

The Factory Manchester

Acoustic study noise emission

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Colophon

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Executed by: Level Acoustics & Vibration
Author(s): Susanne Bron-van der Jagt Dr., Theo Raijmakers MSc., Remy Wenmaekers Dr.
E-mail: info@levelav.nl
Telephone: +31 40 247 2700

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1 INTRODUCTION

Factory is the place for the creation of sound, and at the same time creation of silence. Serving both aspects in optima forma, and finding the right balance between the two, that is what the acoustic design of Factory is about. With the aural perception of the users and visitors always as the starting point.

Factory will be the home for very diverse types of productions, one after another or several at the same time. All in one space or “separated” from each other in the Theatre and the Warehouse.

The building is located west of the office building Bonded Warehouse and is spanning over Water Street. Figure 1 shows the site plan in context with the future surroundings. The future Riverside Tower 4 (called north tower in this report) and the north east tower (under construction) are new residential buildings. The future east tower will be a public/office building.

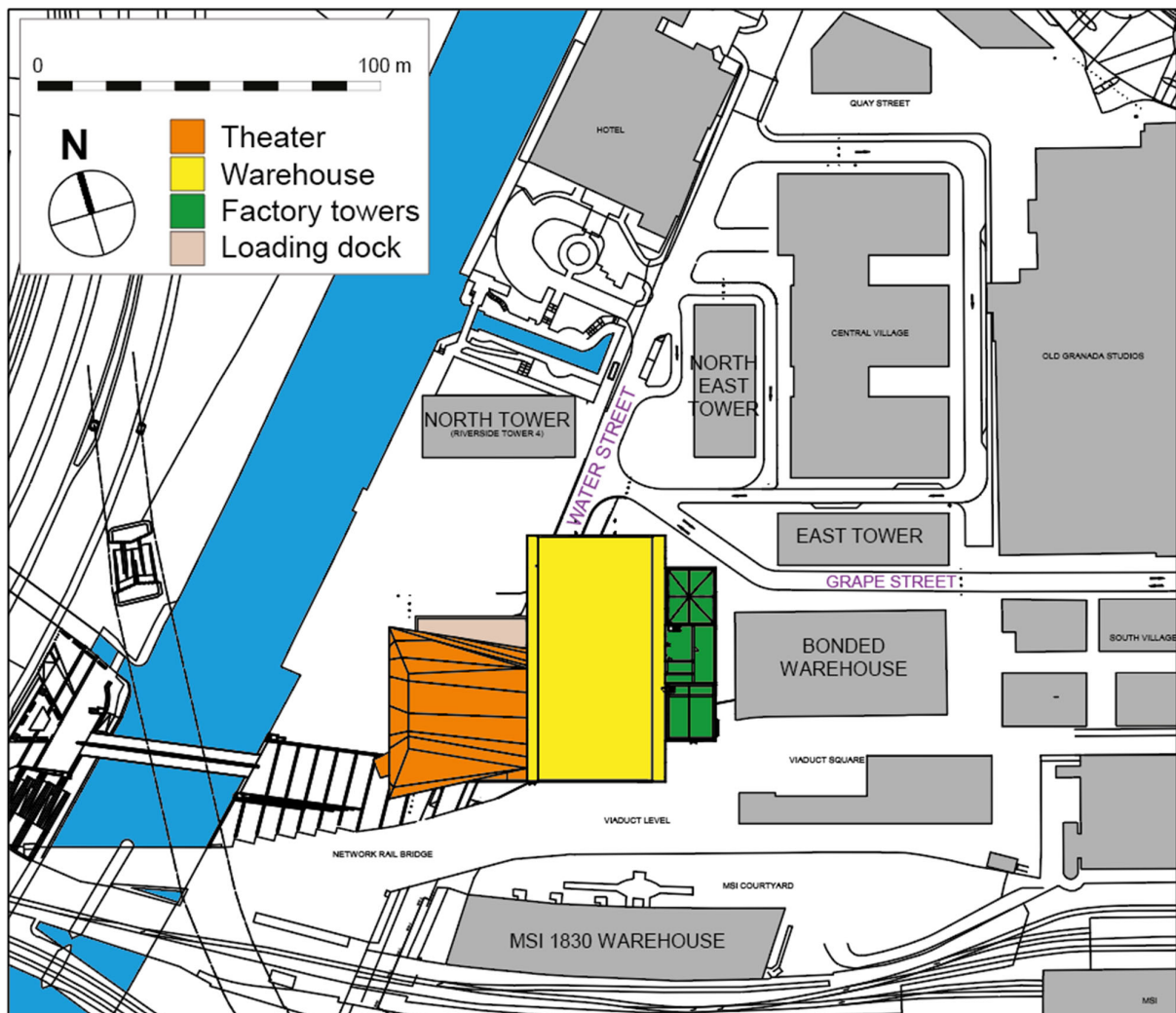


Figure 1: site plan in future context

2 ASSESSMENT CRITERIA

A key element of the design is to control noise breakout from The Factory to its surroundings, in particular towards nearby residential areas. The nearest proposed residential building is 23m from the venue's facade. The following criteria have therefore been set for amplified music and mechanical noise in The Factory in the previous stages of the project, by Arup and Sandy Brown consultants in conjunction with the MCC Environmental Protection Department.

2.1 Background noise levels in the area

Arup has performed a noise survey in order to determine background noise levels L_{A90} on the building site (Appendix B of "The Factory Stage 2 Acoustic Design Report", ref, R01_SJS, 8 April 2016). The outcome of this survey is:

- L_{A90} = 55 dBA during daytime (07:00-23:00)
- L_{A90} = 48 dBA during night-time (23:00-07:00).

These values also are included in section 9.51 of the Deloitte report "Factory, Manchester. Environmental Statement – Volume 1", October 2016.

2.2 Music

2.2.1 Low frequencies

Criteria for sound levels at facades of residential buildings are described in the Deloitte report "Factory, Manchester. Environmental Statement – Volume 1", October 2016.

From section 9.48 of this report:

Through consultation with MCC, it has been established that the Proposed Development should be designed so that low frequency sound emission within any dwelling does not exceed 47dBLeq in the 63Hz octave frequency band and 41dBLeq in the 125Hz band.

From appendix 9.4 of this report:

Arup met with Richard Knightley of the MCC Environmental Protection Department on 3 March 2016 and agreed the following criteria for dwellings with windows open for ventilation:

Music noise levels in the 63Hz and 125Hz octave centre frequency bands should be controlled so as not to exceed (in habitable rooms) 47dBLeq and 41dBLeq, respectively.

MCC does not specify a time period for the noise criteria, although Arup recommends that 5 minutes is appropriate.

The noise break out assessments have assumed all surrounding residential buildings (existing or proposed) are naturally ventilated. In the noise modelling calculations, an attenuation of 5dB through an open window at these low frequencies has been assumed. This is a conservative assumption as research has shown that the attenuation could be more than 5dB. This assumption provides a worst case noise intrusion and gives the design a small degree of safety in meeting the criteria.

The criteria for low frequency noise levels at residential façades are therefore 52dBLeq and 46dBLeq in the octave bands centred at 63Hz and 125Hz respectively. These are free-field noise levels with no façade correction applied.

The maximally allowed sound level on the façade of residential building (North Tower and North West Tower) is:

- $L_{eq} = 52$ dB for the 63 Hz octave band
- $L_{eq} = 46$ dB for the 125 Hz octave band

2.2.2 Overall noise level

In addition for residential buildings (North West Tower and North Tower) the overall A-weighted noise breakout level must be 10 dB below the background noise level (L_{A90}). Based on the environmental noise study referred to in section 2.1 this has led to the following criteria for the maximally allowed sound level at the façade of the North Tower and the North West Tower:

- Daytime (07.00-23.00h): $55 - 10 = 45$ dB(A);
- Night-time (23.00-07.00h): $48 - 10 = 38$ dB(A).

2.3 Mechanical noise

Also criteria are set for mechanical services noise. The overall A-weighted breakout noise level must be 5 dB below the background noise levels (L_{A90}) as mentioned in section 2.1. The criterium applies to residential apartment buildings and hotels which are the North West Tower and North Tower.

Based on the environmental noise study referred to in section 2.1 this has led to the following criteria for the maximally allowed breakout noise levels:

- $55 - 5 = 50$ dB L_{Aeq} during daytime (07.00-23.00h)
- $48 - 5 = 43$ dB L_{Aeq} during night-time (23.00-07.00h)

3 ENVIRONMENTAL NOISE MODELLING

To determine the required sound insulation of the building envelope, with which the mentioned criteria can be met, a 3D noise model of The Factory and its (future) surroundings has been made. For this, environmental noise modelling software Geonoise V2020.2 was used. With this software the sound radiation of music sound by all relevant façade, roof and ceiling parts of The Factory and the sound propagation through the environment towards the sound sensitive buildings in the direct vicinity of The Factory have been calculated. The calculation results have been compared with the assessment criteria. During the design process this has been done for various design alternatives. More detailed input data and the calculation results for the final design are described in the next sections. The calculations are in accordance with the international standard ISO 9613-2: 1996, "Attenuation of sound during propagation outdoors - Part 2: General method of calculation".

3.1 Geometry

Figure 2 shows the 3D model of The Factory (red), the residential towers (blue) and the office buildings (yellow).

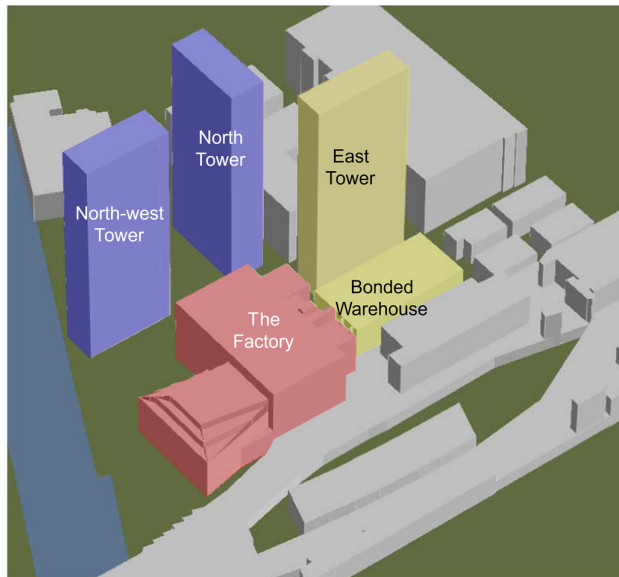


Figure 2: 3D noise model

4 SOUND SOURCES

The sound sources responsible for the sound emission of The Factory can be divided in three groups:

- Amplified music during events in the Theatre, the Warehouse and in the foyers
- Noise from MEP equipment
- Noise from emergency equipment (smoke fans and emergency generator).

4.1 Amplified music in the Theatre and the Warehouse

The Theatre and the Warehouse will be used for a wide variety of performances. In the most extreme case, three performances can take place at the same time. High sound levels up to 106 dB(A) are to be expected in each space, with a considerable amount of low frequency sound. The acoustic design has been based on the maximum internal sound production levels and spectra presented in table 1.

Table 1: Maximum sound levels for Warehouse and Theatre

Octave band mid frequency [Hz]	L _p octave band values [dB]								Sound level L _{pA} dB(A)
	63	125	250	500	1000	2000	4000	8000	
Warehouse	110	105	104	104	101	97	93	90	106
Theatre	100	100	104	104	101	97	93	90	106
Foyers	74	74	78	78	75	71	67	63	80

Simultaneous use of Theatre, Warehouse and foyers has been accounted for in the modelling.

