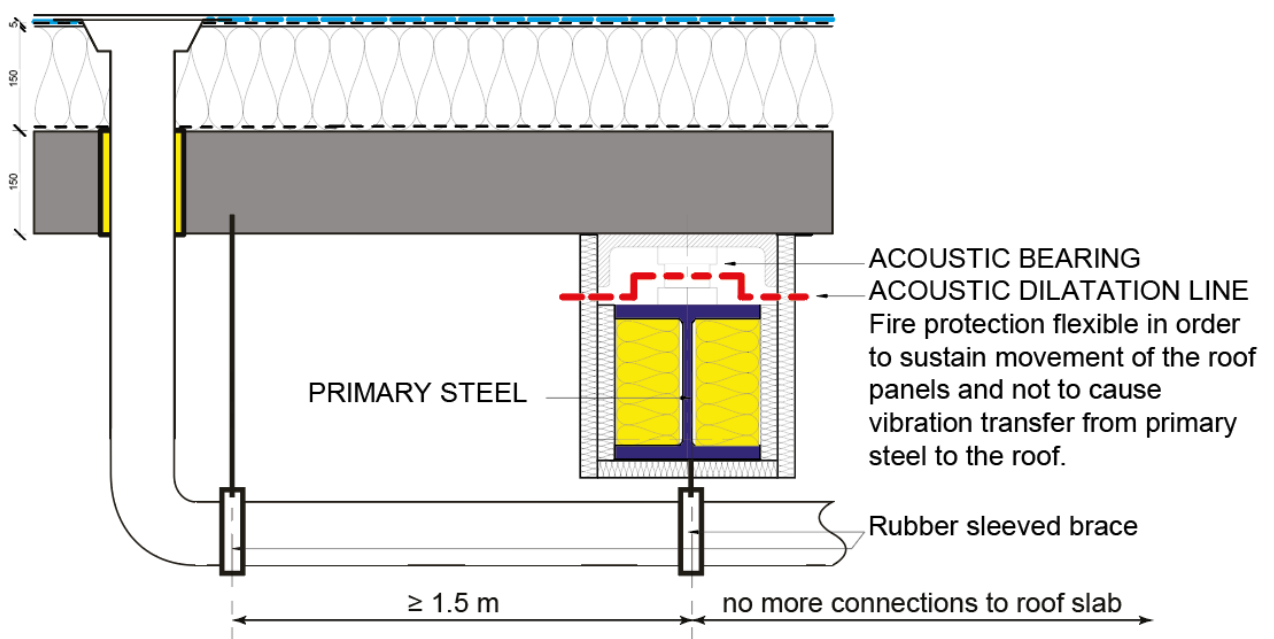


C.9 Fan coil units supported by sound insulating ceiling

Unit hunged from sound insulating ceiling.

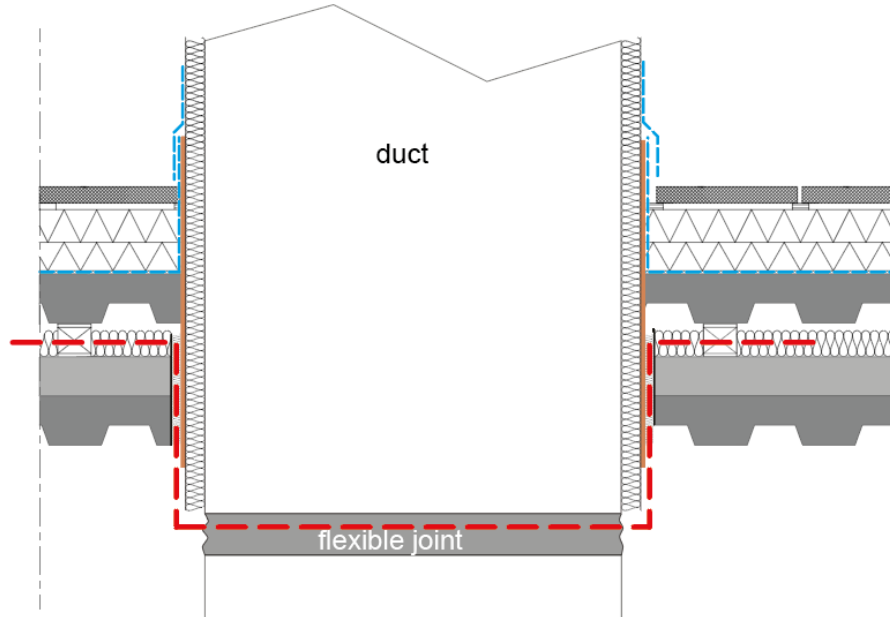


C.10 Roof water drainage

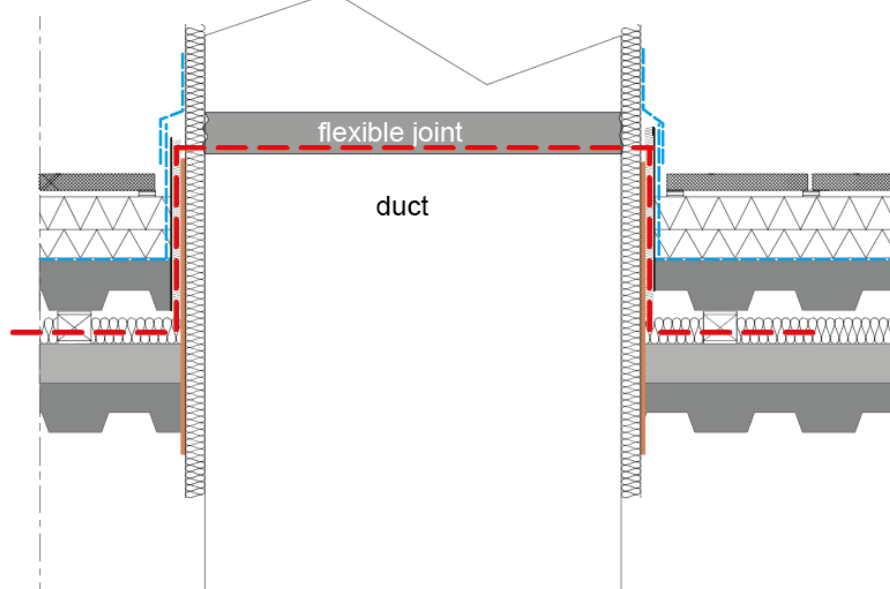


C.11 Floating slab duct penetrations

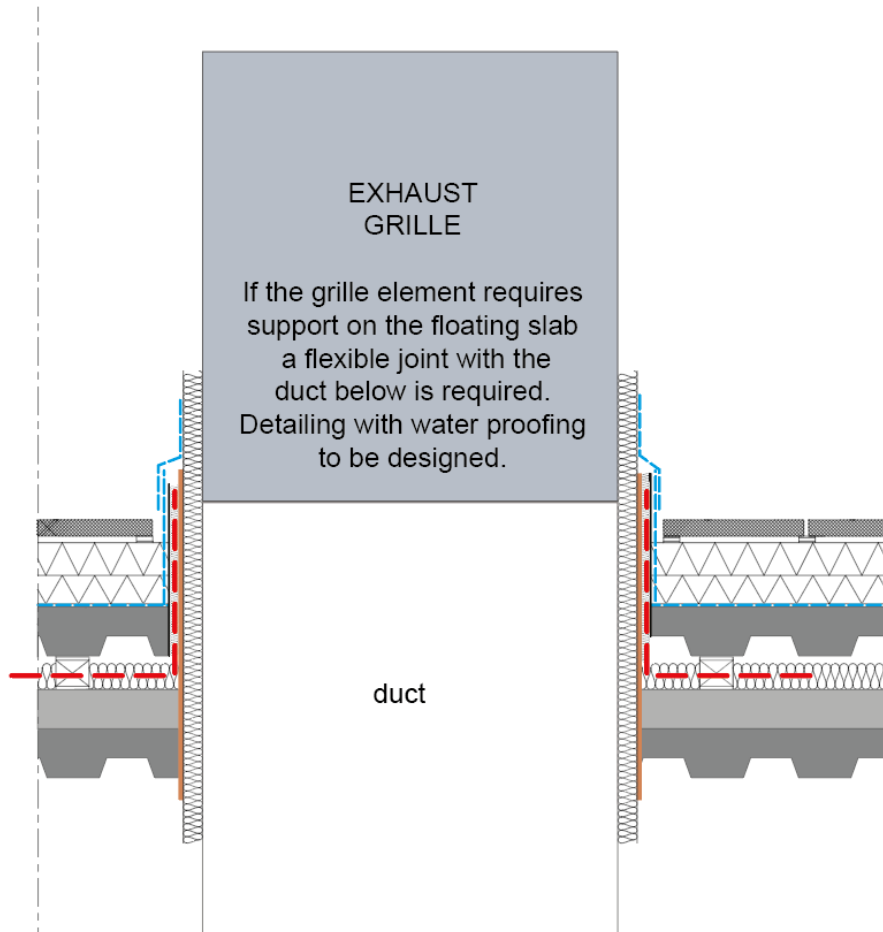
Duct and/or duct sleeve connected to sloating slab



Duct and/or duct sleeve connected to structural slab

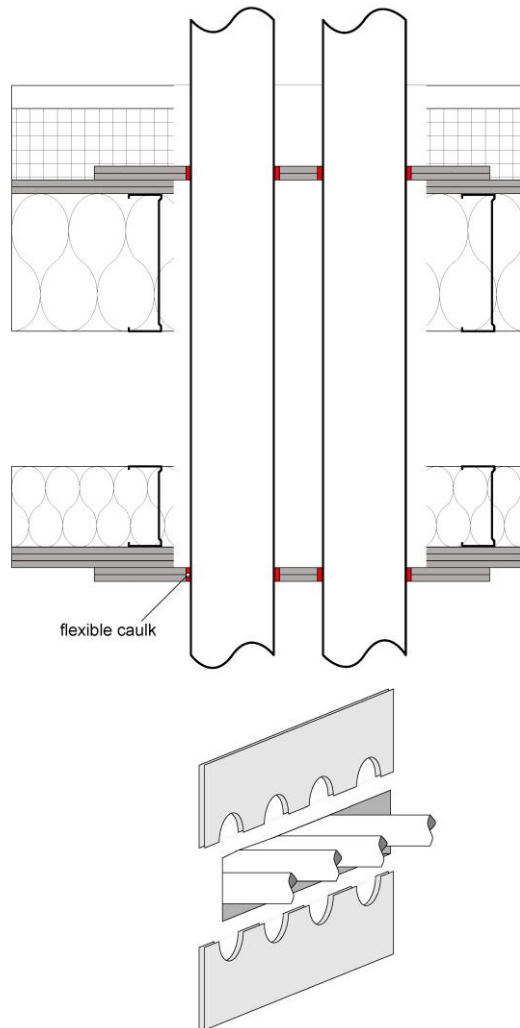


Duct and/or duct sleeve connected to structural slab



FAÇADE PENETRATION

Principle:



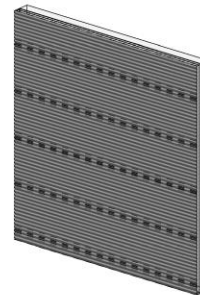
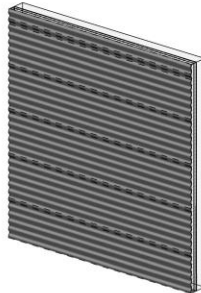
Number of cementboard or plasterboard sheets:

Penetrations through these panels require acoustic sealant.

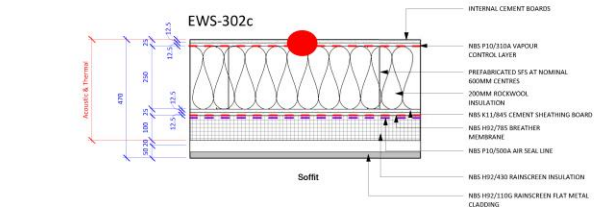
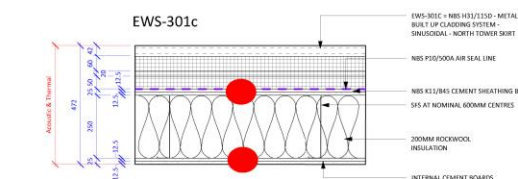
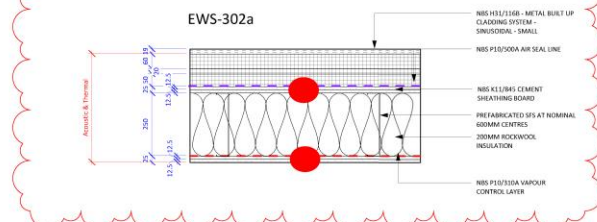
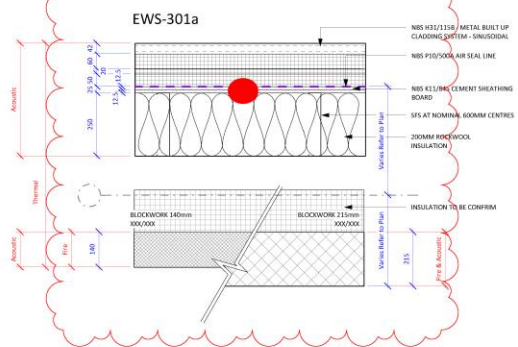
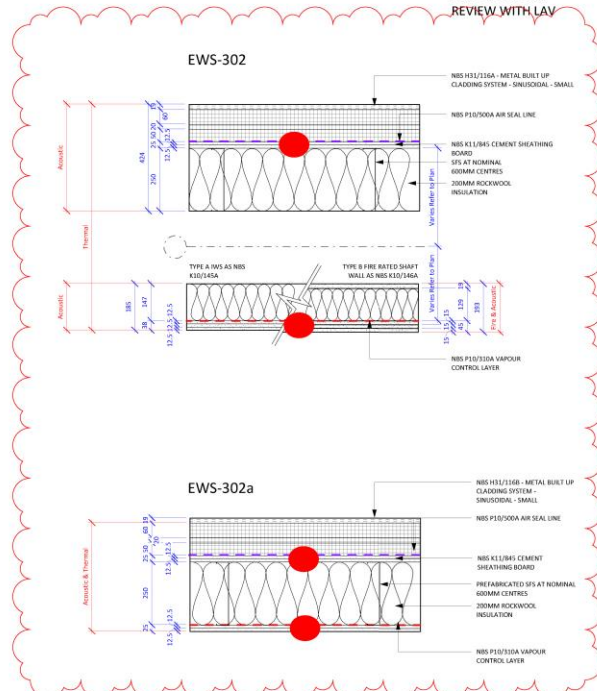
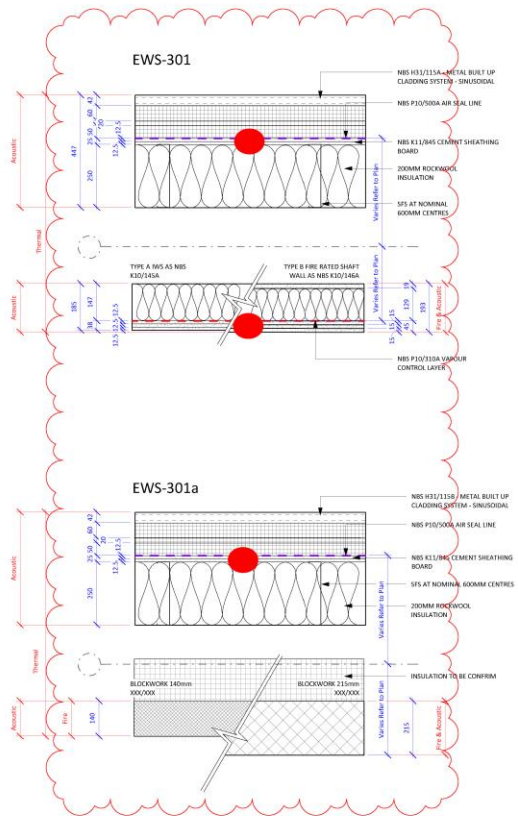
- Oversized opening needs to be closed first with contra milled cementboard/ plasterboard. At least two layers at each location.