Noise breakout of music via MEP ductwork has been calculated and if significant taken into account in the noise emission calculations regarding music sound.

4.1.1 Background music and activities in the foyer spaces

In our modelling we accounted for a sound production level of 80 dB(A) in the foyer spaces, for example sound caused by walking and talking of people, sound coming from bar equipment etcetera. The used sound spectrum is similar to the Theatre sound spectrum given in table 1. This implies that background music with limited sound levels may be played. It is assumed that events with relatively loud music are not to be planned in the foyer spaces.

4.2 MEP equipment

The acoustic information of mechanical services systems are based on specifications provided by the supplier. This information is included in annexes F1 to F4.

The mechanical services noise emission sources in the acoustic model are based on these specifications. A description of these modelled noise sources is included in annex B.

In the noise emission calculations, all MEP sound sources are considered and assumed running continuously, also during night-time. This is a safe approach because normally the MEP equipment will not run all night during events.

4.3 Deliveries and loading

The sections 9.56 to 9.58 of the Deloitte report "Factory, Manchester. Environmental Statement – Volume 1", October 2016, describe the expected delivery and loading conditions in section:

9.56 There are two issues to consider: deliveries of heavy equipment associated with events and deliveries of smaller and lighter goods associated with the running of the venue, such as office supplies and food and beverages.

9.57 Deliveries of heavy equipment associated with events will be taken through a fully enclosed service area, so are not assessed further.

9.58 Deliveries of smaller and lighter goods would be to other delivery areas during normal delivery hours and would therefore not add significantly to the overall daytime ambient noise. A quantitative assessment has therefore not been undertaken.

These conditions are such that substantial breakout noise is not to be expected from these activities and as such are not considered in the calculations.

4.4 Emergency equipment

The acoustic specifications of the smoke exhaust fans and emergency generator are provided by the suppliers. This information is included in annex F3 and F4.

The emergency equipment noise emission sources in the acoustic model are based on these specifications. A description of these noise sources is included in annex C.

Short term period testing of the emergency generator normally takes place monthly test during daytime hours.

5 BUILDING ENVELOPE SOUND INSULATION

Following from the assumed internal noise levels within The Factory and the criteria on the facades of the surrounding buildings, minimum sound insulation requirements have been determined for the various façade, roof and outdoor floor structures.

In the 3D environmental noise model, the exterior skin of The Factory has been approximated using a combination of:

- Surface elements defining the sound radiation of vertical façade elements, and horizontal roof and ceiling elements,
- Depending on the sound radiating facade/roof/ceiling element, its location and orientation towards the surrounding environment, the element has been implemented in the calculation model either as a noise radiating surface element or as point sources, each representing a partial surface of a façade or roof area.

The required airborne sound insulation of each façade element (including doors and windows) is defined in terms of:

- R_A for spaces with typical indoor sound sources like the human voice
- R_{Atr} with frequency range 50 – 5000 Hz for spaces with music as a source (enlarged spectrum, according to ISO 717 ($R_{Atr} = R_w + C_{tr\ 50-5000}$),
- R_{63Hz} and R_{125Hz} for envelope elements that are part of the sound insulating structure around the Theatre and the Warehouse.

The Theatre and the Warehouse are designed as a box-in-box structure. The sound from the Theatre and Warehouse therefore will be transmitted through a multi-layered structure, each layer with a sound insulation defined in terms as mentioned above. Schematically this is shown in figure 3.

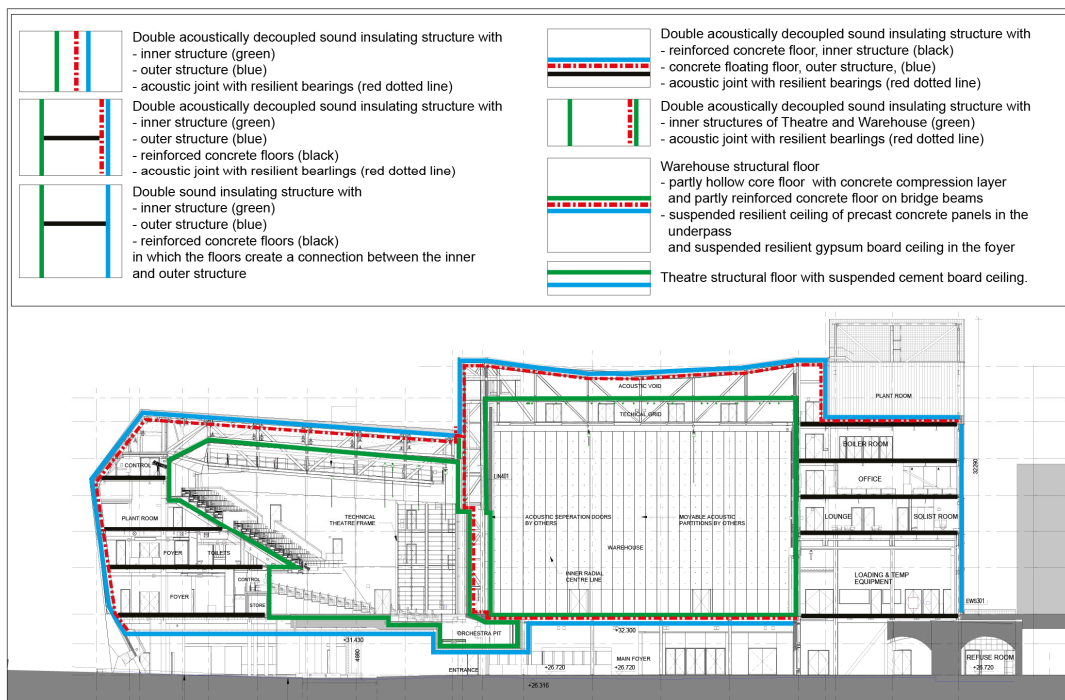


Figure 3: principle of sound insulating structures

The concrete façade elements of the Theatre and Warehouse (outer box) are mounted with resilient (acoustically insulating) bearings and therefore together with the inner-box elements can be modelled as double acoustically separated structures.

A different situation is at hand at the east side of the Warehouse. In figure 4 this is illustrated. The factory towers and the Warehouse are not acoustically separated. This will cause noise transmission into the tower spaces not only by direct sound transmission through the partition walls but also by flanking sound transmission through the tower floors and roof slabs, which are connected to the Warehouse partition wall. Part of this flanking sound is radiated into the towers' spaces and (directly) transmitted (together with the direct sound) to the tower façades/roofs. And part of the flanking sound is transmitted as structure-borne sound through the floor structures to the tower façades. The three types of sound transmission bring the tower façades/roofs into vibration; these vibrations are radiated as sound to the environment. All types of sound transmission are physically described and implemented in the modelling. Sound insulating measures at different places in these sound transmission paths have been implemented in the design in order to sufficiently reduce the sound transmission via all types of transmission paths.

Penetrations of MEP through the façade are considered in the modelling as described in detail in MF-LAV-XX-XX-RP-YA-01-0016 "Factory –acoustic performance specifications Mechanical Services". The picture next to table B1 in annex B shows the location of mechanical services sound sources.

The sound insulation of the multi-layered structures and total sound insulation between the warehouse and different tower facade and roof elements is determined according the European standards EN 12354 "Building acoustics — Estimation of acoustic performance of buildings from the performance of elements".

The sound emission sources are defined with:

- L_p : Indoor maximum sound level (un-weighted octave band values)
- R' : Sound insulation of the multi-layered structure, including the flanking sound transmission of the described transmission paths (un-weighted octave band values).

Annex A shows the specifications of all music emission sources and their location.

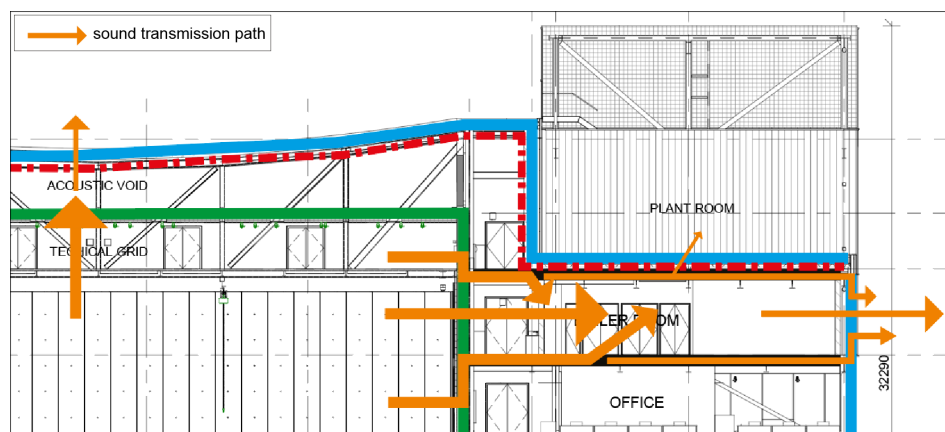


Figure 4: sound transmission paths through Warehouse roof and through the towers.

6 CALCULATION RESULTS

Figure 2 shows a plot of the 3D model with The Factory and its direct surroundings in plan. The red dots show the points on the façades of the buildings for which the noise emission levels from The Factory have been calculated at different heights. These locations are representative for the evaluation of the noise breakout from The Factory to its surroundings: they represent the façade parts on surrounding buildings with the highest noise immission. For the three towers noise levels are calculated at heights 10, 30, 50, 70 90 and 110 m. For the Bonded warehouse noise levels are calculated at the 10 and 20 m height.

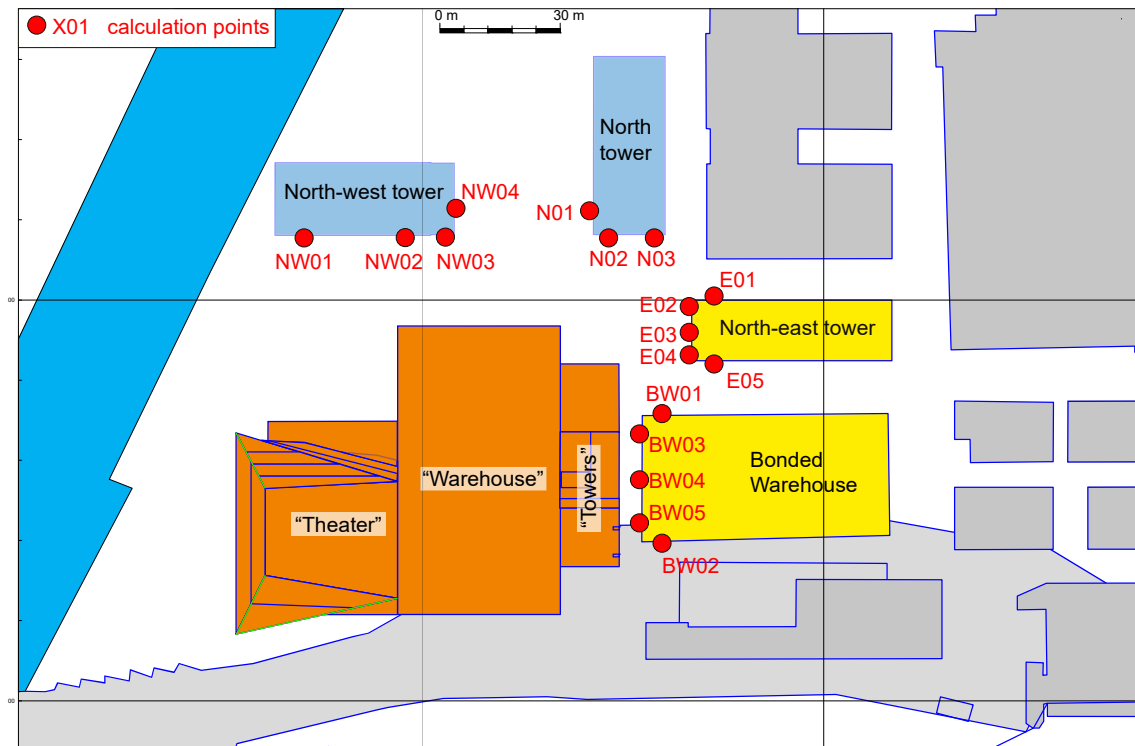


Figure 5: Factory and surrounding buildings (incl. immission calculation points (red dots) at all relevant heights)

6.1 Music performances

For each calculation point the maximum predicted noise immission level on the façades of the two residential towers (North-west Tower and North Tower) and the office buildings (the North East Tower and the Bonded Warehouse) are shown in table 2 for the 63 Hz and 125 Hz octave bands during daytime and night-time. The sound immission criteria at the bottom of the table apply to the orange-coloured table cells (only residential).