In case the opening is not bigger than the pipe diameter+25 mm it can be sealed directly with flexible caulk. Caulk depth at least equal to the total thickness of the panel layers.

See details on following pages for location



AREAS OF EWS-302
ACOUSTICALLY
ISOLATED WALL AT
LEVEL 08 UNDER
REVIEW WITH LAV





Annex D: acoustic insulation of rain water and drainage pipes



Pipes acoustically insulated.
Rubber sleeved braces

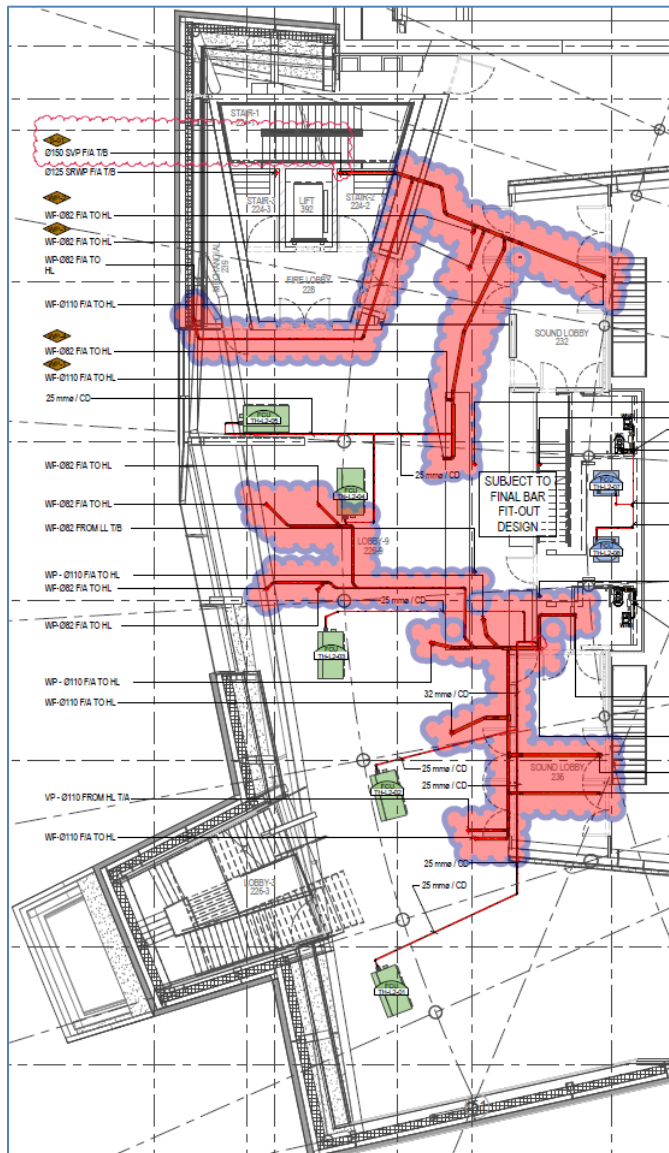


Figure 14: theater 2nd floor

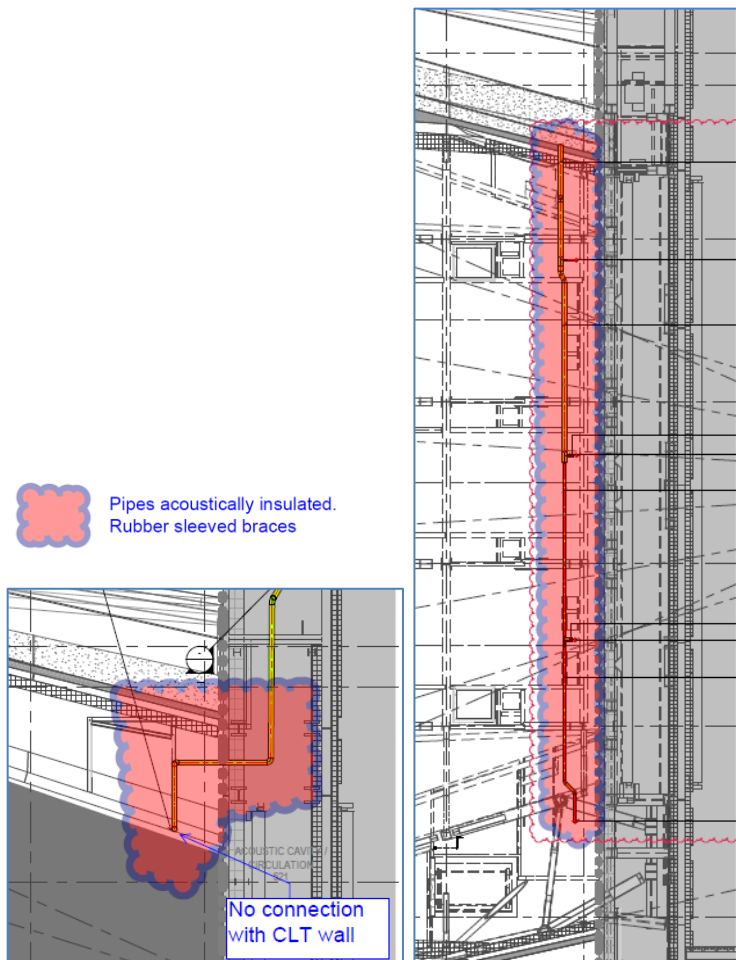


Figure 15: theatre 5th floor / theatre 6th floor



Pipes acoustically insulated.
Rubber sleeved braces

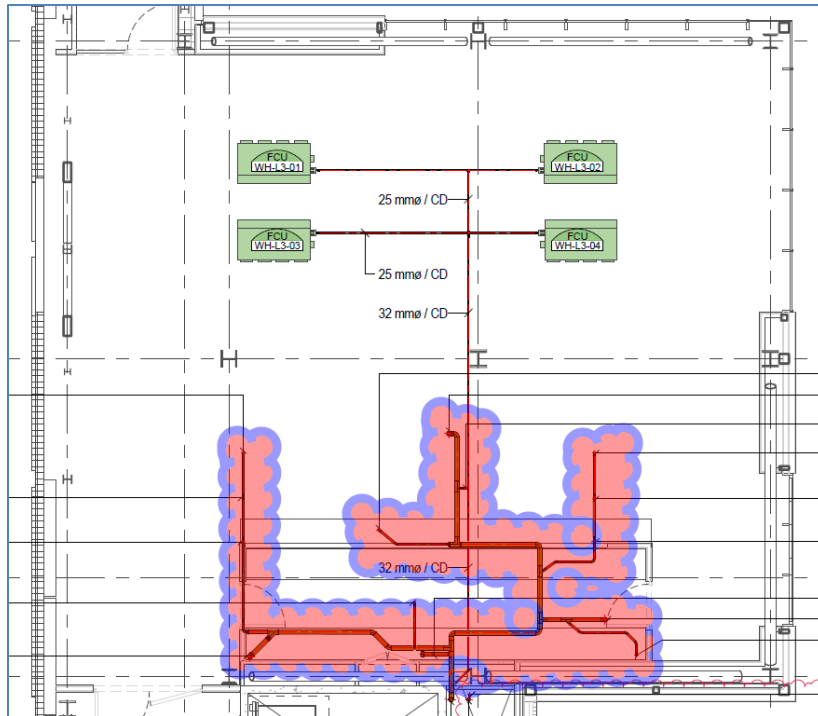


Figure 16: north tower 3rd floor

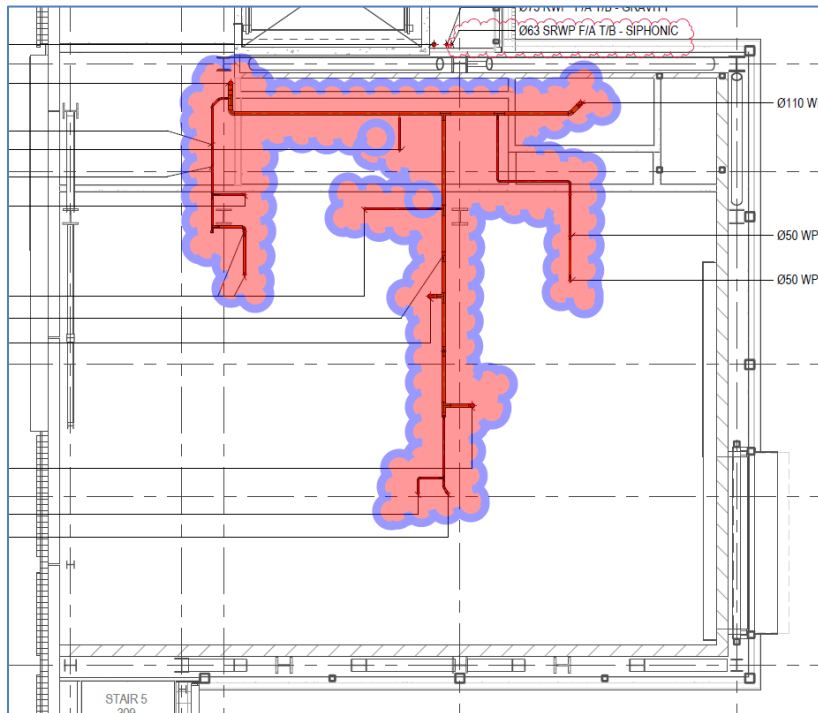


Figure 17: south tower, 3rd floor

Some examples:

EASYmass pipe insulation

<https://www.easy-noisecontrol.com/product/easymass-pipe-insulation/>

EASYmass pipe insulation works on the basis of the mass-spring principle. It is composed of a thin layer of foam covered with a ground plane of approx. 4 kg/m². This composition results in the excellent noise-insulating properties of EASYmass pipe insulation.

The visible side is finished with 2 mm PVC foam in the colour anthracite.

MERFISOL

<https://mediahub.merford.com/m/61c2df029d66e78c/original/Merfisol-Black-ALU.pdf>

Composition

Merfisol Black ALU is a sound insulating plate that is made of 2 mm-thick fireproof solid plastic finished with strengthened aluminium foil. The back side of the plate has an 8 mm-thick springy layer of an acoustic ALU foam. This springy layer provides an acoustic separation between the base and plastic mass, which results in a considerable improvement of the sound insulation.

MERFOLOOD

<https://mediahub.merford.com/m/25a69cc25d38f862/original/Merflood.pdf>

composition

Merflood is a sound-insulating plate made from a 0.35 mm layer of lead with a 10 mm thick cushioning layer on its underside. This provides acoustic separation of the substrate and the lead layer. On its upper side the lead is fitted with a 2 mm thick anti-condensation finish.

SuperLag Superflex Prime

www.cmsdanskin.co.uk

A highly flexible material consisting of a three part laminate, incorporating a spacer or isolating layer, a very flexible heavy mass layer and an outer flame/ vapour barrier meeting class '0' of the Building Regulations (E&W). Being of a laminated construction it overcomes the need for a separate isolation layer normally required beneath most forms of acoustic lagging.

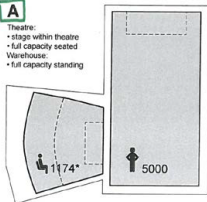
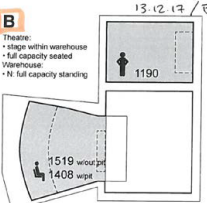
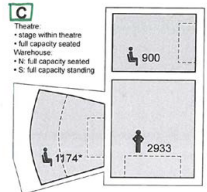
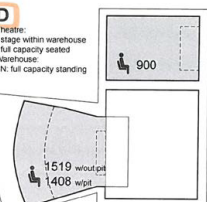
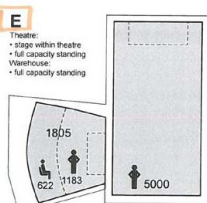
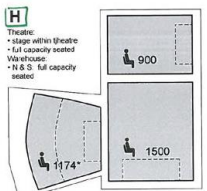
Annex E: Occupancy scenarios

Matrix on the next page presents status of compliance with Theatre and Warehouse building service noise criteria if the current proposed HALTON TSA-630(C) diffusers are used

Occupancy scenarios criteria highlighted in green in the matrix indicates where Level Acoustics have advised that the proposed diffuser selections will enable compliance with the criteria.

Warehouse occupancy scenario	Maximum assumed flow rate [l/s]			
	Warehouse north/south divided		Warehouse south open to theatre	Undivided Warehouse
	maximum seated (900 north, 1500 south)	maximum standing (1190 north, 2933 south)	1519 seated	Up to 5000 standing
Cooling mode	571	714	571	714
Heating mode	553	553	553	553
Pre-heat mode (prior to event)	1105	1105	1105	1105

Proposed building service noise criteria following Stage 4 design development

Occupancy Scenario	Theatre		Warehouse	
	Cooling mode	Heating mode	Cooling mode	Heating mode
A  Theatre: • stage within theatre • full capacity seated • full capacity standing Warehouse: • 5000	≤NR 27 & ≤29 dBA	≤NR 27 & ≤29 dBA	Unamplified events: ≤N/A Amplified events: ≤NR 45 & ≤46 dBA	Unamplified events/rehearsals: NR ≤ N/A Amplified events/rehearsals or construction work: ≤ NR 45 & ≤46 dBA No activities (pre-heating): no requirement
B  Theatre: • stage within warehouse • full capacity seated • full capacity standing Warehouse: • 1190 1519 without pit 1408 with pit	Theatre & Orchestra Pit: ≤NR 27 & ≤29 dBA Stage: ≤NR 30	Theatre & Orchestra Pit: ≤NR 27 & ≤29 dBA Stage: ≤NR 30 No activities (pre-heating): no requirement	Unamplified events: ≤NR 30 Amplified events: ≤NR 45 & ≤46 dBA	Unamplified events/rehearsals: NR ≤ 30 Amplified events/rehearsals or construction work: ≤ NR 45 & ≤46 dBA No activities (pre-heating): no requirement
C  Theatre: • stage within theatre • full capacity seated • full capacity standing Warehouse: • 900 1174, 2933	≤NR 27 & ≤29 dBA	≤NR 27 & ≤29 dBA	Unamplified events: ≤NR 30 Amplified events: ≤NR 45 & ≤46 dBA	Unamplified events/rehearsals: NR ≤ 30 Amplified events/rehearsals or construction work: ≤ NR 45 & ≤46 dBA No activities (pre-heating): no requirement
D  Theatre: • stage within warehouse • full capacity seated • full capacity standing Warehouse: • 900 1519 without pit 1408 with pit	Theatre & Orchestra Pit: ≤NR 27 & ≤29 dBA Stage: ≤NR 30	Theatre & Orchestra Pit: ≤NR 27 & ≤29 dBA Stage: ≤NR 30 No activities (pre-heating): no requirement	Unamplified events: ≤NR 30 Amplified events: ≤NR 45 & ≤46 dBA	Unamplified events/rehearsals: NR ≤ 30 Amplified events/rehearsals or construction work: ≤ NR 45 & ≤46 dBA No activities (pre-heating): no requirement
E  Theatre: • stage within theatre • full capacity seated • full capacity standing Warehouse: • 5000 1805, 622, 1183	≤NR 33 & ≤35 dBA	≤NR 33 & ≤35 dBA	Unamplified events: ≤N/A Amplified events: ≤NR 45 & ≤46 dBA	Unamplified events/rehearsals: NR ≤ N/A Amplified events/rehearsals or construction work: ≤ NR 45 & ≤46 dBA No activities (pre-heating): no requirement
H  Theatre: • stage within theatre • full capacity seated • full capacity standing Warehouse: • 900 1174, 1500	≤NR 27 & ≤29 dBA	≤NR 27 & ≤29 dBA	Unamplified events: ≤NR 30 Amplified events: ≤NR 45 & ≤46 dBA	Unamplified events/rehearsals: NR ≤ 30 Amplified events/rehearsals or construction work: ≤ NR 45 & ≤46 dBA No activities (pre-heating): no requirement

Annex F: Duct sound insulation materials

F1: BARYFOL X2 24 kg/m²



SOUND INSULATION

BARYFOL X2 – plastic mass layer

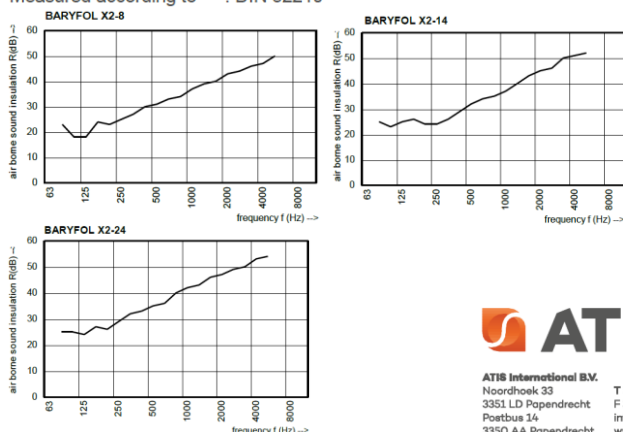


BARYFOL X2	Thickness	Weight
X2-8 J	3,3 mm	8 kg/m ²
X2-14 J	6 mm	14 kg/m ²
X2-24 JJ	10 mm	24 kg/m ²
J = 1 side jute JJ = 2 side jute other weights/m ² available		

Description	Baryfol X2 is a heavy flexible plastic layer with inorganic filters. There is jute weaving on one or both sides. Baryfol X2 has a dark grey colour. Baryfol X2 is used inside.
Characteristics	• High sound insulating value • Flame retardant in accordance with DIN 75200, DIN 5510 T.2 S4; SR2; ST2 • CE approved (according guideline pleasure vessels 94/25/EG) • Easy to cut with a (Stanley) knife, with scissors or to saw with a band saw • Resistant to (DIN-EN-ISO 2812-1): water, petrol, battery acid, brake fluid, hydraulic oil, mineral oil (10W40), solvents (propanol 2) and cold cleaning agent • Temperature resistant (DIN-EN-434) to 80 °C • Shore A hardness 70-90N
Application	For isolating of air ducts, dividing walls, enclosures, cabins and piping, automotive- / bus industry, yacht and ship building, aerator housings
Processing	Glue on jute-side with TEROKAL-2444 contact adhesive (about 300 g/m ²), or possibly with BARYVIBRO V607 2-component adhesive (about 1,0 kg/m ²). To avoid noise leaks it is important that seams between mats and other openings like bushings are carefully sealed with a silicone rubber mastic.
Sizes	Sheets of 1000 x 1000 mm (± 10%) For weights and thicknesses see table above Dye-cut to size parts available

SOUND INSULATION CURVE (R)

Insulation material : BARYFOL X2
Base : 1 mm steel plate
Measured according to : DIN 52210



ATIS International B.V.
Noordhoek 33
3351 LD Papendrecht
Poortbus 14
3350 AA Papendrecht

T 31 (0)78 615 00 44
F 31 (0)78 615 49 48
info@atis-international.com
www.atis-international.com

F2: Soundac Barrier Mat 24 kg/m²

Soundac® Barrier Mat

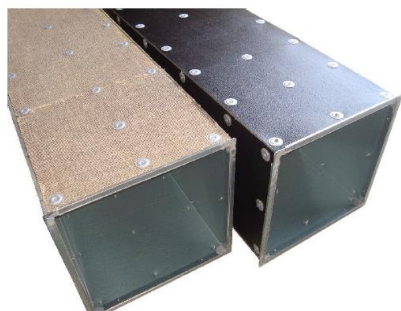
Very flexible vinyl barrier mat for an optimal sound insulation

Soundac® Barrier Mat is a vinyl barrier mat that is very suitable for improving the sound insulation of steel, aluminium, wood or plastic materials. The best sound reductions can be achieved if the subsoil is lighter than the barrier mat.

Soundac® Barrier Mat is very effective in overcoming the coincidence resonance dip that is found in stiff and lightweight sheets of e.g. steel, aluminium and wood. The Barrier Mats are commonly used in plywood floor of motor yachts, airducts and partition walls. These sheets are well suited and easily combined the sound absorbing Soundac® AS and Accent.

Description

Soundac® Barrier Mat is composed of polymers filled with the natural mineral barium sulphate. The product is free of heavy metals and bitumen.



Soundac® BM1094 en IS240HH on airducts

Converting

Soundac® Barrier Mat is easily cut to size with a knife, saw or scissors. Before application the subsoil needs to be dry and free of dust and grease. Preferably the sheets needs to be fully glued to the subsoil with a contact glue suitable for vinyl materials. For an optimal mounting the sheets should be mechanically attached to the subsoil with a spacing of approx. 20 cm.

To avoid leakage of noise and for an optimal sound insulation it is important that the sheets are well connected to each other. Seams between sheets and connections should be sealed properly with an elastic sealant.

Customization

It is possible to produce specific types to your requirements. It is also possible to convert Soundac® Barrier Mat in our own production facility in any desirable dimension. We have several possibilities of which we happily inform you.

Characteristics

- Type material PVC (Polyvinylchloride)
- Base colour Anthracite
- Possible finishing Hessian backing, black topcoat
Hessian backing on both sides
- Density 2,500 kg/m³
- Fire behaviour FMVSS 302 self-extinguishing
- Thickness tolerance* -10%/+20%
- Weight tolerance -10%/+10%
- Hardness 90 Shore A
- Tensile strength monolayer 2.6 MPa (gem.), 1.1 MPa (min.)
- Elong. at break monolayer 100% (gem.), 30 % (min.)
- Operating temperature -30°C to ca. +93°C
- Short exposure to extremes
- Soundac® BM/IS will naturally have a slight vinyl odour

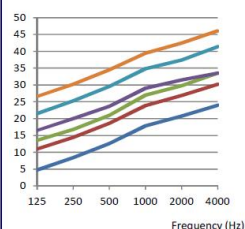
Despite the careful composition of this datasheet no rights can be derived from this. Changes are reserved.

* Soundac® BM/IS materials are made to weight tolerance. Production to thickness tolerance is possible.

Properties

- Sound insulating
- High density
- Very flexible
- Available from stock
- CE-certificate for yacht building

Airborne sound insulation R (dB) NEN-EN-ISO 140



Type	kg/m ²	R _w
BM0020	2.0	14
BM0040	4.0	20
BM0050	5.0	22
BM0070	7.5	25
BM1094	14.0	30
IS240HH	24.0	34



Hessian backing and black topcoat



Hessian backing on both sides

CE-certificate

Soundac® BM-materials are in compliance with directive RL 2013/53/EU (ISO 4589-3:1996), which makes them suitable for use in yacht building.

Annex G: mechanical noise level study in Theatre - south Warehouse

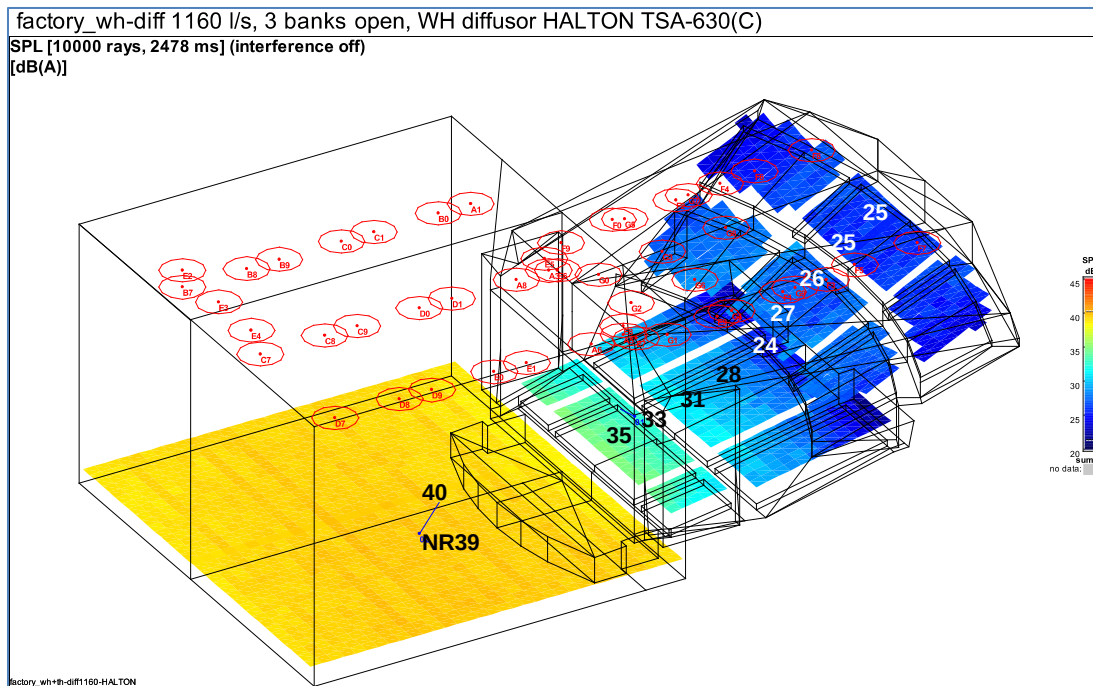


Figure 18

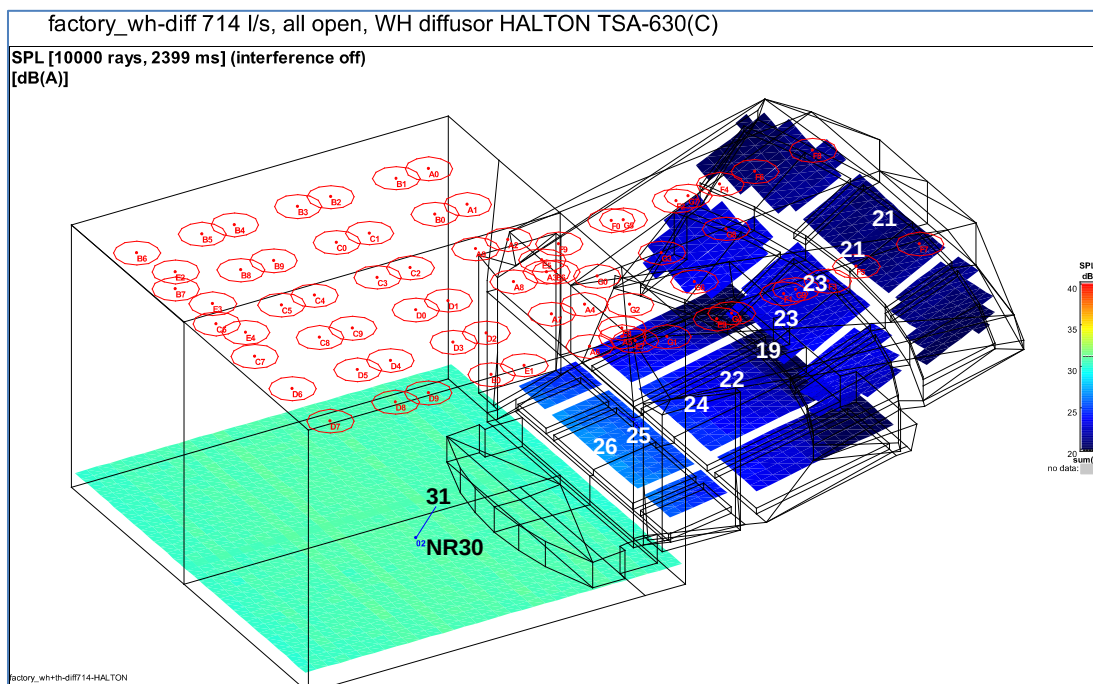


Figure 19

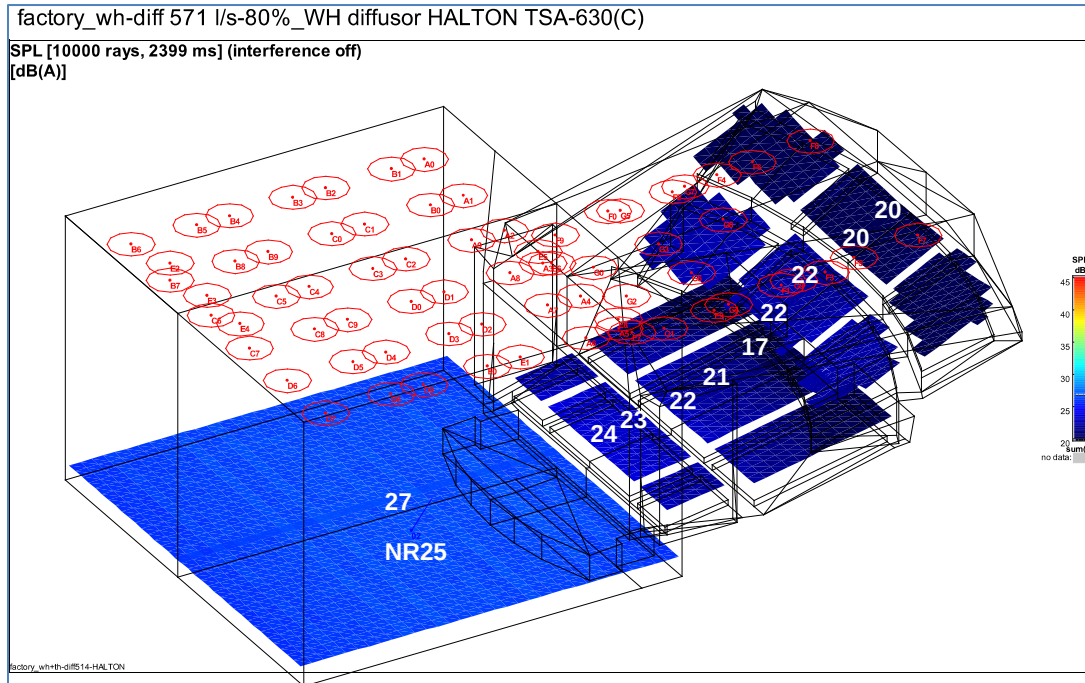


Figure 20

Annex H: Fan coil units

Schedule ref.: MF-BDP-ZZ-ZZ-SH-M-68-0011 Rev. C09

FCU SOUND POWER LEVELS		l/s	Inlet/Cased Radiated						Discharge Radiated					
			125	250	500	1k	2k	4k	125	250	500	1k	2k	4k
			dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
TH-L2-01	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L2-02	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L2-03	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L2-04	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L2-05	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L2-06	TPZ120	528	66.8	66.9	63.2	61.1	57.3	51.5						
TH-L2-07a	CWCH65	105	40	38	37	24	21	13						
TH-L2-07b	CWCH65	105	40	38	37	24	21	13						
TH-L3-01	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L3-02	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L3-03	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L3-04	SPR9-5ADC	510	61	58.9	54.2	46.2	43.1	36.4	53.5	50.3	42.5	38.6	32.6	24.9
TH-L4-01	CWC155	500	71.5	68.6	66.1	65.2	60.3	54.4						
TH-L4-02	CWC155	500	71.5	68.6	66.1	65.2	60.3	54.4						
TH-L4-03	CWC155	500	71.5	68.6	66.1	65.2	60.3	54.4						
TH-L4-04	TPZ74	228	53.2	56.2	55.8	51.1	48.6	41.8						
TH-L6-01	CWC65	105	40	38	37	24	21	13						
TH-L6-02	CWC65	105	40	38	37	24	21	13						
TH-L6-03	CWC65	170	55	55	51	50	42	32						
TH-L6-04	CWC65	170	55	55	51	50	42	32						
TH-L5-01	TPZ96	242	50.7	53.4	54.5	49.1	45.8	40.6						
TH-L5-02	TPZ96	242	50.7	53.4	54.5	49.1	45.8	40.6						
TH-L5-03	TPZ78	228	53.2	56.2	55.8	51.1	48.6	41.8						
AR-GF-01	SPR8-5ADC	473	59.7	58.4	54.7	45.9	41.8	36.3	51.9	48.2	40.8	36.2	30.1	22
AR-GF-02	SPR8-5ADC	473	59.7	58.4	54.7	45.9	41.8	36.3	51.9	48.2	40.8	36.2	30.1	22
WH-GF-01	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-02	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-03	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-04	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-05	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-06	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-07	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-08	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-09	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-10	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-11	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-12	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-13	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-14	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-15	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-16	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-GF-17	SPR9-5ADC	509	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9
WH-L2-01	SPR3-2ADC	289	52.5	51.2	47.5	39.3	34.8	29.9	53.5	50.3	42.5	38.6	32.6	24.9
WH-L2-02	SPR3-2ADC	289	52.5	51.2	47.5	39.3	34.8	29.9	53.5	50.3	42.5	38.6	32.6	24.9
WH-L2-03	SPR3-2ADC	289	52.5	51.2	47.5	39.3	34.8	29.9	53.5	50.3	42.5	38.6	32.6	24.9
WH-L2-04	CWCH75	155	48	48	45	41	32	21						
WH-L2-05	CWCH75	155	48	48	45	41	32	21						
WH-L3-01	SPR8-5ADC	364	50.6	45.7	35.1	19.2	17.2	14	53.5	50.3	42.5	38.6	32.6	24.9
WH-L3-02	SPR8-5ADC	364	50.6	45.7	35.1	19.2	17.2	14	53.5	50.3	42.5	38.6	32.6	24.9
WH-L3-03	SPR8-5ADC	364	50.6	45.7	35.1	19.2	17.2	14	53.5	50.3	42.5	38.6	32.6	24.9
WH-L3-04	SPR8-5ADC	364	50.6	45.7	35.1	19.2	17.2	14	53.5	50.3	42.5	38.6	32.6	24.9

Continued on next page.