The results show that for music performances the noise immission level criterium of max 52 dB at the 63 Hz octave band and max 46 dB at the 125 Hz octave band and LpA max set for daytime and nighttime are not exceeded at the residential towers (North-west and North tower).

Table 2: overview music noise immission values at 63 and 125 Hz octave bands (dB) and overall A-weighted value L_{pA} (dB(A))

		Music					
		L_p 63 Hz		L_p 125 Hz		L_{pA} max	
		day	night	day	night	day	night
Building	calc. point	dB	dB	dB	dB	dB(A)	
North-west tower	NW01	45	45	42	42	29	29
	NW02	46	46	41	41	28	28
	NW03	47	47	40	40	28	28
	NW04	46	46	38	38	25	25
North tower	N01	47	47	38	38	26	26
	N02	51	51	42	42	30	30
	N03	52	52	43	43	31	31
East tower	E01	45	45	35	35	23	23
	E02	55	55	45	45	33	33
	E03	55	55	45	45	33	33
	E04	56	56	46	46	34	34
	E05	55	55	45	45	32	32
Bonded Warehouse	BW01	57	57	46	46	34	34
	BW02	55	55	47	47	34	34
	BW03	64	64	54	54	42	42
	BW04	65	65	55	55	43	43
	BW05	62	62	53	53	40	40
criteria (day/night)		52	52	46	46	45	38

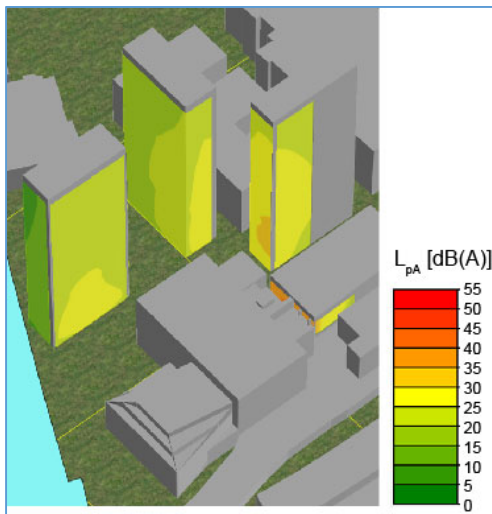


Figure 6: music sound immission level L_{pA} distribution at facades of towers and Bonded Warehouse.

6.2 MEP noise

The maximum predicted equivalent noise immission levels on the façade of the two residential towers are shown in next table for the daytime (07.00-23.00h) and night-time (23.00-07.00h). The sound immission criteria at the bottom of the table apply to the orange-coloured table cells.

The results show that the immission sound levels by MEP noise on the facades of the North Tower and North-West tower meet the criteria set for daytime and night-time.

Table 3: overview maximum overall noise immission values $L_{pA,max}$ [dB(A)]

Building	calc. point	MEP	
		$L_{pA,max}$	
		day	night
		dB(A)	dB(A)
North-west tower	NW01	42	42
	NW02	40	40
	NW03	40	40
	NW04	36	36
North tower	N01	38	38
	N02	40	40
	N03	41	41
East tower	E01	26	26
	E02	42	42
	E03	42	42
	E04	43	43
	E05	41	41
Bonded Warehouse	BW01	37	37
	BW02	46	46
	BW03	50	50
	BW04	56	56
	BW05	52	52
criteria (day/night)		50	43

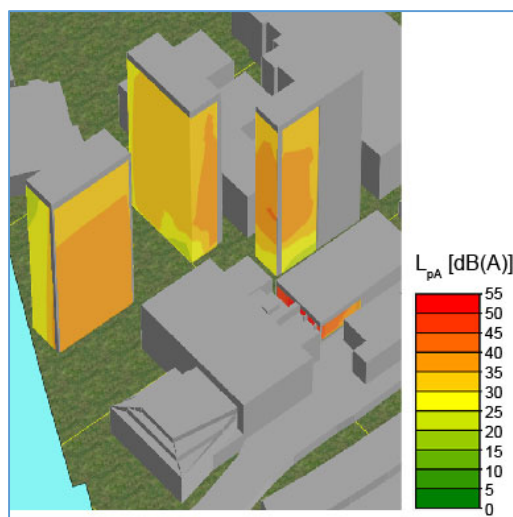


Figure 7: MEP sound immission distribution at facades of towers and Bonded Warehouse.

6.3 Emergency generator

Monthly short term period testing of the emergency generator will be conducted during daytime. The results of noise emission calculations are shown in table 4.

No criteria are set for this occurrence.

Table 4: overview maximum overall noise immission values $L_{pA,max}$ [dB(A)]

Building	calc. point	Emergency	
		$L_{pA,max}$	
		day	night
		dB(A)	dB(A)
North-west tower	NW01	44	-
	NW02	46	-
	NW03	47	-
	NW04	46	-
North tower	N01	47	-
	N02	49	-
	N03	49	-
East tower	E01	36	-
	E02	50	-
	E03	52	-
	E04	52	-
	E05	51	-
Bonded Warehouse	BW01	46	-
	BW02	48	-
	BW03	56	-
	BW04	55	-
	BW05	54	-
criteria (day/night)		-	-

During a test run of the smoke exhaust and emergency generator the maximum predicted noise level on the facades of the residential towers is $L_{pA,max} = 47$ dB(A) at the North West Tower and 49 dB(A) at the North Tower.

7 QUALITY CONTROL AND TESTING

In the Quality Plan the contractor (LOR) describes the strategy how quality is controlled during the building process. During construction, Level Acoustics & Vibration performs site visits together with inspection by the Architect to verify that the acoustic solutions are executed as designed. As soon as construction works are finished, acoustic commissioning testing will be done by Level Acoustics & Vibration. The testing methodology is described in MF-LAV-XX-XX-RP-YA-01-0041. Main focus will be to verify noise ingress levels at the residential towers.

ANNEX A: MUSIC EMISSION SOURCES

In the following four pictures the location of the music emission sources is shown.

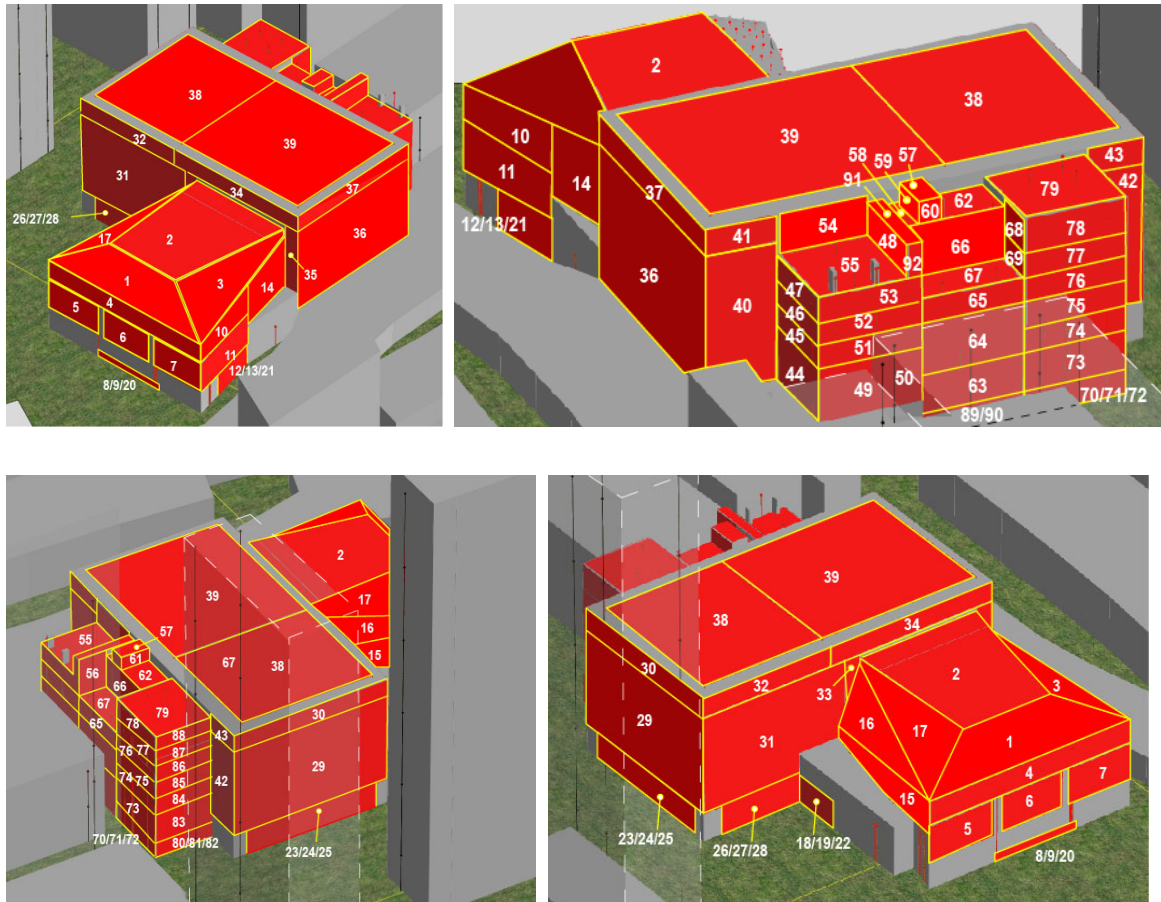


Figure A 1

The table A1 on the next pages contains a short description of the music sources, numbered with the corresponding numbers in figure A1 above.

The “reference” is the source name in the acoustic model.

Tables A2 and A3 provide the acoustic properties of the music sources, including the attenuators sound insertion loss.

The radiated sound power level per sqm is determined by

$$SWL/m^2 = SPL - R' - C_d [dB]$$

in which

- C_d is the diffusion coefficient (5 dB)
- SPL is the indoor sound level
- R' is the sound insulation of the structure, including flanking sound transmission
- SWL/m^2 is the transmitted sound power level per sqm.

In the program Geomilieu it is not possible to model faces in underpasses and faces underneath overhangs. For example, the sound transmitted through the Warehouse floor to the underpass and the dispersion to the underpass openings at the building perimeter is modelled in a separate 3D model in CATT-acoustic. Figure A2 shows pictures of the three models with the sound sources for the Warehouse soffit, Theatre soffit and ground floor foyer.