FCU SOUND POWER LEVELS			Inlet/Cased Radiated							Discharge Radiated						
				125	250	500	1k	2k	4k		125	250	500	1k	2k	4k
			l/s	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
WH-L4-01	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-02	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-03	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-04	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-05	CWCH45	105	39	40	38	26	21	13								
WH-L4-06	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-07	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-08	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-09	CWCH45	105	39	40	38	26	21	13								
WH-L4-10	CWCH45	105	39	40	38	26	21	13								
WH-L4-11	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-12	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-13	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L4-14	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L5-01	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-02	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-03	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-04	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-05	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-06	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-07	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-08	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-09	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-10	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-11	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-12	SPR4-3ADC	364	54.1	47.8	37.5	22.9	22	20.6	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L5-13	SPR3-2ADC	201	45.4	38.3	33.5	23.7	17.2	11.2	41	37.7	30	24.4	17.8	9.1		
WH-L5-14	SPR3-2ADC	201	45.4	38.3	33.5	23.7	17.2	11.2	41	37.7	30	24.4	17.8	9.1		
WH-L6-01	SPR9-5ADC	510	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L6-02	SPR9-5ADC	510	57	51.9	40.2	26.2	25.1	24.4	53.5	50.3	42.5	38.6	32.6	24.9		
WH-L6-05	SPR8-5ADC	382	52.4	47	36.4	21.9	19.8	17.3	48.9	44.9	35.8	32.2	26.1	17		
WH-L6-06	CWCH95	240	51.3	51.3	49.6	49	34.3	27.2								
WH-L7-03	CWCH155	430	69.2	64.9	62.2	62	56.2	47.1								
WH-L7-04	CWCH155	500	71.5	68.6	66.1	65.2	60.3	54.4								

Next table shows the estimated sound pressure levels and are compliant with the requirements. The sound pressure levels have been achieved using data provided by the manufacturer (Quartz) for acoustic information.

FCU noise level									
		125	250	500	1k	2k	4k		
Location	LpA	dB	dB	dB	dB	dB	dB	NR req	NR
Level 2 Foyer	45	51	49	44	37	33	26	40	40
Theatre Lift Car Rm,	64	65	65	61	59	55	50	60	59
Control room level 2	28	32	30	29	16	13	5	25	25
Level 3 foyer	45	51	49	44	36	33	26	40	40
Electrical Room-DUTY	59	61	58	55	55	50	44	60	55
Electrical Room-STAND-BY	59	61	58	55	55	50	44	60	55
Control room L5 (recording/editing)	28	32	30	29	16	13	5	25	25
Control room L5 (follow spot mode)	45	47	47	43	42	34	24	45	42
AV Rack 5-543 (NR level in theater)	14	18	19	13	-2	-13	-27	25	8
Battery Room	50	46	49	49	44	42	35	45	45
kitchen	50	55	53	49	41	36	31	45	45
foyer warehouse	41	51	47	37	31	26	20	40	37
Workshop	40	46	44	39	32	27	21	45	35
Stage Mng 215	42	44	44	41	37	28	17	40	37
Security 216	42	44	44	41	37	28	17	40	37
Green room	37	46	42	34	29	23	16	35	32
Dressing Rm, 403	42	41	41	39	39	24	17	40	39
Dressing Rm, 404	43	42	42	41	40	25	18	40	40
Dressing Rm, 405	43	42	42	41	40	25	18	40	40
Dressing Rm, 406	42	41	41	39	39	24	17	40	39
Dressing Rm, 407	30	32	33	31	19	14	6	40	27
Dressing Rm, 419	42	41	41	40	39	24	17	40	39
Costume/Laundry 413	44	43	43	42	41	26	19	45	41
Dressing Rm, 425	41	41	41	39	39	24	17	40	39
Dressing Rm, 426	28	30	31	29	17	12	4	40	25
Dressing Rm, 427	28	30	31	29	17	12	4	40	25
Dressing Rm, 428	43	43	43	41	40	26	18	40	40
Dressing Rm, 421	43	43	43	41	40	26	18	40	40
Lounge 402	41	41	41	39	39	24	17	45	39
Lounge 415	41	41	41	39	39	24	17	45	39
Office - centre core	38	47	43	34	29	24	17	40	33
Office - north tower	39	48	44	35	30	24	18	40	34
Office - north tower	39	48	44	35	30	25	18	40	34
North Meeting Rm	29	39	33	27	19	12	5	35	23
South Meeting Rm	29	39	33	27	19	12	5	35	23
Corporate/Board Rm	37	47	43	33	27	22	16	35	33
Meeting Rm 603	34	44	40	30	23	17	11	35	29
Crew room	41	41	41	39	38	24	17	40	38
Equipment room 705	58	62	57	55	55	49	40	60	55
Equipment room 712	63	65	62	60	59	54	48	60	59

Annex I: AV mounts

ANTI VIBRATION MOUNTS							
Description	Note	Inertial base	weight	description	type	no. of mounts ⁽²⁾	deflection ⁽³⁾
			[kg]	[-]	[-]	[-]	[mm]
Fan Coil Units (MF-BDP-ZZ-ZZ-SH-M-68-0011 Rev. C07)							
TH-L2-01 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L2-02 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L2-03 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L2-04 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L2-05 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L2-06 [TPZ120]	Wall mounted		60	Rubber hanger	RH28	4	3
TH-L2-07 [CWC65]	concealed		25	Rubber hanger	RH28	4	1
TH-L2-08 [CWC65]	concealed		25	Rubber hanger	RH28	4	1
TH-L3-01 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L3-02 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L3-03 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L3-04 [SPR9-5ADC]	concealed		109	Rubber hanger	RH28	4	6
TH-L4-01 [CWC155]	concealed		44	Rubber hanger	RH28	4	2
TH-L4-02 [CWC155]	concealed		44	Rubber hanger	RH28	4	2
TH-L4-03 [CWC155]	concealed		44	Rubber hanger	RH28	4	2
TH-L4-04 [TPZ74]	concealed		33	Rubber hanger	RH28	4	2
TH-L6-01 [CWC65]	cassette		25	Spring hanger	SH20/20	4	6
TH-L6-02 [CWC65]	cassette		25	Spring hanger	SH20/20	4	6
TH-L6-03 [CWC65]	cassette		25	Spring hanger	SH20/20	4	6
TH-L6-04 [CWC65]	cassette		25	Spring hanger	SH20/20	4	6
TH-L5-01 [TPZ96]			39	Rubber hanger	RH28	4	2
TH-L5-02 [TPZ96]			39	Rubber hanger	RH28	4	2
TH-L5-03 [TPZ78]	Floor mounted		35	Rubber hanger	RH28	4	2
AR-GF-01 [SPR8-5ADC]	concealed		105	Rubber hanger	RH28	4	6
AR-GF-02 [SPR8-5ADC]	concealed		105	Rubber hanger	RH28	4	6
WH-GF-01 [SPR9-5ADC]	exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-02 [SPR9-5ADC]	exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-03 [SPR9-5ADC]	exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-04 [SPR9-5ADC]	exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-05 [SPR9-5ADC]	exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-06 [SPR9-5ADC]	exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-07 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-08 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-09 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-10 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-11 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-12 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-13 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-14 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-15 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-16 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-GF-17 [SPR9-5ADC]	Exposed		109	Ceiling with spring hangers. FCU integrated in ceiling			
WH-L2-01 [SPR3-2ADC]	Exposed		57	Rubber hanger	RH28	4	3
WH-L2-02 [SPR3-2ADC]	Exposed		57	Rubber hanger	RH28	4	3
WH-L2-03 [SPR3-2ADC]	Exposed		57	Rubber hanger	RH28	4	3
WH-L2-04 [CWC65]	cassette		25	Spring hanger	SH20/20	4	6
WH-L2-05 [CWC65]	cassette		25	Spring hanger	SH20/20	4	6
WH-L3-01 [SPR8-5ADC]	Exposed		105	Rubber hanger	RH28	4	6
WH-L3-02 [SPR8-5ADC]	Exposed		105	Rubber hanger	RH28	4	6
WH-L3-03 [SPR8-5ADC]	Exposed		105	Rubber hanger	RH28	4	6
WH-L3-04 [SPR8-5ADC]	Exposed		105	Rubber hanger	RH28	4	6
WH-L4-01 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-02 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-03 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-04 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-05 [CWC65]	cassette		24	Spring hanger	SH20/20	4	6
WH-L4-06 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-07 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-08 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-09 [CWC65]	cassette		24	Spring hanger	SH20/20	4	6
WH-L4-10 [CWC65]	cassette		24	Spring hanger	SH20/20	4	6
WH-L4-11 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-12 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-13 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L4-14 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L5-01 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-02 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-03 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-04 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-05 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-06 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-07 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-08 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-09 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-10 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-11 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-12 [SPR4-3ADC]	Exposed		75	Rubber hanger	RH28	4	4
WH-L5-13 [SPR3-2ADC]	Exposed		57	Rubber hanger	RH28	4	3
WH-L5-14 [SPR3-2ADC]	Exposed		57	Rubber hanger	RH28	4	3
WH-L6-01 [SPR9-5ADC]	Exposed		109	Rubber hanger	RH28	4	6
WH-L6-02 [SPR9-5ADC]	Exposed		109	Rubber hanger	RH28	4	6
WH-L6-05 [SPR8-5ADC]	Exposed		105	Rubber hanger	RH28	4	6
WH-L6-06 [CWC65]	cassette		36	Rubber hanger	RH28	4	2
WH-L7-03 [CWC155]	cassette		40	Rubber hanger	RH28	4	2
WH-L7-04 [CWC155]	cassette		40	Rubber hanger	RH28	4	2

(continued on next page)

Description	Note	Inertial base	weight [kg]	description [-]	type [-]	no. of mounts [-]	deflection ⁽¹⁾ [mm]
Air Handling Units ⁽²⁾ (MF-BDP-ZZ-ZH-M-68-0024 Rev. C06)							
AHU 1 AHU-TH-L1-01 ORCHESTRA PIT			620	Rubber pads	05.103.45	6	4
AHU 2 AHU-TH-L4-01 THEATRE TOILETS			1.425	Rubber pads	05.103.45	14	4
AHU 3 AHU-TH-L4-02 AUDITORIUM BALCONY			4.545	Rubber pads	05.103.45	46	4
AHU No. 4; AHU-TH-L4-03, Theatre Auditorium stalls			7.078	Rubber pads	05.103.45	70	4
AHU 5 AHU-TH-L5-01 THEATRE AUDITORIUM REAR			2.775	Rubber pads	05.103.45	28	4
AHU No. 6; AHU-TOW-L3-01, Level 04 down			4.617	AV pads underneath floating slab (fo ≤ 10 Hz)	-		
AHU No. 07 - AHU-TOW-L6-01			3.000	AV pads underneath floating slab (fo ≤ 10 Hz)	-		
AHU No. 08; AHU-TOW-L7-01 South Warehouse			6.620	AV pads underneath floating slab (fo ≤ 10 Hz)	-		
AHU No. 09; AHU-TOW-L7-02, South Warehouse			6.620	AV pads underneath floating slab (fo ≤ 10 Hz)	-		
AHU No. 10; AHU-TOW-L7-03, North Warehouse			4.799	Rubber pads	05.103.45	48	4
AHU No. 11; AHU-TOW-L7-04, North Warehouse			7.277	Rubber pads	05.103.45	72	4
Duct and attenuator hangers							
inside theater plantroom				steel spring hangers	tbd ⁽⁶⁾	tbd ⁽⁶⁾	4
sensitive areas (see section 6.4.2)				steel spring hangers	tbd ⁽⁶⁾	tbd ⁽⁶⁾	2
Emergency generator - MF-CHT-XX-XTS-E-01-0002, date 30-4-2020							
Genaset model: P250-5			800	engine rubber bearings	Ref. CATERPILLAR 344-9895	4	2
Water cooled chillers - type TX-W /1B1A (MF-BDP-ZZ-ZH-M-68-0013 Rev. C02)							
CH-WH-L6-01 / CH-WH-L6-02 / CH-WH-L6-03			4.070	according manufacturer no AV-mounts required	-		
Pumps (MF-BDP-ZZ-ZH-M-68-0008 Rev. C04 / MF-CHT-XX-XX-TS-M-01-0007)							
CP-WH-L6-01&02	2900 RPM	Y	187	specifief in MF-CHT-XX-XX-TS-M-01-0007	NSM-1A1-BK		
CP-WH-L6-03,04&05	1450 RPM	Y	205	specifief in MF-CHT-XX-XX-TS-M-01-0007	NSM-1A1-BK		
CP-WH-L6-06&07	1450 RPM	Y	118	specifief in MF-CHT-XX-XX-TS-M-01-0007	NSM-1A1-RD		
CP-WH-L6-08&09	2900 RPM	Y	93,5	specifief in MF-CHT-XX-XX-TS-M-01-0007	NSM-1A1-RD		
Pumps (MF-BDP-ZZ-ZH-P-68-0004 Rev. C05 / MF-CHT-XX-XX-TS-M-01-0007)							
CW-AR-GF-01	3500 RPM		385	Rubber mounts			3
CP-TH-L4-01	2800 RPM		6,7	Rubber mounts			3
CP-WH-L5-02	2800 RPM		6,7	Rubber mounts			3
CP-WH-L6-03	2390 RPM		3,4	Rubber mounts			3
SP-TH-L5-01			60	Rubber mounts			3
Air coolers - DAC-WH-L8-01 to 04 (MF-BDP-ZZ-ZH-M-68-0012 Rev. C04)							
CH WH-08-01 / CH WH-08-02 / CH WH-08-03 / CH WH-08-04				No AVM - directly on floating slab			
Supply and Extract Fan (MF-BDP-ZZ-ZH-M-68-0025 Rev. C05)							
FAN-TH-L2-EF1	data provide by CHT		44	Suspended or slab mounted	19.100.Y.F	4	2
FAN-TH-L1-EF1	data provide by CHT		2,4	not required	-		
FAN-WH-L6-SF1 & SF2	data provide by CHT		40	Suspended or slab mounted	19.100.Y.F	4	2
Kitchen Extract Fan (MF-BDP-ZZ-ZH-M-68-0039 Rev. C04)							
KEF 01			<10		19.100.Y.F	4	1
KEF 02			44				
Smoke Extract Fan (MF-BDP-ZZ-ZH-M-68-0033 Rev. C05)							
SEF-TH-05-01 & 02	data provide by CHT		401	Spring bearing	ES25/250 red	4	10
SEF-TH-05-03 & 04	data provide by CHT		211	Spring bearing	ES20/70 red	4	15
SEF-TH-05-05 & 06	data provide by CHT		211	Spring bearing	ES20/70 red	4	15
SEF-WH-07-01 & 02	data provide by CHT		401	Spring bearing	ECS25/300 wh/px	4	8
SEF-WH-07-03 & 04	data provide by CHT		666	Spring bearing	ECS25/600 wh/br	4	7
SEF-WH-08-01 & 02	data provide by CHT		211	Spring bearing	ES20/70 red	4	15
Pipework, drainage							
Pipework to pressurisation units				see chapter 6.1			
Pipework general				see chapter 6.1			

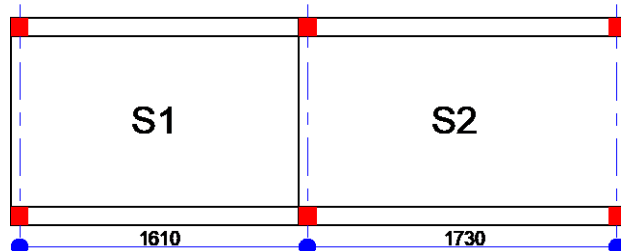
Annex J: AHU pad distribution

In this annex the AHU plans are shown with the distribution of AV-mounts

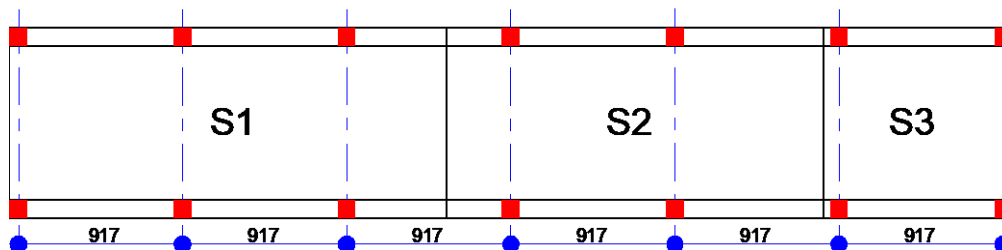


Pads: STUDFLEX PADS (DOUBLE LAYER) - 100 mm x 100 mm, deflection 4 mm

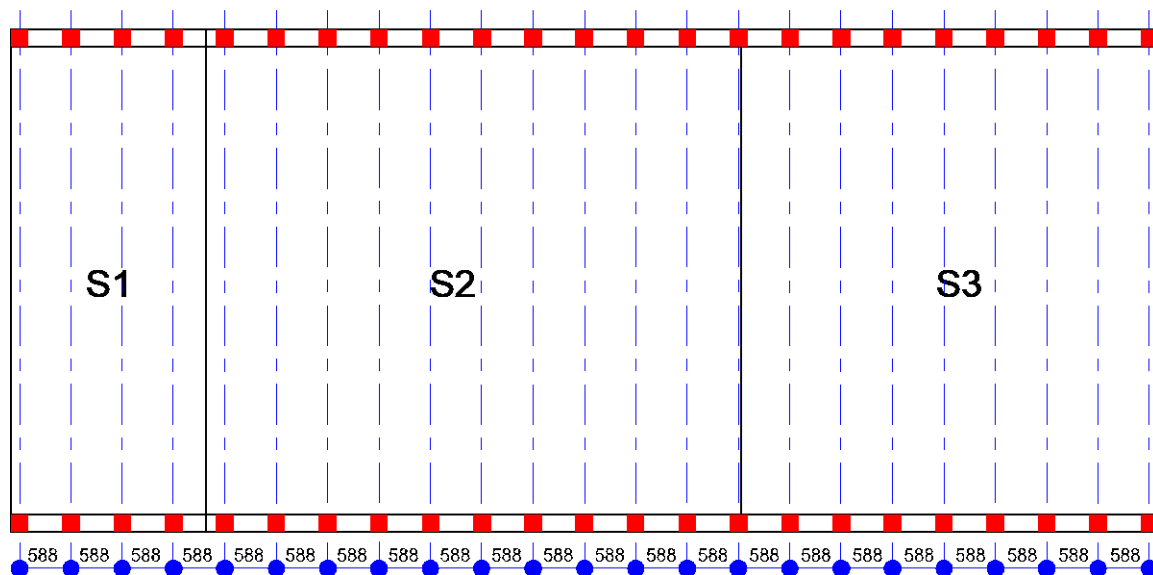
AHU 1 AHU-TH-L1-01 ORCHESTRA PIT



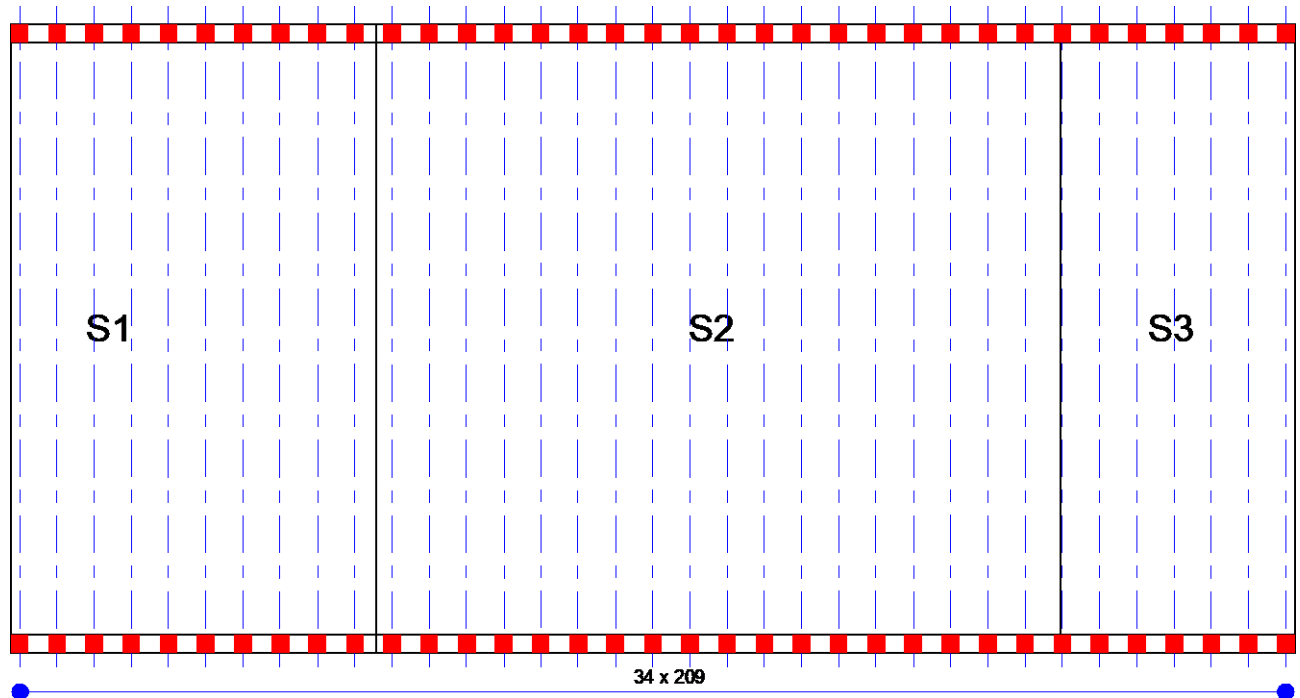
AHU 2 AHU-TH-L4-01 THEATRE TOILETS



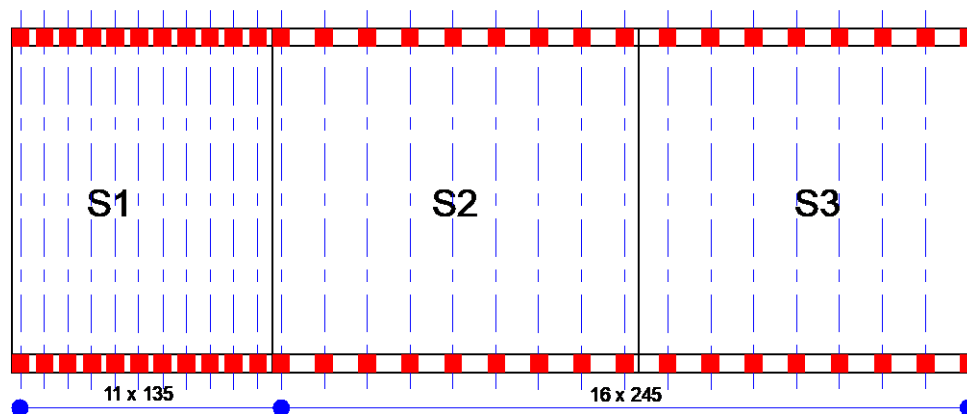
AHU 3 AHU-TH-L4-02 AUDITORIUM BALCONY



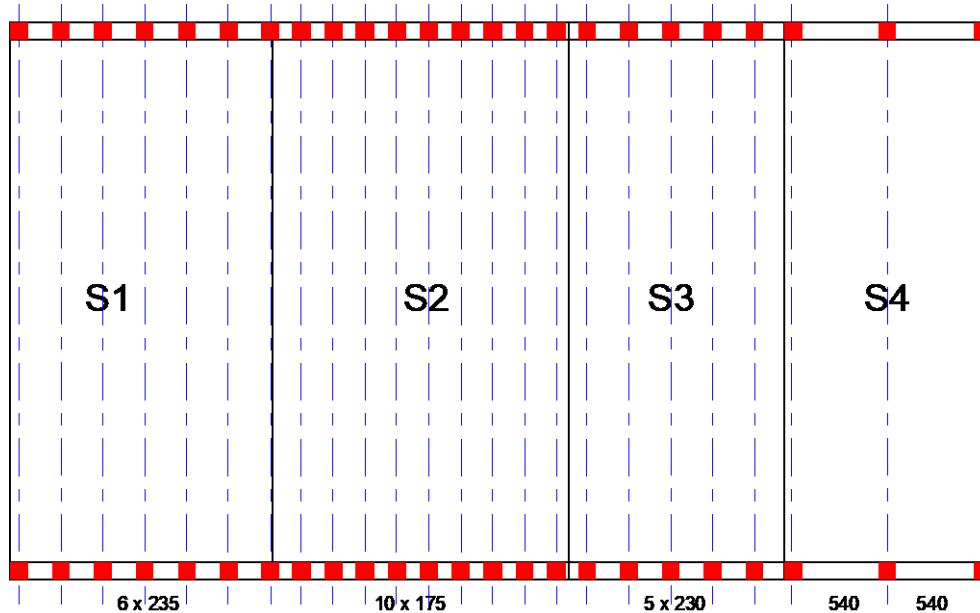
AHU No. 4; AHU-TH-L4-03, Theatre Auditorium stalls



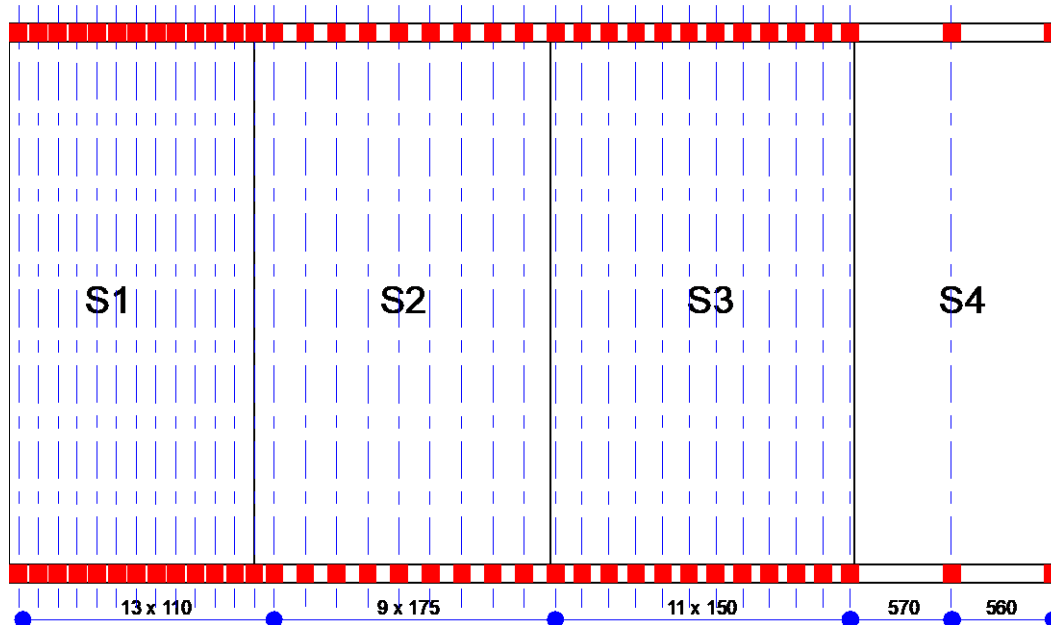
AHU 5 AHU-TH-L5-01 THEATRE AUDITORIUM REAR