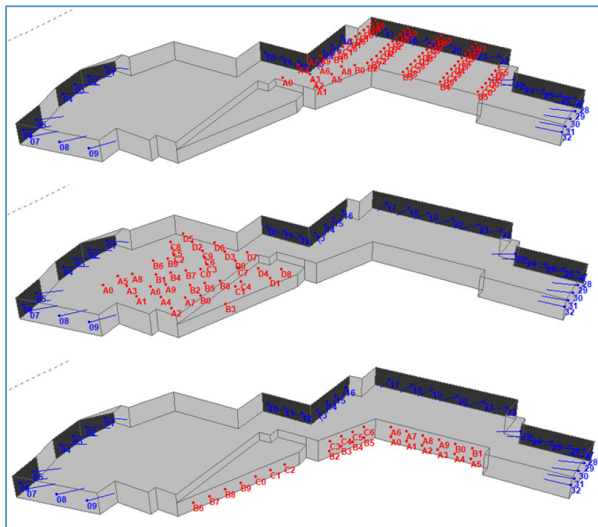


Figure A 2: acoustic models underpass for the Warehouse soffit, Theatre soffit and ground floor foyer

In Geomilieu these underpass openings are modelled as sound radiating surfaces. For the correct relation between sound power level per sqm radiated by the warehouse floor and the sound power level per sqm at the underpass opening a sound insulation dispersment correction is determined (last 8 columns in table A3).

The inner and outer layer of the Theatre and Warehouse enclosures are described with a short reference:

- CLT = cross laminated timber (the number is the thickness in mm)
- PC = precast concrete (the number is the thickness in mm)
- BB = concrete floor on bridge beams (the number is the thickness in mm)
- CF = reinforced concrete floor slab (the number is the thickness in mm)
- Type A = wall lining type (annex D2)
- RD = rib deck + thickness (the number is the thickness in mm)
- SCR = screed + thickness (the number is the thickness in mm)
- EWSxxx = lightweight structure detail code (annex D1)

Table A 1

no	description	reference	inner structure	outer structure	R _{Atr} (50-5000Hz)	
					inner dB(A)	outer dB(A)
1	theatre roof west	TH_D	CLT120	PC200	33	48
2	theatre roof	tht_roof1	CLT200	PC200	37	48
3	theatre roof south	TH_E	CLT120	PC200	33	48
4	theater level 4 - west facade	th l4 w	CLT120	PC200	33	48
5	foyer level 2 west	foy l2 wn	-	PC200	-	48
6	foyer level 2 west (glazing)	foy l2 w-gl	-	EWS103	-	43
7	foyer level 2 west	foy l2 ws	-	PC200	-	48
8	warehouse floor via west opening wh	th gf w wh	CF300+BB	PC100	60	40
9	theater floor via west opening th	th gf w th	CF400+BB	EWS951	63	30
10	theater level 4 - south facade	th l4 s	CLT120	PC200	33	48
11	foyer level 2 south	foy l2 s	-	PC200	-	48
12	theater floor via south opening th	th gf s th	CF400+BB	EWS951	63	30
13	warehouse floor via south opening th	th gf s wh	CF300+BB	PC100	60	40
14	tht level 4-5 south (concrete)	th l4-5 s	CLT120	PC200	33	48
15	theatre nord facade L3	TH_A	CLT120	PC200	33	48
16	theatre nord level 5	TH_B	CLT120	PC200	33	48
17	theatre nord roof	TH_C	CLT120	PC200	33	48
18	theater floor via nord opening th	th gf n th	CF400+BB	EWS951	63	30
19	warehouse floor via north opening th	th gf n wh	CF300+BB	PC100	60	40
20	wh foyer via west opening th	th gf w fo	-	EWS102	-	45
21	wh foyer via south opening th	th gf s fo	-	EWS102	-	45
22	wh foyer via nord opening th	th gf n fo	-	EWS102	-	45
23	wh foyer via north opening wh	wh_gf_n_fo	-	EWS102	-	45
24	theater floor via north opening wh	wh_gf_n_th	CF400+BB	EWS951	63	30
25	warehouse floor via north opening wh	wh_gf_n_wh	CF300+BB	PC100	60	40
26	wh foyer via west opening wh	wh_gf_w_fo	-	EWS102	-	45
27	theater floor via west opening wh	wh_gf_w_th	CF400+BB	EWS951	63	30
28	warehouse floor via west opening wh	wh_gf_w_wh	CF300+BB	PC100	60	40
29	warehouse nord facade	whn_n	PC300	PC200	50	48
30	warehouse nord facade - plenum	whn_n_pl	PC300	PC200	50	48
31	warehouse w facade	whn_w_1	PC300	PC200	50	48
31	warehouse nord west facade - plenum	whn_w_2	PC300	PC200	50	48
32	warehouse w facade	whn_w_pl	PC300	PC200	50	48
33	warehouse south west facade	whs_w	PC300	PC200	50	48
34	warehouse west facade - plenum	whs_w_pl	PC300	PC200	50	48
35	warehouse south west facade	whs_w	PC300	PC200	50	48
36	warehouse south facade	whs_s	PC300	PC200	50	48
37	warehouse south facade - plenum	whs_s_pl	PC300	PC200	50	48
38	warehouse north roof	whn_roof	HR130	RHC150	78	
39	warehouse south roof	whs_roof	HR130	RHC150	78	
40	warehouse east facade	whs_e	PC300	PC200	50	48
41	warehouse east facade - plenum	whs_e_pl	PC300	PC200	50	48
42	warehouse east facade	whn_e	PC300	PC200	50	48
43	warehouse east facade - plenum	whn_e_pl	PC300	PC200	50	48
44	south tower - including emergency exit	TSs02	BW215	EWS301	30	30
45	south tower	TSs04	-	EWS161	-	43
46	south tower	TSs05	-	EWS101	-	43

Continued in table A2

Table A 2

no	description	reference	inner structure	outer structure	R_{Atr} (50-5000Hz)	
					inner dB(A)	outer dB(A)
47	south tower - crew room	TSs06	Type A	EWS301	30	30
48	south tower	TSs07	type B	BW101	30	?
49	south tower	TSe02	BW215	EWS301	30	30
50	south tower	TSe02b	type A	EWS301	30	30
51	south tower	TSe04	- / type A	EWS161 / EWS301	- / 30	43 / 30
52	north tower	TSe05	-	EWS101	-	43
53	south tower - CHILLER ROOM EAST	TSe06	Type A	EWS301	30	30
54	south tower - east fac - I7	TSe07	type A	EWS301	30	30
55	south tower - CHILLER ROOM NORTH	TSn06	type A	EWS301	30	30
55	south tow - roof - 7	Ts-rf-musi	RD140-SCR120	RFS-151	62	
56	south tower	TSn07	type A	EWS301	30	30
57	mid tower roof stairwell	lw17-5	RD140-SCR120	RFS-151	62	
58	mid tower roof	lw17-4	RD140-SCR120	RFS-151	62	
59	staircase mid tower	TMs08	type B	EWS303	30	30
60	staircase mid tower	TMe08	type B	EWS303	30	30
61	staircase mid tower	TMn08	type B	EWS303	30	30
62	mid tower roof L8	lw17-2	RD140-SCR120	RFS-151	62	
63	mid tower east	TMe01-2	type A	EWS303	30	30
64	mid tower	TMe03-4	type B	EWS302	30	30
65	north tower	TMe05	-	EWS101	-	43
66	mid tower	TMe06-7	type A	EWS302	30	30
67	middle tow - roof - 6	LW17-3	RD140-SCR120	RFS-151	62	
68	north tower AHU-room7	TNs07	type A	EWS301	30	30
69	north tower	TNs06	type A	EWS301	30	30
70	wh foyer via tower opening eastside	TNe-gf fo	-	EWS102	-	45
71	theater floor via opening tower eastside	TNe-gf th	CF400+BB	EWS951	63	30
72	warehouse floor via opening tower eastside	TNe-gf wh	CF300+BB	PC100	60	40
73	north tower	TNe02	type A	EWS301	30	30
74	north tower	TNe03	type A	EWS301	30	30
75	north tower	TNe04	- / type A	EWS161 / EWS301	- / 30	43 / 30
76	north tower	TNe05	-	EWS101	-	43
77	north tower	TNe06	type A	EWS301	30	30
78	north tower AHU-room7	TNe07	type A	EWS564	30	30
79	north tow - roof - 8	LW12	RD140-SCR120	RFS-151	62	
80	warehouse floor via opening north tower	TNn-gf-wh	CF300+BB	PC100	60	40
81	wh foyer via opening north tower	TNn-gf-fo	-	EWS102	-	45
82	theater floor via opening north tower	TNn-gf-th	CF400+BB	EWS951	63	30
83	north tower	TNn02	type A	EWS301	30	30
84	north tower	TNn03	- / type A	EWS101 / EWS301	- / 30	43 / 30
85	north tower	TNn04	- / type A	EWS161 / EWS301	- / 30	43 / 30
86	north tower	TNn05	-	EWS101	-	43
87	north tower	TNn06	- / type A	EWS101 / EWS301	- / 30	43 / 30
88	north tower-AHU-room7	TNn07	type A	534	30	30
89	mid tower north - east egress overhang	TMn01-2a	-	EWS303	-	45
90	mid tower north - north egress overhang	TMn01-2b	-	EWS303	-	45
91	roof south tower level 8	LW17-1	RD140-SCR120	RFS-151	62	
92	south tower - east fac - I7	TSe07b	type A	EWS301	30	30

Table A 3

	nr	reference	INDOOR SOUND PRESURE LEVEL SPL [dB]								SOUND INSULATION R' (including flanking) [dB]								RADIATED SOUND POWER LEVEL SWL/m² [dB]							
			63	125	250	500	1k	2k	4k	8k	63	125	250	500	1k	2k	4k	8k	63	125	250	500	1k	2k	4k	8k
Foyers	5	foyl2 wn	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	6	foyl2 w-gl	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	55.0	55.0	55.0	55.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	7	foyl2 ws	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	11	foyl2 s	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	20	th gf w fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	21	th gf s fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	22	th gf n fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	23	wh gf n fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	26	wh gf w fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	70	ThNe-gf fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
Theater	81	ThNn-gf fo	74.5	74.4	77.9	78.5	75.3	71.3	67.2	63.4	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0	36.5	38.4	33.9	25.5	13.3	1.3	-7.8	-11.6
	1	tht_roof1	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	53.0	58.0	74.0	86.0	95.0	102.0	108.0	108.0	42.5	37.4	24.9	13.5	1.3	-9.7	-19.8	-23.6
	2	tht_roof2	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	53.0	58.0	74.0	86.0	95.0	102.0	108.0	108.0	42.5	37.4	24.9	13.5	1.3	-9.7	-19.8	-23.6
	3	TH_E	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	54.0	58.0	74.0	86.0	95.0	102.0	108.0	108.0	41.5	37.4	24.9	13.5	1.3	-9.7	-19.8	-23.6
	4	th i4 w	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	53.0	55.0	68.0	86.0	95.0	102.0	108.0	108.0	42.5	40.4	30.9	13.5	1.3	-9.7	-19.8	-23.6
	9	th gf w th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	10	th i4 s	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	53.0	55.0	68.0	86.0	95.0	102.0	108.0	108.0	42.5	40.4	30.9	13.5	1.3	-9.7	-19.8	-23.6
	12	th gf s th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	14	th i4 s s	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	53.0	55.0	68.0	86.0	95.0	102.0	108.0	108.0	42.5	40.4	30.9	13.5	1.3	-9.7	-19.8	-23.6
	15	TH_A	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	54.0	58.0	74.0	86.0	95.0	102.0	108.0	108.0	41.5	37.4	24.9	13.5	1.3	-9.7	-19.8	-23.6
Towers	16	TH_B	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	54.0	58.0	74.0	86.0	95.0	102.0	108.0	108.0	41.5	37.4	24.9	13.5	1.3	-9.7	-19.8	-23.6
	17	TH_C	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	54.0	58.0	74.0	86.0	95.0	102.0	108.0	108.0	41.5	37.4	24.9	13.5	1.3	-9.7	-19.8	-23.6
	18	th gf n th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	24	wh gf n th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	27	wh gf w th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	71	ThNe-gf th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	82	ThNn-gf th	100.5	100.4	103.9	104.5	101.3	97.3	93.2	89.4	41.0	37.0	53.0	61.0	69.0	76.0	79.0	81.0	54.5	58.4	45.9	38.5	27.3	16.3	9.2	3.4
	44	TSs02	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	48.6	52.5	60.4	63.4	69.9	68.9	74.9	74.1	56.8	47.8	38.4	36.0	26.3	23.3	13.2	10.2
	45	TSs04	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
	46	TSs05	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
Warehouses	47	TSs06	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
	48	TSs07	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
	49	TSs02	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	48.6	52.5	67.5	77.1	77.6	77.6	83.7	65.9	56.8	47.8	31.3	22.3	18.6	14.6	4.4	18.4
	50	TSs02b	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	48.6	52.5	67.5	77.1	77.6	77.6	83.7	65.9	56.8	47.8	31.3	22.3	18.6	14.6	4.4	18.4
	51	TSs04	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
	52	TSs05	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
	53	TSs06	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
	54	TSs07	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	44.2	53.2	66.1	80.5	91.5	98.8	107.1	92.4	61.2	47.1	32.7	18.9	4.7	-6.6	-19.0	-8.1
	55	TS-rmusi	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	56.2	71.4	81.0	102.0	118.0	132.0	145.0	150.0	49.2	28.9	17.8	-2.6	-21.8	-39.8	-56.9	-65.7
	56	TSn06	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	50.6	55.5	65.0	80.0	91.0	98.0	97.0	92.0	54.8	44.8	33.8	19.4	5.2	-5.8	-8.9	-7.7
57	lw17-5	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	56.2	71.4	81.0	102.0	118.0	132.0	145.0	150.0	49.2	28.9	17.8	-2.6	-21.8	-39.8	-56.9	-65.7	
58	lw17-4	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	56.2	71.4	81.0	102.0	118.0	132.0	145.0	150.0	49.2	28.9	17.8	-2.6	-21.8	-39.8	-56.9	-65.7	
59	ThMe08	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	43.6	50.5	57.0	79.0	94.0	112.0	93.0	87.0	61.8	49.8	41.8	20.4	2.2	-19.8	-4.9	-2.7	
60	ThMe08	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	43.6	50.5	57.0	79.0	94.0	112.0	93.0	87.0	61.8	49.8	41.8	20.4	2.2	-19.8	-4.9	-2.7	
61	ThMn08	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	43.6	50.5	57.0	79.0	94.0	112.0	93.0	87.0	61.8	49.8	41.8	20.4	2.2	-19.8	-4.9	-2.7	
62	lw17-2	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	56.2	71.4	81.0	102.0	118.0	132.0	145.0	150.0	49.2	28.9	17.8	-2.6	-21.8	-39.8	-56.9	-65.7	
63	ThMe01-2	110.4	105.3	103.8	104.4	101.2	97.2	93.1	89.3	42.6	47.5	57.0	79.0	94.0	112.0	93.0	87.0	6								

ANNEX B: MECHANICAL NOISE EMISSION SOURCES

Table B1 to B5 provide the acoustic specifications of mechanical sound sources. The figure next to table B1 shows the location of the sources. The red numbers refer to the emergency equipment (annex C).

Table B 1: mechanical sound sources

nr	reference	description
1	60	smoke exhaust duct L7 south tower
2	88	truck-lift fan
3	89	truck-lift fan
4	90	truck-lift fan
5	AHU01i	01 AHU-TH-L1-01 ORCHESTRA PIT intake
6	AHU02e	02 AHU-TH-L4-01 TOILETS exhaust
7	AHU02i	02 AHU-TH-L4-01 TOILETS intake
8	AHU03e	03 AHU-TH-L4-02 BALCONY exhaust
9	AHU03i	03 AHU-TH-L4-02 BALCONY intake
10	AHU04e	04 AHU-TH-L4-03 stalls exhaust
11	AHU04i	04 AHU-TH-L4-03 stalls intake
12	AHU05e	05 AHU-TH-L5-01 REAR stalls exhaust
13	AHU05i	05 AHU-TH-L5-01 REAR stalls intake
14	AHU06e	06 AHU-TOW-L3-01 exhaust Level 04 down
15	AHU06i	06 AHU-TOW-L3-01 intake Level 04 down
16	AHU07e	07 AHU-TOW-L6-01 exhaust
17	AHU07i	07 AHU-TOW-L6-01 intake
18	AHU08e	08 AHU-TOW-L7-01 exhaust South WH
19	AHU08i	08 AHU-TOW-L7-01 intake South WH
20	AHU09e	09 AHU-TOW-L7-02 exhaust South WH
21	AHU09i	09 AHU-TOW-L7-02 intake South WH
22	AHU10e	10 AHU-TOW-L7-03 exhaust North WH
23	AHU10i	10 AHU-TOW-L7-03 intake north WH
24	AHU11e	11 AHU-TOW-L7-04 exhaust north WH
25	AHU11i	11 AHU-TOW-L7-04 intake North WH
26	fan 1	dry air cooler
27	fan 2	dry air cooler
28	fan 3	dry air cooler
29	fan 4	dry air cooler
30	kit ext	kitchen extract I6 - INDICATIEF + ext demper
31	WH-L6-SF1	supply fan chiller room

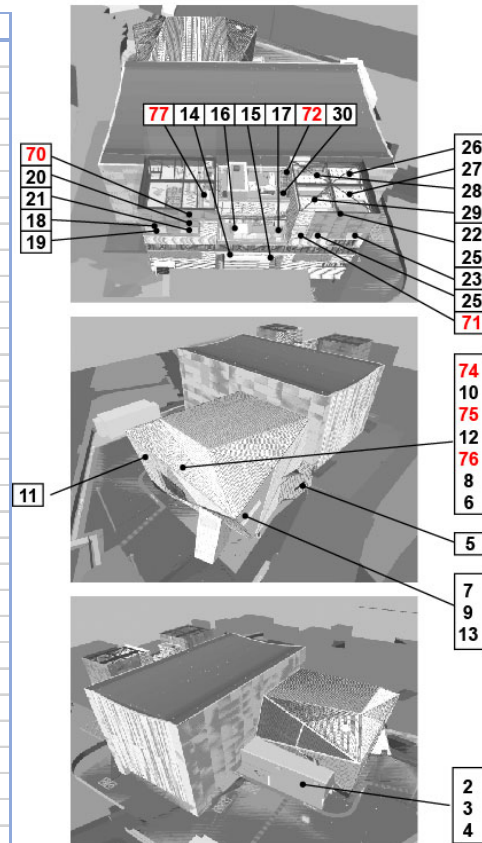


Table B 2: acoustic specifications

nr	reference	SOUND POWER LEVEL SWL [dB]								ATTENUATOR INSERTION LOSS [dB]							
		63	125	250	500	1k	2k	4k	8k	63	125	250	500	1k	2k	4k	8k
1	60	88	73	61	52	45	40	37	36	5	5	5	5	5	5	5	5
2	88	71	80	77	72	70	66	63	59	0	0	0	0	0	0	0	0
3	89	71	80	77	72	70	66	63	59	0	0	0	0	0	0	0	0
4	90	71	80	77	72	70	66	63	59	0	0	0	0	0	0	0	0
5	AHU01i	56	59	53	53	49	41	40	37	4	12	24	22	19	16	12	9
6	AHU02e	61	58	62	50	45	46	48	49	5	11	16	19	27	32	26	21
7	AHU02i	59	54	53	42	28	31	33	35	5	11	16	19	27	32	26	21
8	AHU03e	72	82	80	84	83	77	73	68	6	17	42	41	47	33	20	18
9	AHU03i	66	79	73	72	73	69	63	71	6	17	42	41	47	33	20	18
10	AHU04e	82	89	83	85	82	78	74	71	4	13	29	27	26	21	14	11
11	AHU04i	73	82	74	71	67	64	60	61	6	17	42	41	47	33	20	18
12	AHU05e	66	69	62	57	45	43	44	45	4	12	24	22	19	16	12	9
13	AHU05i	60	65	53	31	32	31	31	34	0	0	0	0	0	0	0	0
14	AHU06e	78	81	92	87	86	80	79	82	4	8	8	14	14	18	18	18
15	AHU06i	70	79	81	74	73	72	82	70	18	30	49	22	55	45	32	26
16	AHU07e	69	74	67	60	51	49	53	53	0	0	0	0	0	0	0	0
17	AHU07i	59	69	57	46	36	36	40	44	0	0	0	0	0	0	0	0
18	AHU08e	81	97	86	87	85	81	78	72	16	25	42	55	47	34	23	20
19	AHU08i	77	98	84	76	73	70	76	64	16	25	42	55	47	34	23	20
20	AHU09e	81	97	86	87	85	81	78	72	16	25	42	55	47	34	23	20
21	AHU09i	77	98	84	76	73	70	76	64	16	25	42	55	47	34	23	20
22	AHU10e	85	89	85	86	83	79	76	73	14	25	42	55	55	49	37	32
23	AHU10i	77	84	76	72	68	65	61	63	14	25	42	55	55	49	37	32
24	AHU11e	85	89	85	86	83	79	76	73	14	25	42	55	55	49	37	32
25	AHU11i	74	85	78	79	77	75	77	76	14	25	42	55	55	49	37	32
26	fan 1	75	70	69	66	65	66	64	58	0	0	0	0	0	0	0	0
27	fan 2	75	70	69	66	65	66	64	58	0	0	0	0	0	0	0	0
28	fan 3	75	70	69	66	65	66	64	58	0	0	0	0	0	0	0	0
29	fan 4	75	70	69	66	65	66	64	58	0	0	0	0	0	0	0	0
30	kit ext	71	76	72	69	65	63	59	55	11	22	43	41	47	33	20	18
31	WH-L6-SF1	76	75	82	85	84	80	76	63	0	0	0	0	0	0	0	0

Table B 3: plant room noise sources

reference	description
1 Ts-rf-chil	chiller room roof
1 Tse06-chil	chiller room
2 plant l4 w	plantroom level 4 - west facade
3 plant l4 s	plantroom level 4 - south facade

Table B 4: indoor sound level and sound insulation

nr	reference	INDOOR SOUND PRESURE LEVEL SPL [dB]								SOUND INSULATION R' (including flanking) [dB]							
		63	125	250	500	1k	2k	4k	8k	63	125	250	500	1k	2k	4k	8k
1	Ts-rf-chil	84.5	76.9	78.6	77.9	81.6	79.6	75.2	77.5	64.0	65.0	76.0	100.0	118.0	133.0	145.0	152.0
2	Tse06-chil	84.5	76.9	78.6	77.9	81.6	79.6	75.2	77.5	35.0	35.0	40.0	50.0	58.0	66.0	72.0	73.0
3	plant l4 w	83.2	77.1	73.6	71.2	71.0	68.0	62.9	27.1	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0
4	plant l4 s	83.2	77.1	73.6	71.2	71.0	68.0	62.9	27.1	33.0	31.0	39.0	48.0	57.0	65.0	70.0	70.0