AHU No. 10; AHU-TOW-L7-03, North Warehouse



AHU No. 11; AHU-TOW-L7-04, North Warehouse



Annex K: VAV Units

Schedule ref MF-BDP-ZZ-ZZ-SH-M-68-0026 Rev. C06

SOUND POWER LEVELS

THE FACTORY VAV REVISION OCT20					air-generated noise, SWL								case-radiated noise, SWL							
type	size	l/s	attenuator		63	125	250	500	1k	2k	4k	8k	63	125	250	500	1k	2k	4k	8k
					[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
TH-04-01	TVJ-D	800x800	1502-6210	TX/800x800	76	75	66	55	50	47	44	43	60	59	48	29	23	22	16	17
TH-04-02	TVJ-D	800x600	1082-3000	TX/800x600	73	71	64	47	39	37	40	45	61	60	50	34	29	30	25	26
TH-04-03	TVJ-D	500x400	470-1500	TX/500x400	71	69	59	45	39	36	38	42	59	57	45	31	27	26	22	23
TH-04-04	TVJ-D	500x400	470-1500	TX/500x400	71	69	59	45	39	36	38	42	59	57	45	31	27	26	22	23
TH-04-05	TVJ-D	500x400	470-1449	TX/500x400	71	69	59	45	38	36	38	42	59	57	45	31	27	26	23	23
TH-04-06	TVJ-D	500x400	470-1449	TX/500x400	71	69	59	45	38	36	38	42	59	57	45	31	27	26	23	23
TH-04-07	TZ-Silenzio-D	315	126-564		62	55	47	37	28	21	23	28	62	57	40	28	19	16	16	14
TH-04-08	TZ-Silenzio-D	315	126-564		62	55	47	37	28	21	23	28	62	57	40	28	19	16	16	14
TH-04-09	TZ-Silenzio-D	315	126-564		62	55	47	37	28	21	23	28	62	57	40	28	19	16	16	14
TH-04-10	TZ-Silenzio-D	315	126-564		62	55	47	37	28	21	23	28	62	57	40	28	19	16	16	14
TH-04-11	TZ-Silenzio-D	315	126-564		62	55	47	37	28	21	23	28	62	57	40	28	19	16	16	14
TH-04-12	TVJ-D	600x600	811-2000	TX/600x600	71	69	61	45	35	35	40	44	61	59	49	34	30	31	27	27
TH-04-13	TVJ-D	600x600	811-2000	TX/600x600	71	69	61	45	35	35	40	44	61	59	49	34	30	31	27	27
TH-04-14	TVJ-D	800x600	1082-4000	TX/800x600	75	73	65	51	45	42	41	43	61	59	49	31	26	25	20	21
TH-04-15	TVJ-D	1000x1000	2404-9250	TX/1000x1000	77	76	69	56	51	47	45	44	61	61	51	31	24	24	18	19
TH-07-16	TVJ-D	600x600	811-1632	TX/600x600	69	67	59	43	32	33	40	45	60	58	49	35	31	33	28	29
TH-07-17	TVJ-D	600x600	811-1632	TX/600x600	69	67	59	43	32	33	40	45	60	58	49	35	31	33	28	29
TH-05-18	TVJ-D	800x600	1082-4248	TX/800x600	75	74	65	52	47	43	41	42	60	59	48	30	25	24	19	20
TH-05-19	TVJ-D	800x600	1082-4248	TX/800x600	75	74	65	52	47	43	41	42	60	59	48	30	25	24	19	20
TH-03-20	TVE	100	4-14		53	46	40	41	41	35	24	16	23	17	14	21	23	25	14	14
TH-03-21	TVE	160	10-97		63	54	50	43	42	43	29	22	33	25	26	22	23	27	15	14
TH-03-22	TVE	160	10-128		65	57	51	42	42	43	29	22	35	28	28	22	23	27	15	14
TH-03-23	TV-E	200	16-221		70	56	52	49	46	44	36	29	44	30	31	29	27	28	22	18
TH-03-24	TV-E	200	16-221		70	56	52	49	46	44	36	29	44	30	31	29	27	28	22	18
TH-03-25	TVE	100	4-20		56	51	44	44	43	37	28	19	26	22	17	23	25	27	17	14
TH-04-26	TVE	100	4-31		59	57	48	47	44	40	31	22	29	28	22	26	26	30	21	14
WH-00-01	TVJ-D	800x800	1502-5000	TX/800x800	75	74	67	51	45	42	41	44	62	60	51	33	27	27	22	23
WH-00-02	TVJ-D	600x600	811-1650	TX/600x600	69	67	60	43	32	33	40	45	60	58	49	35	31	33	28	29
WH-02-03	TVE	250	25-280	CS050/250x1000	63	53	41	28	18	31	29	24	41	32	29	30	29	34	25	21
WH-02-04	TVE	250	25-280	CS050/250x1000	63	53	41	28	18	31	29	24	41	32	29	30	29	34	25	21
WH-02-05	TV-E	160	10-138		66	58	54	49	47	45	37	30	37	30	31	29	29	29	23	18
WH-02-06	TV-E	100	4-35		60	58	50	47	45	41	32	23	30	29	23	27	27	31	22	15
WH-03-07	TA-Silenzio	250	75-480		63	55	49	37	27	20	19	23	61	58	46	38	30	25	20	15
WH-03-08	TZ-Silenzio	315	126-600		63	55	47	37	29	23	24	28	63	59	46	37	30	25	20	16
WH-04-09	TZ-Silenzio	315	126-821		66	59	51	41	36	29	27	31	67	63	49	40	32	26	22	18
WH-04-10	TA-Silenzio	315	126-684		62	55	49	37	28	19	22	25	65	61	47	38	31	25	21	17
WH-04-11	TZ-Silenzio	315	126-668		64	57	49	39	31	25	25	29	65	60	47	38	31	25	21	17
WH-04-12	TA-Silenzio	250	75-563		65	57	51	39	30	24	22	24	63	60	48	39	31	25	21	16
WH-05-14	TA-Silenzio	315	126-684		62	55	49	37	28	19	22	25	65	61	47	38	31	25	21	17
WH-05-13	TZ-Silenzio	315	126-684		64	57	49	39	32	25	25	29	65	61	47	38	31	25	21	17
WH-06-16	TA-Silenzio	315	126-900		64	58	52	40	32	26	26	28	68	64	50	40	33	27	22	18
WH-06-15	TZ-Silenzio	315	126-900		67	60	52	42	37	31	28	31	68	64	50	40	33	27	22	18
WH-06-17	TVE	200	16-250		73	59	55	53	51	48	41	34	46	33	34	33	32	32	27	22
WH-06-18	TVE	200	16-250		73	59	55	53	51	48	41	34	46	33	34	33	32	32	27	22
WH-05-19	TVJ-D	500x500	545-1140	TX/500x500	67	65	57	42	31	32	39	44	59	57	47	34	31	32	28	29
WH-05-20	TVJ-D	500x500	545-1140	TX/500x500	67	65	57	42	31	32	39	44	59	57	47	34	31	32	28	29

VAV NOISE LEVELS			LpA	63	125	250	500	1k	2k	4k	8k		
			dB(A)	dB	dB	dB	dB	dB	dB	dB	dB	NR req	NR
Back Stalls Extract	TH-04-01	TVJ-D	8	33	16	-22	-39	-53	-50	-33	-21	25	0
Foyer 3 Extract	TH-04-02	TVJ-D	24	47	37	13	-12	-32	-31	-12	3	40	17
Foyer 3 Supply	TH-04-03	TV-J-D-	27	44	42	27	3	-18	-21	-7	4	40	23
Foyer 3 Supply	TH-04-04	TV-J-D-	27	44	42	27	3	-18	-21	-7	4	40	23
Balcony Seats	TH-04-05	TV-J-D-	6	30	17	-21	-43	-76	-73	-39	-20	25	0
Balcony Seats	TH-04-06	TV-J-D-	6	30	17	-21	-43	-76	-73	-39	-20	25	0
Rear Stalls South	TH-04-07	TZ-Silenzio-D	14	40	15	-42	-62	-90	-91	-59	-38	25	6
Rear Stalls Mid South	TH-04-08	TZ-Silenzio-D	19	44	30	-2	-23	-45	-60	-41	-22	25	11
Rear Stalls Centre	TH-04-09	TZ-Silenzio-D	19	44	30	-2	-23	-45	-60	-41	-22	25	11
Rear Stalls Mid North	TH-04-10	TZ-Silenzio-D	19	44	30	-2	-23	-45	-60	-41	-22	25	11
Rear Stalls North	TH-04-11	TZ-Silenzio-D	19	44	30	-2	-23	-45	-60	-41	-22	25	11
Foyer 2 Supply	TH-04-12	TV-J-D-	27	44	42	29	3	-22	-22	-5	6	40	23
Foyer 2 Supply	TH-04-13	TV-J-D-	27	44	42	29	3	-22	-22	-5	6	40	23
Foyer 2 Extract	TH-04-14	TVJ-D	24	47	37	12	-10	-28	-28	-13	-1	40	17
Front Stalls Extract	TH-04-15	TVJ-D	14	39	22	-14	-33	-47	-45	-27	-15	25	4
Back Stalls Supply	TH-07-16	TVJ-D	10	34	21	-9	-45	-69	-53	-23	-9	25	0
Back Stalls Supply	TH-07-17	TVJ-D	7	31	18	-12	-48	-72	-56	-26	-12	25	0
Front Stalls Supply	TH-05-18	TVJ-D	10	33	23	-4	-35	-53	-42	-21	-11	25	1
Front Stalls Supply	TH-05-19	TVJ-D	10	33	23	-4	-35	-53	-42	-21	-11	25	1
TH Dis WC	TH-03-20	TVE	42	51	44	38	39	39	33	22	14	40	39
Urinal room	TH-03-21	TVE	43	57	48	44	37	36	37	23	16	40	40
TH Male WC	TH-03-22	TVE	41	56	48	42	33	33	34	20	13	40	37
TH Female WC	TH-03-23	TV-E-	44	61	47	43	40	37	35	27	20	40	38
TH Female WC	TH-03-24	TV-E-	44	61	47	43	40	37	35	27	20	40	38
Cleaners store	TH-03-25	TVE	46	55	50	43	43	42	36	27	18	50	42
AWC 436	TH-04-26	TVE	45	54	52	43	42	39	35	26	17	40	39
WH Foyer Supply	WH-00-01	TVJ-D	26	50	38	2	-24	-51	-53	-24	-5	40	19
Storage Buffer Supply	WH-00-02	TVJ-D	32	49	47	35	8	-18	-17	2	14	50	29
Loading bay Supply	WH-02-03	TVE	26	49	38	22	-5	-24	3	9	5	45	19
Loading bay Extract	WH-02-04	TVE	21	44	33	17	-10	-29	-2	4	0	45	13
Workshop Supply	WH-02-05	TV-E	38	51	43	39	34	32	30	22	15	45	33
Workshop Extract	WH-02-06	TV-E	38	48	46	38	35	33	29	20	11	45	33
Greenroom Extract	WH-03-07	TA-Silenzio	17	40	30	8	-16	-35	-45	-34	-18	35	9
Greenroom Supply	WH-03-08	TZ-Silenzio	19	42	33	6	-12	-25	-34	-22	-9	35	12
Level 04 North Supply	WH-04-09	TZ-Silenzio	41	60	55	40	31	23	17	13	10	40	37
Level 04 North Extract	WH-04-10	TA-Silenzio	36	55	50	35	26	19	13	9	6	40	32
Level 04 South Supply	WH-04-11	TZ-Silenzio	31	51	45	31	22	15	9	5	2	40	26
Level 04 South Extract	WH-04-12	TA-Silenzio	31	49	44	32	23	15	9	5	0	40	26
Level 05 North Supply	WH-05-14	TA-Silenzio	31	50	45	31	22	15	9	5	1	40	27
Level 05 North Extract	WH-05-13	TZ-Silenzio	32	51	45	31	22	15	9	5	2	40	27
Level 06 meeting	WH-06-16	TA-Silenzio	31	49	45	30	20	13	7	2	-1	30	26
Level 06 meeting	WH-06-15	TZ-Silenzio	36	56	50	35	25	18	12	7	5	30	33
Level 06 meeting	WH-06-17	TVE	27	53	32	13	13	2	14	12	8	30	22
Level 06 meeting	WH-06-18	TVE	40	57	43	39	37	35	32	25	18	30	35
Level 05 South Supply	WH-05-19	TVJ-D	29	45	43	30	16	13	14	10	11	40	24
Level 05 South Extract	WH-05-20	TVJ-D	35	51	48	36	21	18	19	15	17	40	31

Additional sound attenuators:

WH-06-15:

Frequency [Hz]	63	125	250	500	1k	2k	4k	8k
Insertion loss [dB]	1	4	7	8	7	5	4	5

WH-06-18:

Frequency [Hz]	63	125	250	500	1k	2k	4k	8k
Insertion loss [dB]	1	1	3	6	11	6	1	2

Annex L: CAV Units

Schedule ref: MF-BDP-ZZ-ZZ-SH-M-68-0027 Rev. C07

SOUND POWER LEVELS

THE FACTORY CAV REVISION OCT2			air-generated noise, SWL								case-radiated noise, SWL							
type	l/s		63 dB	125 dB	2590 dB	500 dB	1k dB	2k dB	4k dB	8k dB	63 dB	125 dB	2590 dB	500 dB	1k dB	2k dB	4k dB	8k dB
TH-02-02	RN/100	48	55	52	39	25	14	14	14	14	29	30	24	31	30	31	23	17
TH-02-03	RN/100	48	55	52	39	25	14	14	14	14	29	30	24	31	30	31	23	17
WH-00-01	EN/600x600	2420	68	61	57	60	60	58	52	45	64	56	53	51	47	42	36	35
WH-02-02	RN/100	24	57	51	43	40	34	30	24	16	28	25	18	25	23	24	19	14
WH-02-03	RN/100	25	58	52	44	40	35	30	25	17	28	25	18	26	23	25	19	14
WH-02-04	RN/200	119	59	51	43	42	42	43	40	34	41	37	31	30	31	34	33	27
WH-02-06	RN/100	32	58	54	46	43	37	33	26	19	29	27	21	28	26	27	20	14
WH-03-07	RN/200	110	59	50	42	42	42	42	39	33	40	36	30	29	31	34	33	27
WH-04-08	RN/250	230	58	51	46	46	44	45	41	34	41	38	34	34	33	37	35	28
WH-04-09	RN/250	230	58	51	46	46	44	45	41	34	41	38	34	34	33	37	35	28
WH-04-10	RN/250	210	57	50	45	45	44	45	41	33	40	36	34	33	32	36	34	27
WH-04-11	RN/160	66	57	54	46	42	39	38	31	25	35	34	29	27	32	32	25	23
WH-04-12	RN/315	348	56	53	49	46	48	49	42	33	41	41	38	34	37	40	35	26
WH-04-13	RN/200	105	58	50	42	41	41	42	39	33	40	35	29	29	30	33	32	26
WH-04-14	RN/200	105	58	50	42	41	41	42	39	33	40	35	29	29	30	33	32	26
WH-04-15	RN/250	168	54	46	43	43	42	43	39	32	37	33	32	31	31	35	32	25
WH-03-16	RN/200	111	59	51	42	42	42	42	39	33	40	36	30	29	31	34	33	27
WH-05-17	EN/300x200	176	61	49	47	47	48	47	41	33	58	44	43	38	35	31	25	22
WH-05-18	EN/300x100	93	50	52	42	41	43	43	39	31	47	48	38	33	31	28	24	21
WH-06-19	RN/125	49	58	56	47	44	39	33	28	24	36	31	23	25	22	19	18	17
WH-04-20	RN/160	96	60	58	49	46	43	41	34	28	38	37	33	30	36	35	28	26
WH-07-21	RN/100	30	58	53	46	42	37	32	26	18	28	27	20	27	25	27	20	14
WH-06-22	RN/160	72	58	55	46	43	40	39	32	25	35	34	29	27	33	33	26	24
WH-06-23	RN/160	76	58	55	47	43	40	39	33	26	36	35	30	28	33	33	26	24
WH-02-24	RN/125	48	58	55	47	43	39	33	28	24	35	34	29	27	32	32	25	23
WH-04-25	RN/160	66	57	54	46	42	39	38	31	25	35	34	29	27	32	32	25	23

CAV noise levels			LpA	63	125	250	500	1k	2k	4k	8k	NR	NR req
			dB(A)	dB	dB	dB	dB	dB	dB	dB	dB		
Level 2 Control room	TH-02-02	RN/100	26	40	35	18	19	18	19	11	5	22	25
Level 5 Control room	TH-02-03	RN/100	24	39	34	16	18	17	18	10	4	21	25
Buffer Storage	WH-00-01	EN/600x600	46	51	43	40	42	41	39	33	27	42	45
Security	WH-02-02	RN/100	25	40	34	26	23	17	14	8	1	19	40
Dis WC	WH-02-03	RN/100	26	41	35	27	23	18	14	9	2	19	40
Stage WC/Shower	WH-02-04	RN/200	32	42	34	26	25	25	27	24	18	30	40
Equipment Room	WH-02-06	RN/100	28	41	37	29	26	20	17	10	3	22	45
3rd Floor Toilets	WH-03-07	RN/200	43	54	45	37	37	37	37	35	29	40	40
4th Floor Toilets	WH-04-08	RN/250	35	42	35	30	30	28	29	26	19	32	40
4th Floor Toilets	WH-04-09	RN/250	42	49	42	37	37	35	36	33	26	39	40
Showers/WC 408&409	WH-04-10	RN/250	36	43	36	31	31	30	31	27	20	34	40
Acc. Bathroom 414	WH-04-11	RN/160	43	53	50	42	39	36	35	28	24	38	40
Shower/WC's & Lounge	WH-04-12	RN/315	40	42	39	35	32	34	35	28	19	38	40
Shower/WC 417	WH-04-13	RN/200	37	47	39	31	30	30	31	28	22	34	40
Shower/WC 416	WH-04-14	RN/200	34	44	36	28	28	28	29	26	20	32	40
Shower/WC 416/417	WH-04-15	RN/250	35	40	32	30	30	29	30	26	19	33	40
3rd Floor Toilets	WH-03-16	RN/200	35	45	37	29	28	29	29	26	20	32	40
5th & 6th Floor Toilets	WH-05-17	EN/300x200	42	52	39	37	37	37	36	30	22	39	40
5th Floor Toilets	WH-05-18	EN/300x100	42	46	47	37	35	37	37	33	25	40	40
6th Floor Toilets	WH-06-19	RN/125	40	52	50	41	38	33	27	23	19	34	40
Bathroom 422 & 423	WH-04-20	RN/160	46	59	56	44	41	39	38	31	29	41	40
Level 7 toilets	WH-07-21	RN/100	39	52	47	40	36	31	27	21	14	32	40
Crew room	WH-06-22	RN/160	37	47	44	35	33	30	29	22	17	32	40
Crew room	WH-06-23	RN/160	37	47	44	36	33	30	29	23	18	32	40
Stage WC/Shower	WH-02-24	RN/125	40	52	49	41	37	33	29	23	20	33	40
Dressing room 407	WH-04-25	RN/160	41	52	49	41	37	35	34	27	22	37	40

Annex M: Chiller specifications

Schedule reference: MF-BDP-ZZ-ZZ-SH-M-68-0013 Rev. C02
See also section 8.1.



REF:	E22139 Chillers	REV:	9.0	Date:	22/01/2020
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Required equipment specification

Three machines are required to meet target specification as follows:

Ref	Chiller Ref	Duty kW	Evap H ₂ O °C	Cond. H ₂ O °C	dB SPL @1m	Max Length	EER	ESEER	SEER
R134a	CH-WH-L6-01 CH-WH-L6-02 CH-WH-L6-03	545	7/12	42/48 20% GLY	-	2910	3.84	8.34	-

Equipment Selected



We have selected the following Mitsubishi machines which have the following headline specification.

Ref	Model	Duty kW	Evap H ₂ O °C	Cond. H ₂ O °C	Sound Power	Length	EER	ESEER	SEER
CH-WH-L6-01 CH-WH-L6-02 CH-WH-L6-03	TX-W / 2A00	545	7/12	42/48 20% GLY	81dB attenuated	2910	3.96	8.59	

Detailed Specifications Chiller – TX-W / 2A00

Code	TX-W /2A00	
Version		
Size	2A00	
UNIT DESCRIPTION	High efficiency water cooled chiller	
Power supply	V/ph/Hz	400/3/50
Note Certified in accordance with the AHRI Water-Cooled Water-Chilling and Heat Pump Water-Heating Packages Certification Program, which is based on AHRI Standard 550/590 (I-P). Certified units may be found in the AHRI Directory at www.ahridirectory.org		
PERFORMANCE AT DESIGNED CONDITIONS		
RUNNING CONDITIONS		
HEAT EXCHANGER USER SIDE		
Fluid inlet temperature (cooling mode)	°C	12.00
Fluid outlet temperature (cooling mode)	°C	7.00
Fluid type		WATER
Glycol	%	0
Fouling factor	m²K/kW	0.000
HEAT EXCHANGER SOURCE SIDE		
Fluid inlet temperature (cooling mode)	°C	42.00
Fluid outlet temperature (cooling mode)	°C	48.00
Fluid		ETHYLENE GLYCOL
Glycol	%	20
Fouling factor	m²K/kW	0.000
COOLING (EN 14511)		
Capacity control	%	83.9
Cooling capacity	kW	545.0
Compressors power input	kW	135.0
Total power input	kW	137.6
EER	kW/kW	3.960
ESEER EN 14511 (referiment)	kW/kW	8.590
Cooling energy class		A
Note *Unit selected at DIFFERENT compressor speed rotation from nominal one.		
COOLING MODE (EN14511) - MAX PERFORMANCE		
Cooling capacity	kW	649.6
Compressors power input	kW	173.0
Total power input	kW	177.0
EER	kW/kW	3.670
SEER		
SEER Official (Reg. EU 2016/2281)		
Fan coil (12/7) - Cooling tower (30/35)		
Type climate		Average
Temp. Plant side		Fan coil (12/7)
Temp. Source side		Cooling tower (30/35)
Type flow		Fixed
Type Temperature		Variable
Prated,c	kW	526
T Design		35.00
Qce		35446.77
SEER		8.90
Performance ns	%	348

EFFICIENCIES

ESEER (EN 14511 VALUE)

Load	%	100	75	50	25
Temp. evaporator inlet	°C	12.00	10.75	9.51	8.26
Temp. evaporator outlet	°C	7.00	7.00	7.00	7.00
Evaporator water flow	l/s	28.60	28.60	28.60	28.60
Condenser input temperature	°C	30.00	26.00	22.00	18.00
Condenser output temperature	°C	35.00	29.63	24.36	19.15
Condenser fluid flow	l/s	33.43	33.43	33.43	33.43
Cooling capacity	kW	596.6	447.4	298.3	149.1
Total power input	kW	106.3	63.50	33.60	13.90
EER	kW/kW	5.610	7.050	8.870	10.70
ESEER EN14511 CALCULATED	kW/kW			8.590	
ESEER	kW/kW			8.870	

PART LOAD DATA

COOLING PARTIAL LOADS

Load	%	100.0	90.0	80.0	70.0	60.0	50.0	40.0	30.0	20.0	10.0
Temp. evaporator inlet	°C	12.00	11.50	11.00	10.50	10.00	9.51	9.01	8.76	8.76	8.76
Temp. evaporator outlet	°C	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Evaporator water flow	l/s	26.12	26.12	26.12	26.12	26.12	26.12	26.12	26.12	26.12	26.12
Pressure drop	kPa	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1
Condenser input temperature	°C	42.00	42.61	43.21	43.81	44.41	45.01	45.59	45.87	45.87	45.87
Condenser output temperature	°C	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00
Condenser fluid flow	l/s	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Pressure drop	kPa	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
Cooling load	kWh	545	491	436	382	327	273	218	164	109	55
Total power input	kW	137.5	123.1	109.4	95.60	81.90	68.20	56.50	44.30	31.20	18.20
EER	kW/kW	3.960	3.980	3.990	3.990	3.990	4.000	3.860	3.690	3.490	3.000

EXCHANGERS

HEAT EXCHANGER USER SIDE

Typology		FLOODED
Quantity	N°	1
Fluid type		WATER
Glycol	%	0
Fouling factor	m²K/kW	0.000
Type of connections		VICTAULIC
Diameter of connections		5"
Min flow	l/s	18.61
Max flow	l/s	45.83
K pressure drop		2.95
Water content	l	132

COOLING

Fluid inlet temperature (cooling mode)	°C	12.00
Fluid outlet temperature (cooling mode)	°C	7.00
Water flow	l/s	26.12
Pressure drop	kPa	26.1
Available unit's head	kPa	0.00

HEAT EXCHANGER SOURCE SIDE

Typology		FLOODED
Quantity	N°	1
Fluid		ETHYLENE GLYCOL
Glycol	%	20
Fouling factor	m²K/kW	0.000
Type of connections		VICTAULIC
Diameter of connections		5"
Min flow	l/s	21.11
Max flow	l/s	53.33
K pressure drop		2.25
Water content	l	152

COOLING

Fluid inlet temperature (cooling mode)	°C	42.00
Fluid outlet temperature (cooling mode)	°C	48.00
Water flow	l/s	28.41
Pressure drop	kPa	26.7
Available unit's head	kPa	0.00

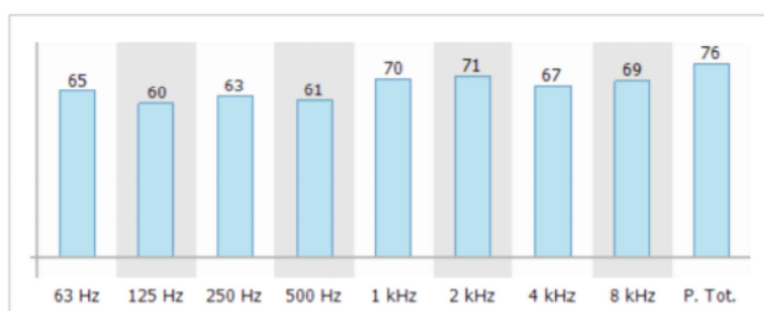
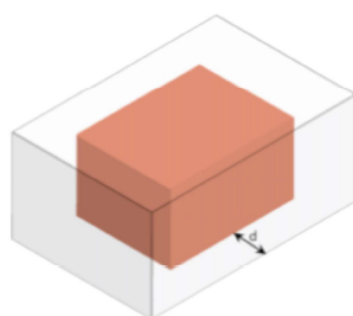
COMPRESSORS

Compressor type		CENTRIFUGAL
Compressors nr.	N°	2
No. Circuits	N°	1
Refrigerant		R134a
Number of capacity steps	N°	0
Min. capacity step	%	
Regulation		STEPLESS
Oil charge	kg	0.00
Refrigerant charge	kg	273
F.L.I. - Max absorbed power	kW	2x102
F.L.A. - Max absorbed current	A	2x160
L.R.A. - Locked rotor amperes for single compressor	A	n.a.

NOISE DATA

SOUND DATA COLD

Frequencies	Hz	63	125	250	500	1000	2000	4000	8000	Tot (A)
Sound power (spectrum)	dB	84	79	82	80	89	90	86	88	95
Sound pressure level (spectrum)	dB	65	60	63	61	70	71	67	69	76



Note

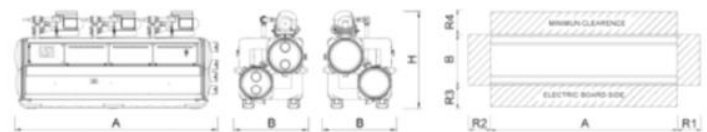
Distance	m	1
Note	Average sound pressure level at 1 m distance, unit in a free field on a reflective surface; non-binding value calculated from the sound power level; Sound power on the basis of measurements made in compliance with ISO 9614.	

ELECTRICAL DATA

Power supply	V/ph/Hz	400/3/50
F.L.I. - Max absorbed power	kW	204.0
F.L.A. - Max absorbed current	A	320
S.A. - Inrush current	A	-

WEIGHT & DIMENSIONS

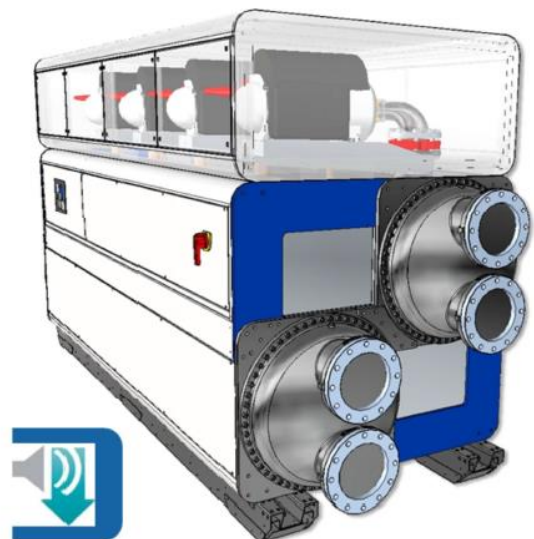
A	mm	2910
B	mm	1560
H	mm	2190
Operating weight	kg	4070
R1	mm	1000
R2	mm	2500
R3	mm	1500
R4	mm	1000



Noise Attenuation to meet $L_pA=81dB$

Options supplied

A314	CLIMAVENETA BRAND
321	400V 3ph 50Hz Phase Power
1016	Manufactured with PED Regulations
6171	Demand Limiting Input
3451	EMC Compliance For Residential App.
1281	2 Water Pass Condenser
1200	STANDARD CONDENSER
1380	WITHOUT 3 WAY VALVE
1410	WITHOUT MODULATING VALVE
2681	EVAP. RIGHT - COND. RIGHT CONN.
2691	Heat Exchangers in Diagonal Configuration
1246	WITH MODULATING SIGNAL 0-10V
1961	Dual Pressure Relief Valves
381	Numbered Wiring in Electrical Panel
3302	Compressor Power Factor Correction 0.95 Lagging
4181	Serial Communications Card For Modbus
6162	Remote Input Signal to Activate a Second Chilled Water Set-point
6197	13" Touch Screen Controls User Interface
3352	WITH VPF SYSTEM (SIG. 0-10V)
3432	Refrigerant Leak Detector and Migration "Pumpdown"
1801	Chilled Water Flow Switch (supplied loose)
2401	Evaporator Electric Trace Heater
2101	High Efficiency Anti-vibration Mounts
2313	Integral Acoustic Enclosure With 30mm Thick Attenuating Material
X111	Warranty to February 2023
	Delivery to Site
	Commissioning



Annex N: Dry coolers

Schedule reference: MF-BDP-ZZ-ZZ-SH-M-68-0012 rev. C03)

Technical specifications:

Required equipment specification

Four machines are required to meet target specification as follows:

Ref	Chiller Ref	Duty kW	Ambient °C	H ₂ O °C	Sound PWR	dB SPL @10m	Max Length
R134a	DAC-WH-L8-01 to 04	585	30	42/48 20% GLY	71	-	6,490

Equipment Selected



We have selected the following Thermokey machines which have the following headline specification.

Ref	Model	Duty kW	Amb.°C	H ₂ O °C	Sound PWR	dB SPL @1m	Length
DAC-WH-L8-01 to 04	SJGR2590.B5/04 Q2EAF(EC)S	585	30	42/48 20%Gly	71	48	6,490

TECHNICAL DATA

DRY COOLER (5) SJGR2590.B5/04 Q2EAF(EC)\$

Number of circuits

84



PERFORMANCE (SINGLE UNIT)

Requested Capacity	585.00kW	Ratio	0.4%
Real Capacity	587.40kW		

TUBE SIDE

Fluid (10)	ETHYLENE GLYCOL 20%		
Inlet Fluid Temp.	48.0°C	Outlet Fluid Temp.	42.0°C
Fluid flow rate	87.37m³/h	Fluid Velocity	1.4m/s
Massic Fluid Flow	88658kg/h	Pressure drops	46kPa

AIR SIDE

Inlet Air Temp. [MAX]	30.0°C	Outlet Air Temp.	44.6°C
Inlet relative hum.	40.0%	Outlet relative hum.	18.0%
		Altitude	0m
		ESP	0.0Pa
		Flow Direction	N/A
Air Flow	122460m³/h	Air Velocity	1.21m/s

FANS TECHNICAL DATA

ERP	Yes	UL	Yes
Fan Number	10N°	Fan Diameter	910mm
Phases-Voltage-Frequency	3-400-50N°/Volt/Hz	Fan type	34050R91ECB2C
Rpm [Nominal data]	570Rpm	Link	EC
Power x 1 [Nominal data]	680Watt	Current x 1 [Nominal data] (1)	1.28A
Rpm [Working point]	417Rpm	Rpm rate [working point / nominal]	73%
Power x 1 [Working point]	215Watt	Current x 1 [Working point] (1)	0.49A
Total Power x n° [Working point]/ [Nominal data]	2150/6800Watt	Total Current x n° [Working point]/ [Nominal data]	4.90/12.80A

Efficiency Energy Class:nominal calculation Water 40-35°C/Air 25°C

D Efficiency Energy Class:calculation on the working point **A+**

FANS NOISE DATA (7)

Sound Pressure Level (4) [Working point]	38dB(A)	Sound Power Level (4) [Working point]	71dB(A)
At the distance of	10m	in accordance with EN 13487/EN ISO 3744 (7)	

HEAT EXCHANGER DATA (3)

Fin Material (2)	AFS fin Turbo	Tubes Material	Copper
Fin Spacing	2.5mm	Internal Volume	448.0dm³
Fin Thickness	0.1mm	Casing material	Galvanized steel painted
Surface	2222.0m²	Number of passes	4
Inlet Connection	2x4"	Connections	Same side
Outlet Connection	2x4"	Fluid Category	Group 2
Max Pressure Design	10 bar		

DIMENSIONS AND WEIGHT (3)

Length	6490mm	Weight (3)	3111kg
Width	2400mm	Number of fixing point	12
Height	2862mm	LDM (Approximate data)	6.49m

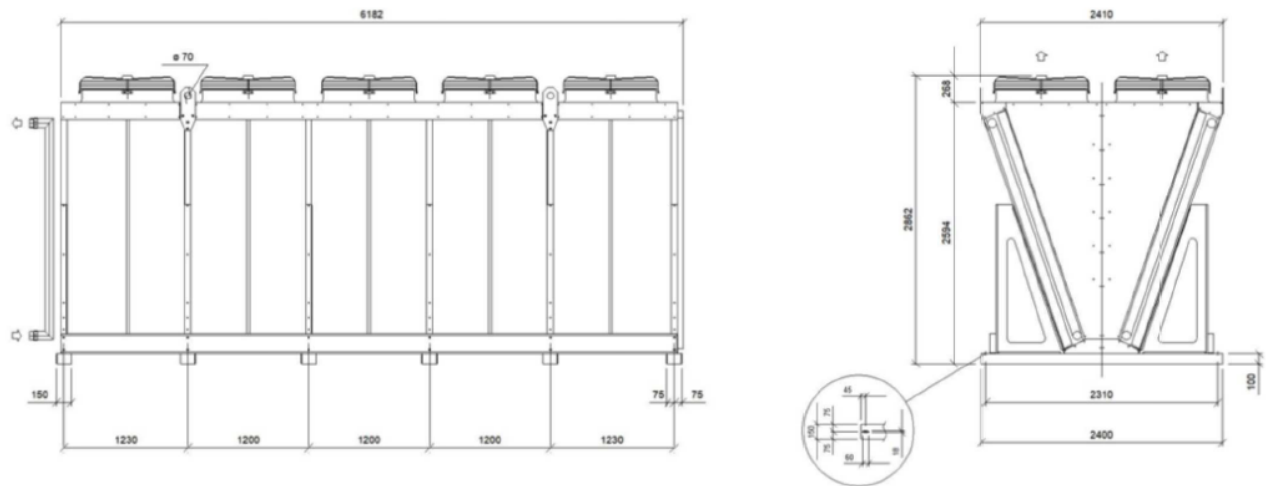
SOUND POWER LEVEL

	Tot.	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Δ [dB(A)]	56	40	43	47	51	51	48	47	37

Data refers to one fan. IMPORTANT: the tolerance in any single octave band is +/-5dB. The tolerance in the overall dB(A) level is +/- 2dB.