Table B 5: radiated sound power levels

nr	reference	RADIATED SOUND POWER LEVEL SWL/m ² [dB]								surf.area [m ²]	RADIATED SOUND POWER LEVEL SWL [dB]							
		63	125	250	500	1k	2k	4k	8k		63	125	250	500	1k	2k	4k	8k
1	Ts-rf-chil	15.5	6.9	-2.4	-27.1	-41.4	-58.4	-74.8	-79.5	312	40.4	31.8	22.6	-2.1	-16.5	-33.5	-49.9	-54.6
2	Tse06-chil	44.5	36.9	33.6	22.9	18.6	8.6	-1.8	-0.5	50	61.5	53.9	50.7	40.0	35.6	25.6	15.2	16.5
3	plant l4 w	45.2	41.1	29.6	18.2	9.0	-2.0	-12.1	-47.9	274	69.6	65.5	54.0	42.6	33.4	22.4	12.3	-23.5
4	plant l4 s	45.2	41.1	29.6	18.2	9.0	-2.0	-12.1	-47.9	123	66.1	62.0	50.5	39.1	29.9	18.9	8.8	-27.0

The radiated sound power level per sqm is determined by

$$SWL/m^2 = SPL - R' - C_d \text{ [dB]}$$

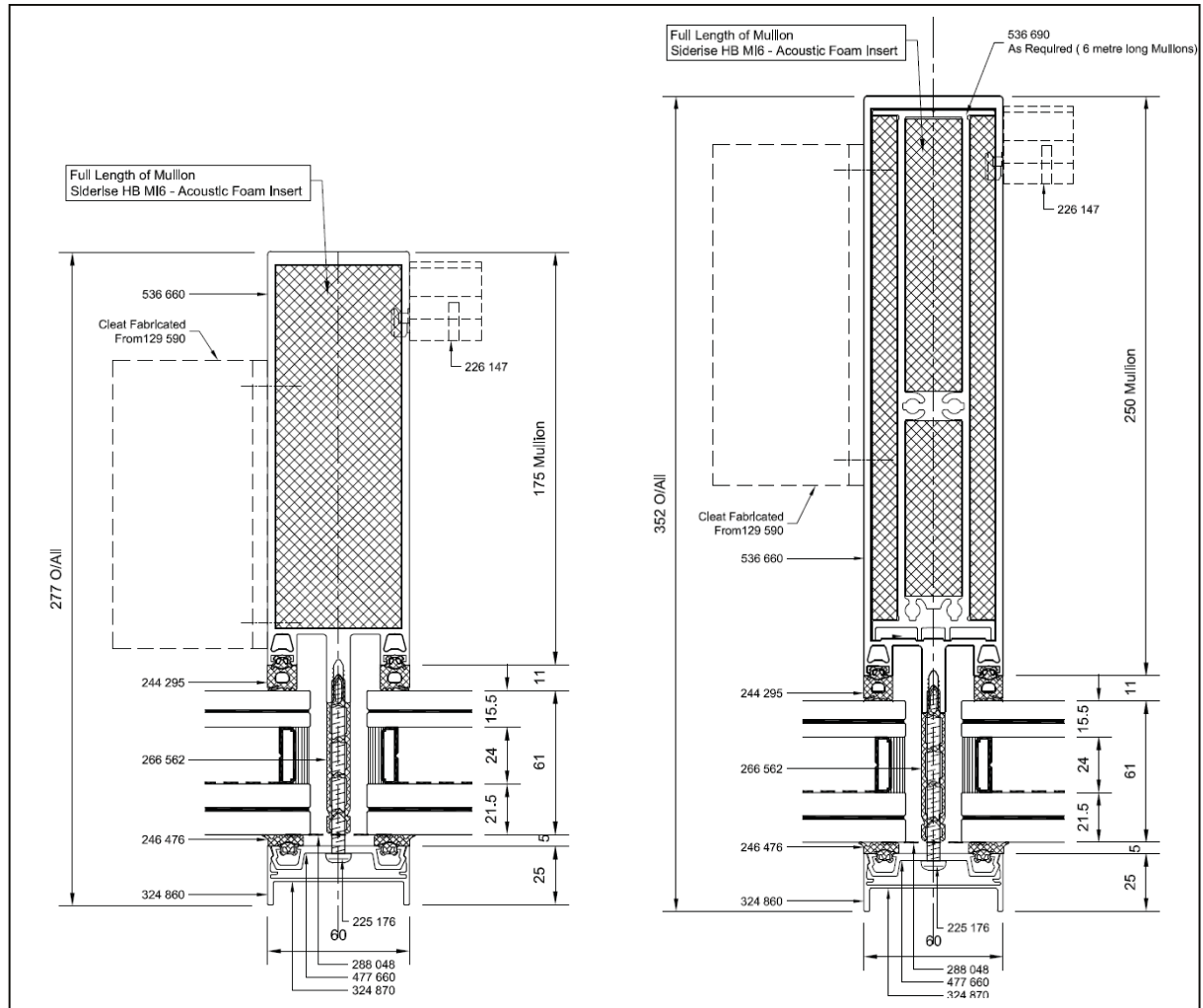
in which

- C_d is the diffusion coefficient (5 dB)
- SPL is the indoor sound level
- R' is the sound insulation of the structure, including flanking sound transmission
- SWL/m^2 is the transmitted sound power level per sqm.

ANNEX C: EMERGENCY EQUIPMENT SOUND SOURCES

Table C 1: Acoustic specifications emergency equipment sound sources

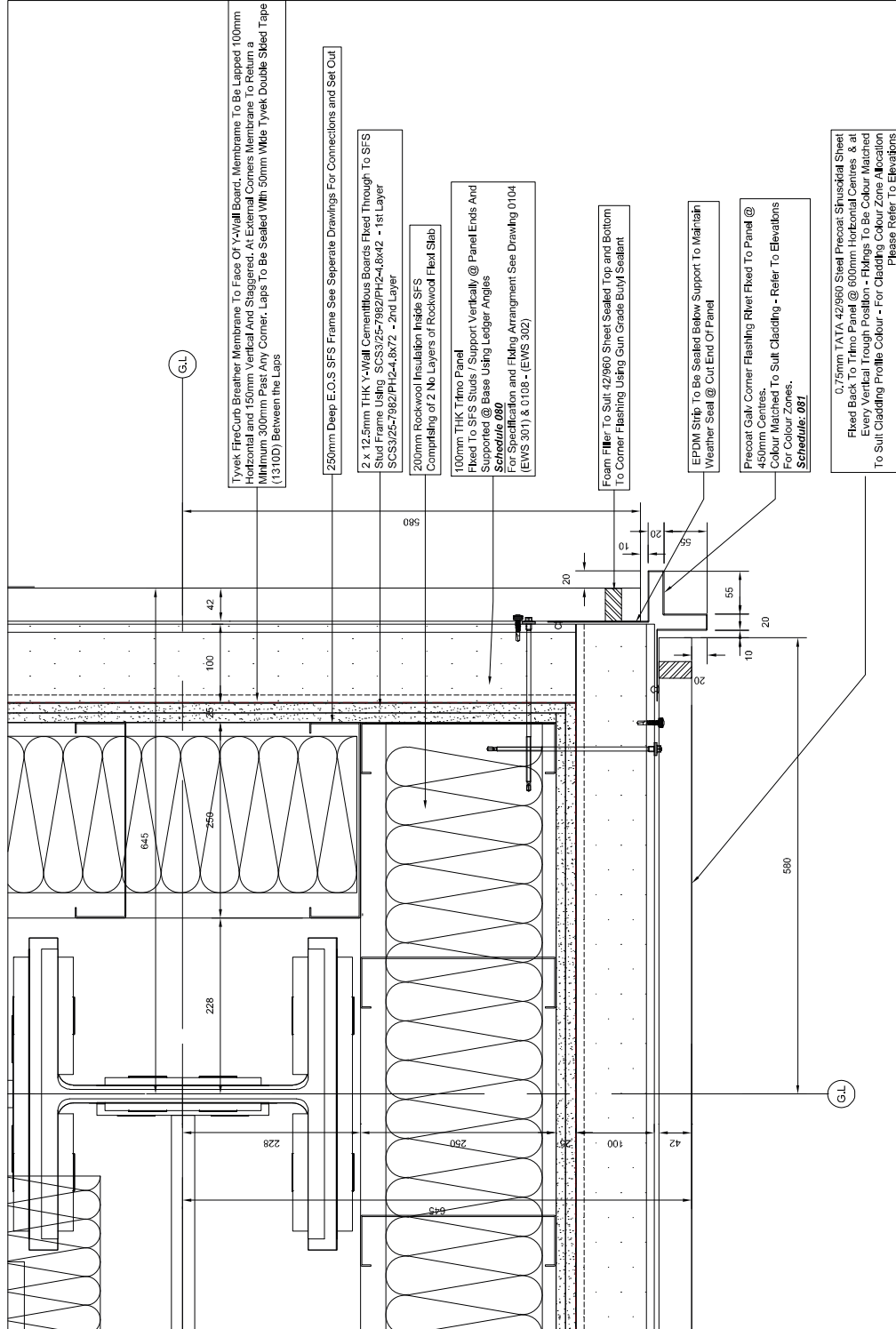
reference	description	SOUND POWER LEVEL SWL [dB]							
		63	125	250	500	1k	2k	4k	8k
emergency	Emergency generator	110	103	95	88	82	77	74	68
72_colt	colt smoke exhaust warehouse tower stair	113	110	107	100	93	90	87	84
74_ELTAH	ELTA smoke exhaust	121	118	114	114	114	106	101	98
70_ELTAHWS	ELTA smoke exhaust south tower	121	118	114	114	114	106	101	98
71_ELTAHWS	ELTA smoke exhaust north tower	121	118	114	114	114	106	101	98
75_colt	colt smoke exhaust	111	109	105	107	107	104	103	99
76_colt	colt smoke exhaust	107	109	105	107	107	104	103	99