In case of AC fans working point is defined by fan supplier in nominal curve (delta or star). In case of EC fans is simulated on working point of unit.

Proposed Drawing



Annex O: Emergency generator specs

Reference: MF-CHT-XX-XXTS-E-01-0002, date 30-4-2020

Following acoustically relevant info is extracted from "MF-CHT-XX-XXTS-E-01-0002", date 30-4-2020

Generator Set Summary

Model:	FG Wilson P250-5
Engine Type:	Perkins® 1506A- E88TAG2, 6 Cylinders
Alternator Type:	Marelli MJB250LB4
Approximate Dimensions:	3975mm L x 1410mm W x 1779mm H (3200kg) Fuel
Consumption:	46.9 Litres Per Hour at 100% Load (MJB)
Tank Capacity:	CALG - 530 Litres
Prime/Continuous:	230 kVA / 184 kW
Emergency/Standby:	250 kVA / 200 kW
Rating:	3 Phase, 400/230 Volts, 50 Hz, 1500 RPM at 0.8 Power Factor
Noise Levels:	76 dBA at 1 Metre in Free field conditions

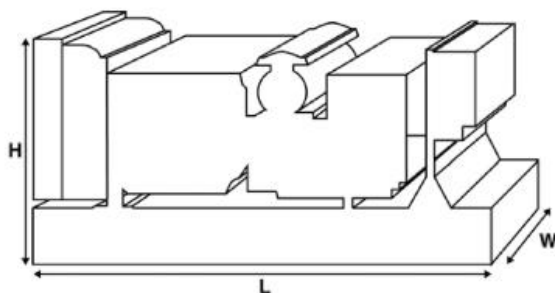
P250-5

Output Ratings

Voltage, Frequency		Prime	Standby
400/230V, 50 Hz	kVA	230	250
	kW	184	200
480/277V, 60 Hz	kVA		
	kW		

Ratings at 0.8 power factor.

Please refer to the output ratings technical data section for specific generator set outputs per voltage.



Dimensions and Weights

Length	mm	2662 (104.8)
Width	mm	1071 (42.2)
Height	mm	1818 (71.6)
Weight (Dry)	kg	2063 (4548)
Weight (Wet)	kg	2096 (4621)

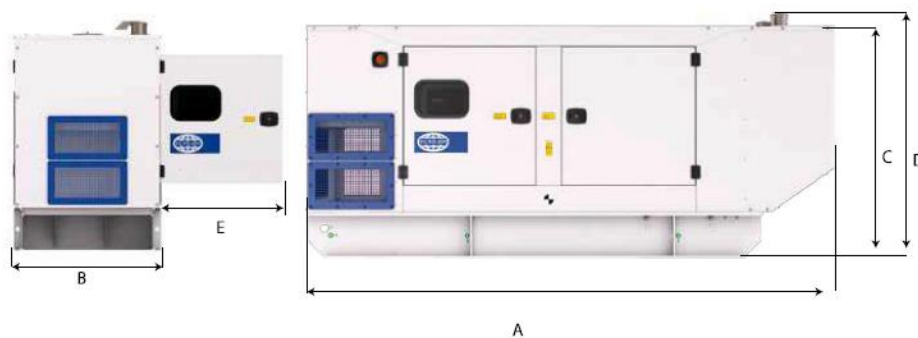
Ratings in accordance with ISO 8528, ISO 3046, IEC 60034, BS5000 and NEMA MG-1.22.
Generator set pictured may include optional accessories.

Engine Technical Data

No. of Cylinders		6
Alignment		IN LINE
Cycle		4 STROKE
Bore	mm (in)	112 (4.4)
Stroke	mm (in)	149 (5.9)
Induction		TURBOCHARGED AIR TO AIR CHARGE COOLED
Cooling Method		WATER
Governing Type		ELECTRONIC
Governing Class		ISO 8528 G2
Compression Ratio		16.1:1
Displacement	L (cu. in)	8.8 (537)
Moment of Inertia:	kg m ² (lb/in ²)	2.4031 (8212)
Voltage		24
Ground		Negative
Battery Charger Amps		45
Engine Weight Dry	kg (lb)	778 (1715)
Engine Weight Wet	kg (lb)	800 (1764)

Sound Pressure Levels (dBA) for Level 2 Enclosure

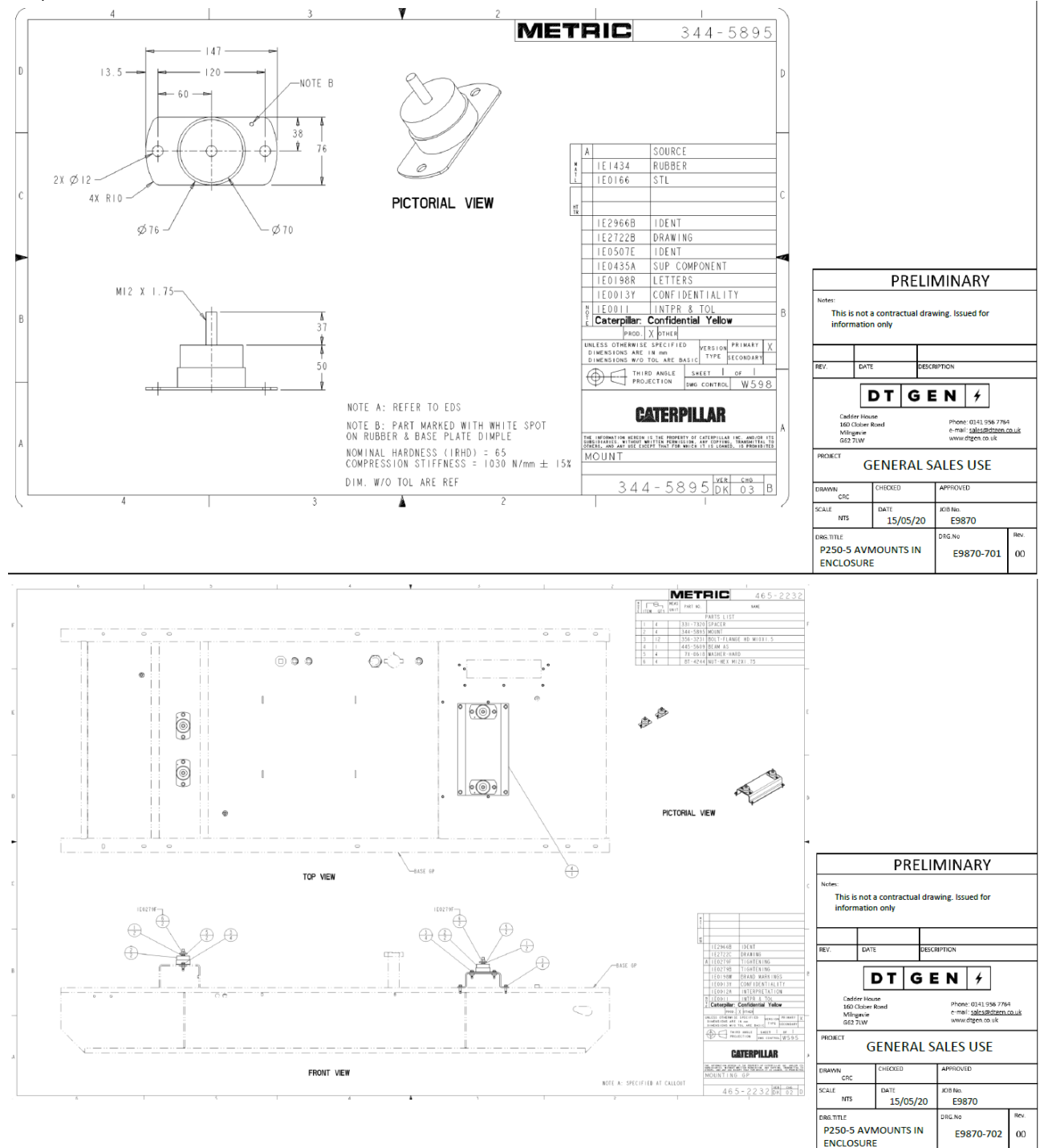
		50 Hz						Ambient Capability °C
Generator Set Model		15 m (50 ft)		7 m (23 ft)		1 m (3 ft)		
		75% Load	100% Load	75% Load	100% Load	75% Load	100% Load	
P250-5	Prime/ standby	61/61	62/62	67/67	68/68	75/75	76/76	49



Dimensions and Weights for Level 2 Enclosure

Generator Set Model	A: mm	B: mm	C: mm	D: mm	E*: mm	Weight: kg	Fuel Capacity: l
P250-S	3975	1400	1950	2032	994	2810	542

Proposed AV-mount by supplier. Dynamic stiffness not mentioned, to be provided by supplier: $k_{dyn} \leq 1,6$ MN/m



From document "DTGen E9870 TS3 The Factory Manchester.pdf"

Genset Model: P250-5
 Engine Type : 1506A TAG3
 Frequency (Hz): 50
 L2

Average Sound Pressure Levels at 1m dB														Average Sound Pressure Levels at 7m dB														Average Sound Pressure Levels at 15m dB													
kVA	kWe	% Load	SB/PP	dBA	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dBA	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dBA	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz											
250	200	100.0	SB	78.3	93.0	88.9	81.0	73.0	69.6	66.1	61.5	57.8	70.0	90.8	79.1	71.9	65.2	59.2	55.4	52.9	48.6	64.0	84.8	73.1	65.9	59.2	53.2	49.4	46.9	42.6											
225	180	90.0		77.9	92.5	88.7	80.6	72.5	69.3	65.8	61.2	57.4	69.5	90.1	78.8	71.5	64.6	58.6	54.6	52.0	47.3	63.5	84.1	72.8	65.5	58.6	52.6	48.6	46.0	41.3											
200	160	80.0		77.6	92.1	88.5	80.3	72.0	69.1	65.5	61.0	56.8	69.0	89.3	78.6	71.1	64.0	58.0	53.9	51.1	46.1	63.0	83.3	72.6	65.1	58.0	52.0	47.9	45.1	40.1											
188	150	75.0		77.5	91.8	88.4	80.1	71.8	69.0	65.4	60.8	56.6	68.8	88.9	78.5	70.9	63.8	57.8	53.6	50.8	45.5	62.8	82.9	72.5	64.9	57.8	51.8	47.6	44.8	39.5											
175	140	70.0		77.3	91.5	88.3	80.0	71.6	68.8	65.2	60.7	56.3	68.5	88.4	78.3	70.7	63.5	57.6	53.3	50.4	45.0	62.5	82.4	72.3	64.7	57.5	51.6	47.3	44.4	39.0											
150	120	60.0		77.0	90.8	88.1	79.6	71.2	68.6	64.9	60.4	55.7	68.1	87.3	78.1	70.4	63.1	57.2	52.8	49.8	43.9	62.1	81.3	72.1	64.4	57.1	51.2	46.8	43.8	37.9											
125	100	50.0		76.7	90.1	87.9	79.4	70.8	68.4	64.6	60.0	55.1	67.6	86.2	77.9	70.1	62.7	56.8	52.3	49.2	43.0	61.6	80.2	71.9	64.1	56.7	50.8	46.3	43.2	37.0											
100	80	40.0		76.5	89.3	87.8	79.1	70.6	68.2	64.2	59.7	54.4	67.2	84.9	77.6	69.7	62.3	56.5	51.9	48.7	42.1	61.2	78.9	71.6	63.7	56.3	50.5	45.9	42.7	36.1											
75	60	30.0		76.2	88.4	87.6	78.8	70.3	67.9	63.9	59.3	53.7	66.8	83.5	77.4	69.4	62.0	56.4	51.6	48.4	41.3	60.8	77.5	71.4	63.4	56.0	50.4	45.6	42.4	35.3											
50	40	20.0		76.0	87.4	87.4	78.6	70.2	67.7	63.6	58.9	53.0	66.4	81.9	77.2	69.2	61.7	56.2	51.4	48.1	40.6	60.4	75.9	71.2	63.2	55.7	50.2	45.4	42.1	34.6											
25	20	10.0		75.8	86.3	87.2	78.4	70.0	67.5	63.2	58.4	52.2	66.0	80.2	76.9	68.9	61.5	56.2	51.3	47.9	39.9	60.0	74.2	70.9	62.9	55.5	50.2	45.3	41.9	33.9											

Annex P: DX Units

Reference: MF-BDP-ZZ-ZZ-SH-M-68-0015 C04

DX-unit SOUND POWER LEVELS				l/s	Inlet/Cased Radiated							
x						dB	dB	dB	dB	dB	dB	dB
TX room 023		CAS-AR-GF-01	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
arch 1 025		DX-AR-GF-01	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
TX room 023		CAS-AR-GF-02	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
arch 1 025		DX-AR-GF-02	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Metering room 026		CAS-WH-GF-03	PKA-M50KAL	150-200		42,4	40,6	46,8	46,7	47,6	44,2	36,3
arch 1 025		DX-WH-GF-03	PUZ-ZM50KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Main IT comms 205		CAS-WH-L2-01	PLA-ZM50EA	200-300		50,7	46,1	43,7	36,5	34,5	25,7	20,3
level 06		DX-WH-L6-09	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Main IT comms 205		CAS-WH-L2-02	PLA-ZM50EA	200-300		50,7	46,1	43,7	36,5	34,5	25,7	20,3
level 06		DX-WH-L6-07	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
equip 206		CAS-WH-L2-03	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-08	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Rack room 307		CAS-WH-L3-01	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-05	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Rack room 307		CAS-WH-L3-02	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-06	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Comms 508		CAS-WH-L5-01	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-03	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Comms 508		CAS-WH-L5-02	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-04	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Comms 608		CAS-WH-L6-01	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-01	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Comms 608		CAS-WH-L6-02	PKA-M100KAL	333-433		52,5	53,2	55,8	51,8	53	50,3	44,2
level 06		DX-WH-L6-02	PUZ-ZM100KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5
Comms room 707		CAS-WH-L7-01	PKA-M50KAL	150-200		42,4	40,6	46,8	46,7	47,6	44,2	36,3
level 08		DX-WH-L8-01	PUZ-ZM50KVAR1			62	61,8	60,8	56,8	53,5	49,1	43,5