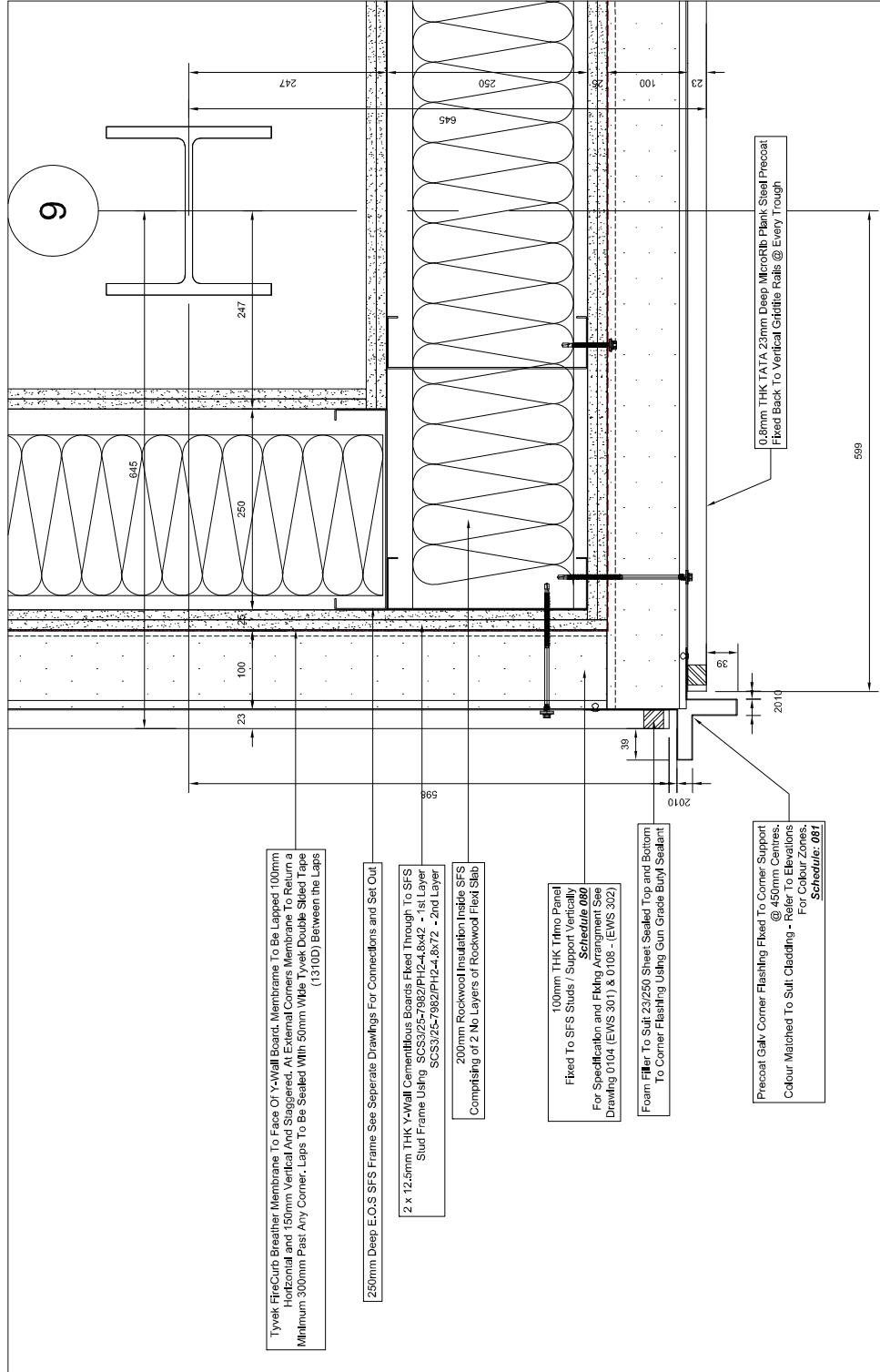
EWS-102

MF-PRA-WH-XX-DR-X-30-0602 (left)

MF-PRA-WH-XX-DR-X-30-0601 (right)

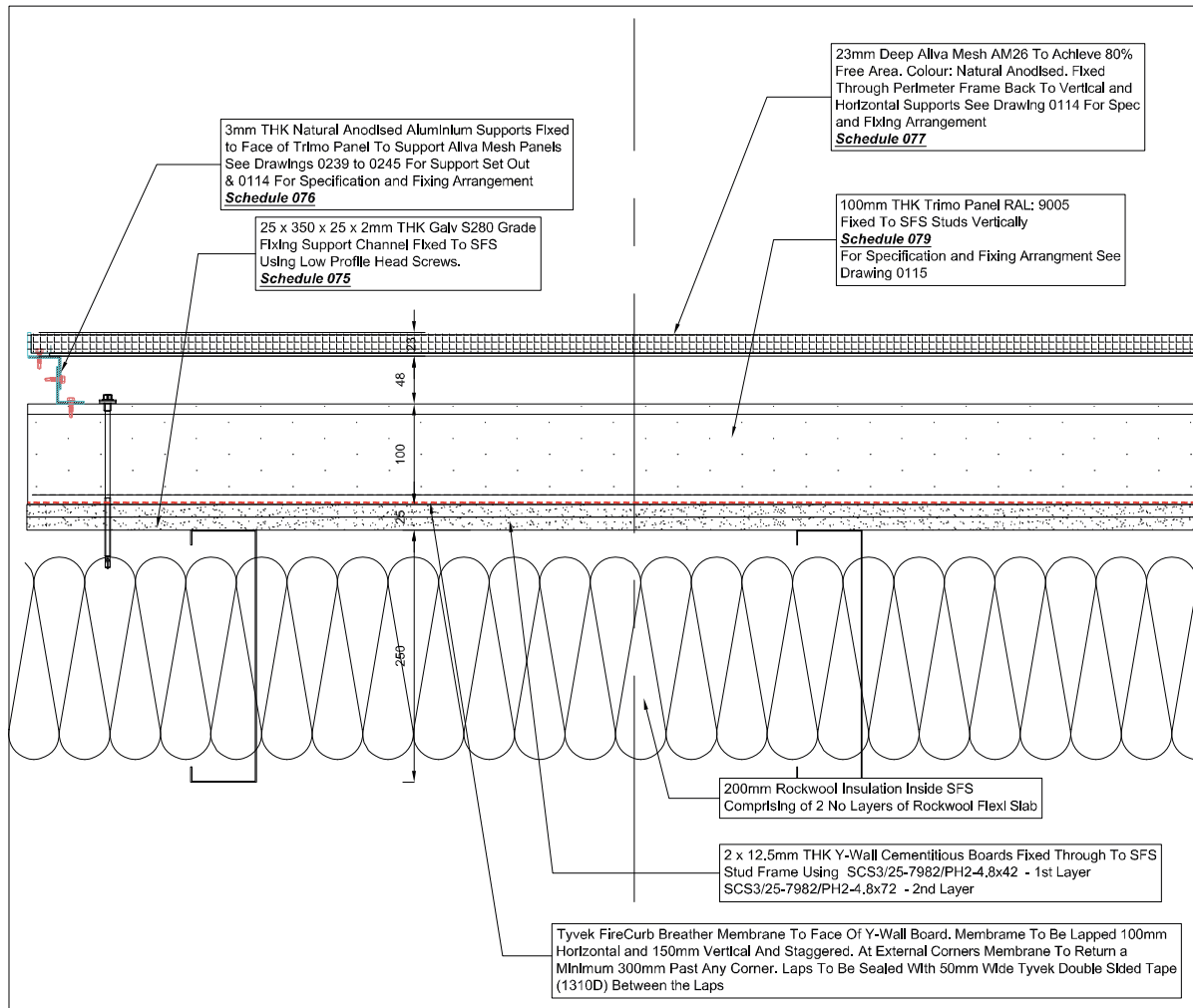


EWS-301
MF-PRA-WH-XX-DR-X-30-0701



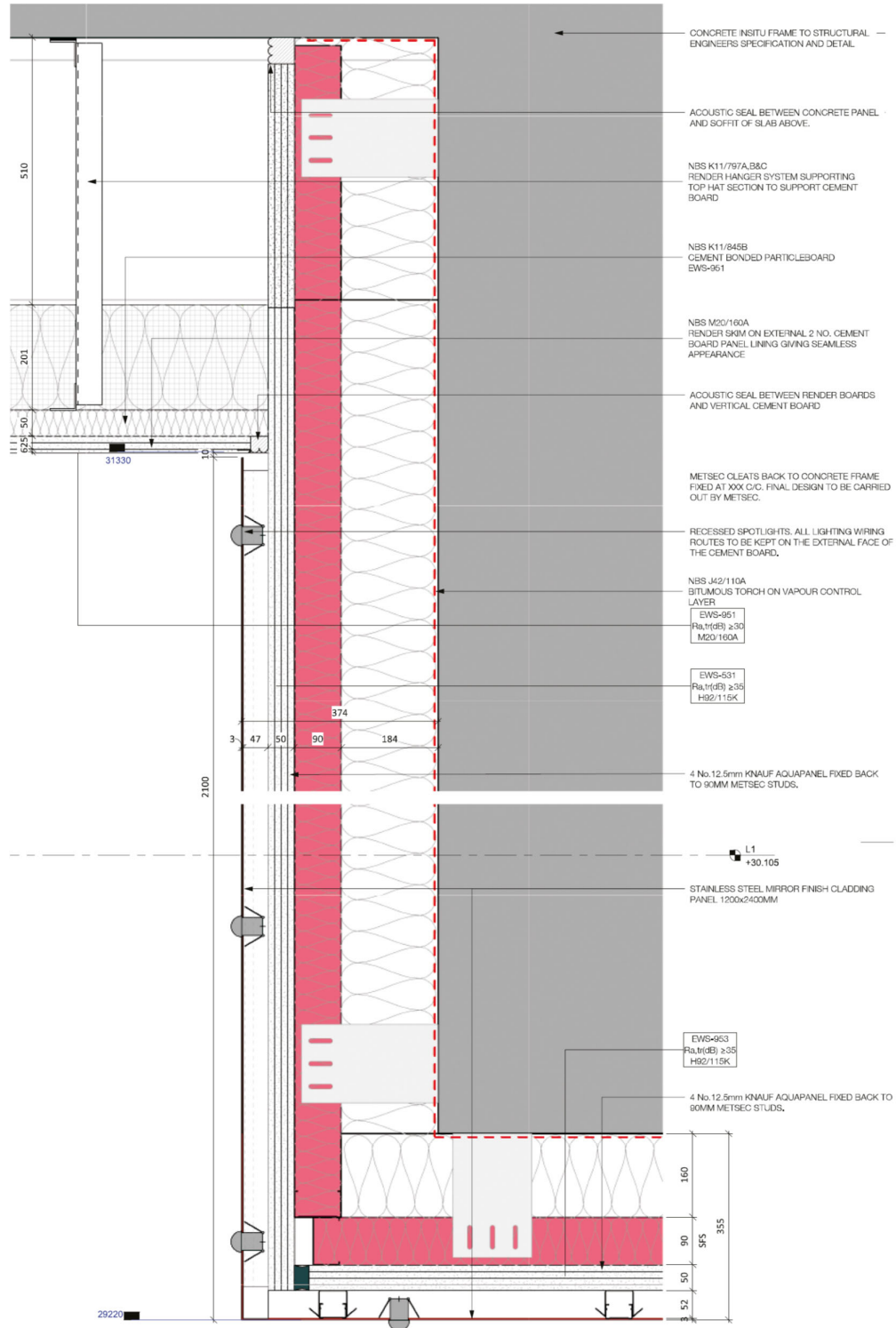
EWS-302

MF-PRA-WH-XX-DR-X-30-0862

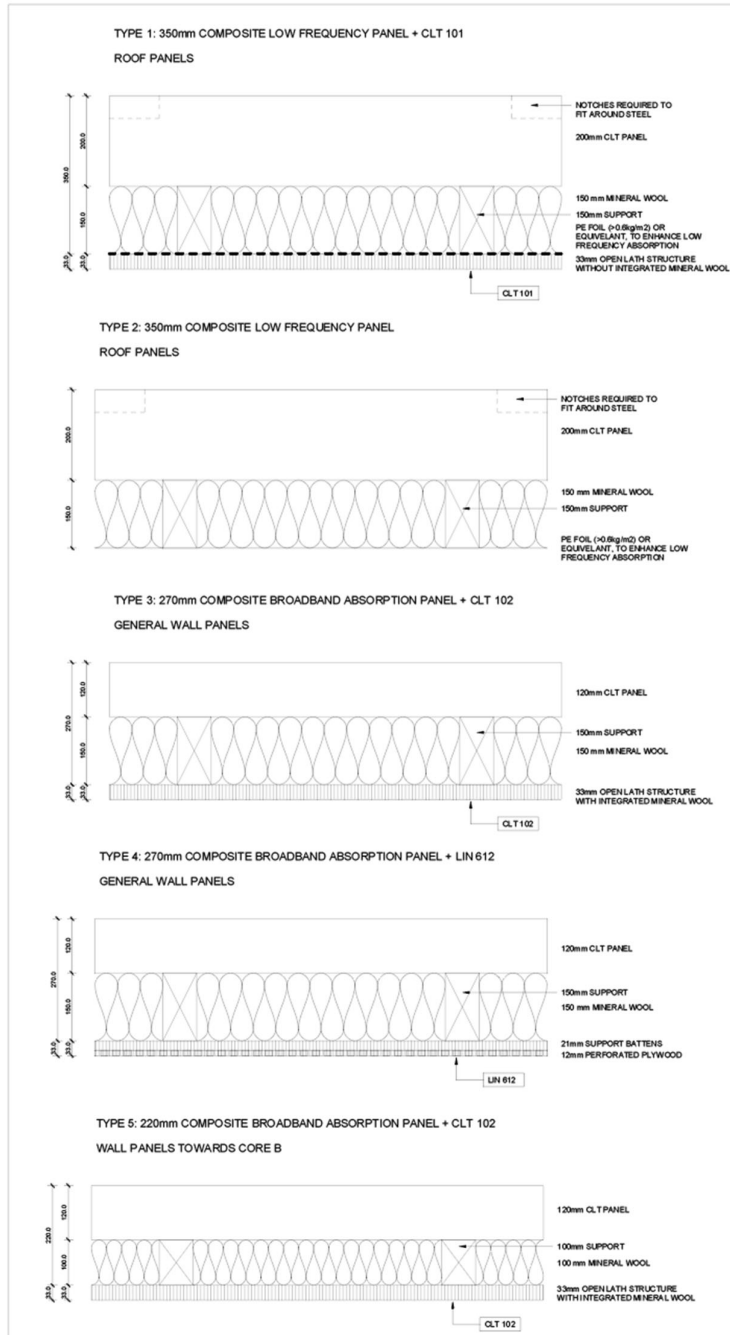


EWS-534

MF-PRA-WH-XX-DR-X-30-0733



EWS-531 / EWS-951 / EWS-953
MF-RYD-TH-XX-DR-A-41-0233



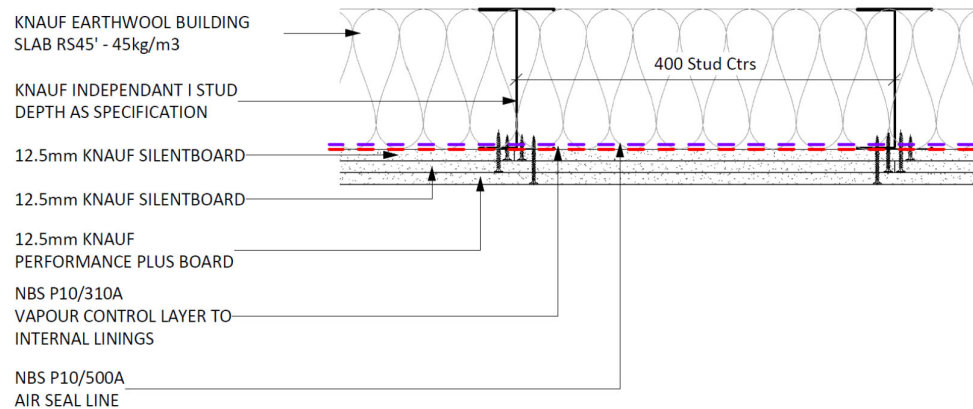
CLT
MF-OMA-TH-XX-DR-A-46-1005

ANNEX D2: TOWER WALL LININGS

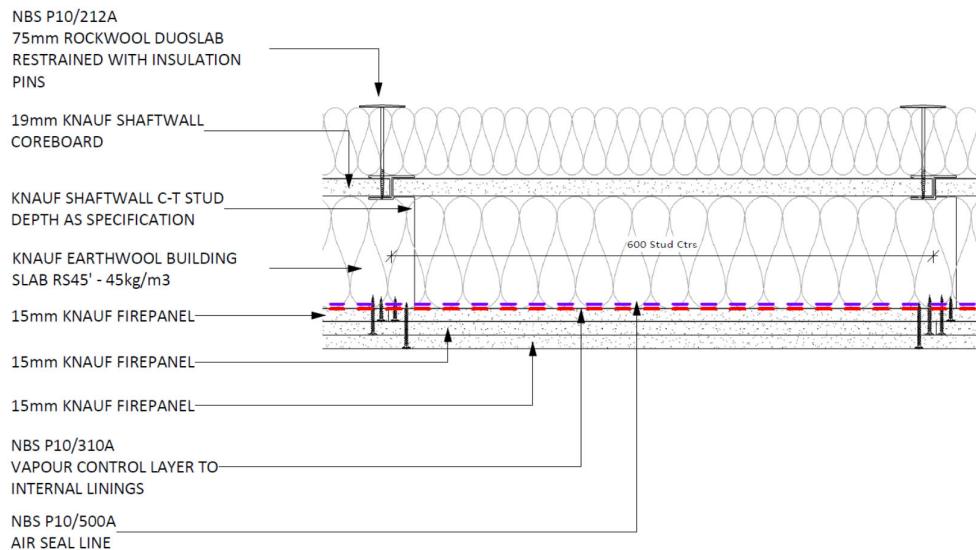
The wall linings and external façade work together as one sound insulating build-up. For the structure borne sound transmission path only the external façade is taken into account.

Reference: MF-RYD-WH-XX-DR-A-89-0100

Type A - NBS K10/145A WALL LINING SYSTEM (METAL STUDS)



Type B - NBS K10/146A METAL STUD SHAFTWALL



ANNEX E: GLAZING TYPES

G3 (EWS-102) vision glass

- 61 mm O/All Glass Unit (Ref – G3) – 85 kg/m³
 - Outer Pane 21.5 mm laminated acoustic low iron
 - Cavity 24 mm Argon filled
 - 15.5 mm laminated acoustic low Iron



G5 (EWS-102) fire rated

- 43.52 mm O/All Glass Unit (Ref - G5) – 55 kg/m³
 - Outer Pane 13.52 mm laminated acoustic low iron
 - Cavity 14 mm Argon filled
 - Inner Pane 16 mm Contraflam 30



G6 (EWS-102) Fire Rated Vision Glass Doors

- 16 mm O/All Glass Unit (Ref – G6) – 40 kg/m³
 - Single Pane – 16 mm Contraflam 30



G4 (EWS-102) Vision Glass Doors

- 43 mm O/All Glass Unit (Ref – G4) – 40 kg/m³
 - Outer Pane 9.5 mm laminated acoustic low iron
 - Cavity 24 mm Argon filled
 - Inner Pane 9.5 mm Laminated Acoustic low iron



G1 (EWS-101) Vision Glass

- 61 mm O/All Glass Unit (Ref G1)
 - Outer pane 21.5 mm Laminated Acoustic Low Iron
 - Cavity 24 mm Argon filled
 - Inner Pane 15.5 mm Laminated Acoustic low Iron



G2 (EWS-161) Opacified Glass

- 61 mm O/All Glass Unit (Ref G2)
 - Outer Pane 21.5 mm Laminated Acoustic
 - Cavity 24 mm Argon filled
 - Inner Pane 15.5 mm Laminated Acoustic
 - 8/1.52 PVB Acoustic/6



The location of the glazing types are shown on the elevations on the next page for the Ground Floor foyer and the Towers on the east side of the building. The Theatre foyer on the west side will have glazing type G2 or equivalent.

ANNEX F1: 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

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	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. 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	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. 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 F2: 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	ACS REGISTRARS ISO 9001	ACS REGISTRARS ISO 14001	ACS REGISTRARS OHSAS 18001
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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

II. 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

II. 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

II. 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

II. 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

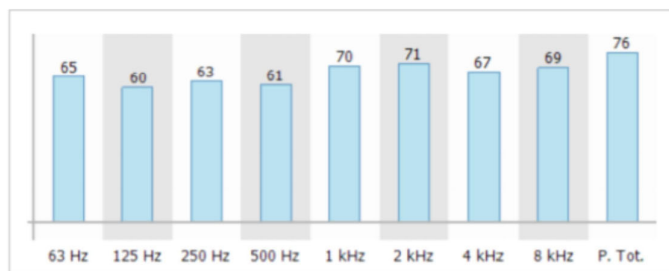
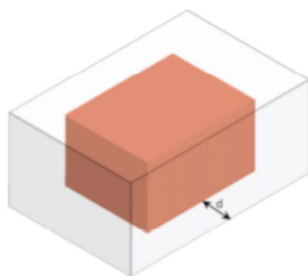
COMPRESSORS

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

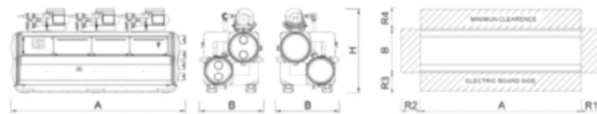
Distance	m	1
Note	Average sound pressure level at 1 m distance, unit in a free field on a reflective surface; non-binding value calculated from the sound power level; Sound power on the basis of measurements made in compliance with ISO 9614.	

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

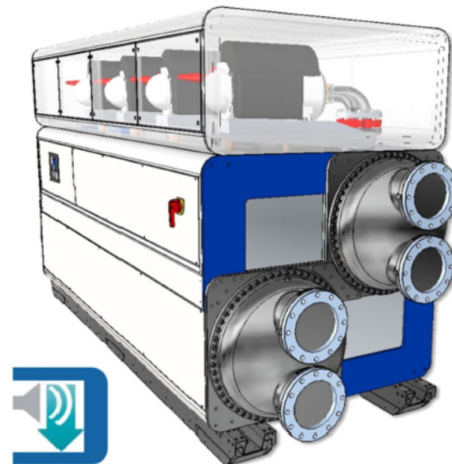
A	mm	2910
B	mm	1560
H	mm	2190
Operating weight	kg	4070
R1	mm	1000
R2	mm	2500
R3	mm	1500
R4	mm	1000



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 F3: 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

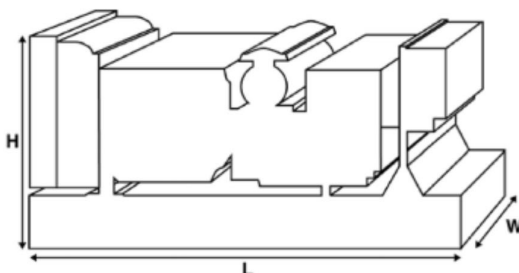
P250-5

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)

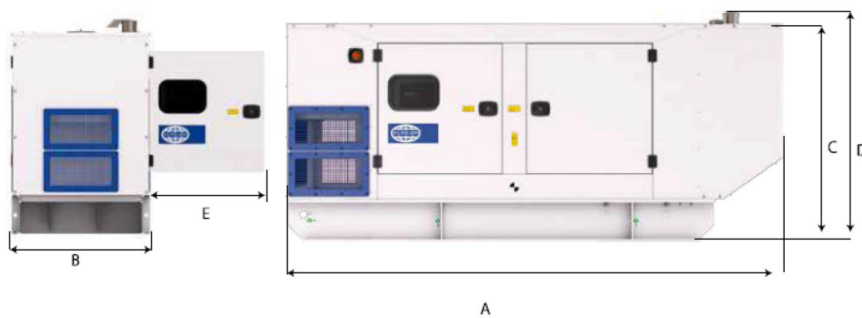
Ratings in accordance with ISO 8528, ISO 3046, IEC 60034, BS5000 and NEMA MG-1.22.
Generator set pictured may include optional accessories.

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

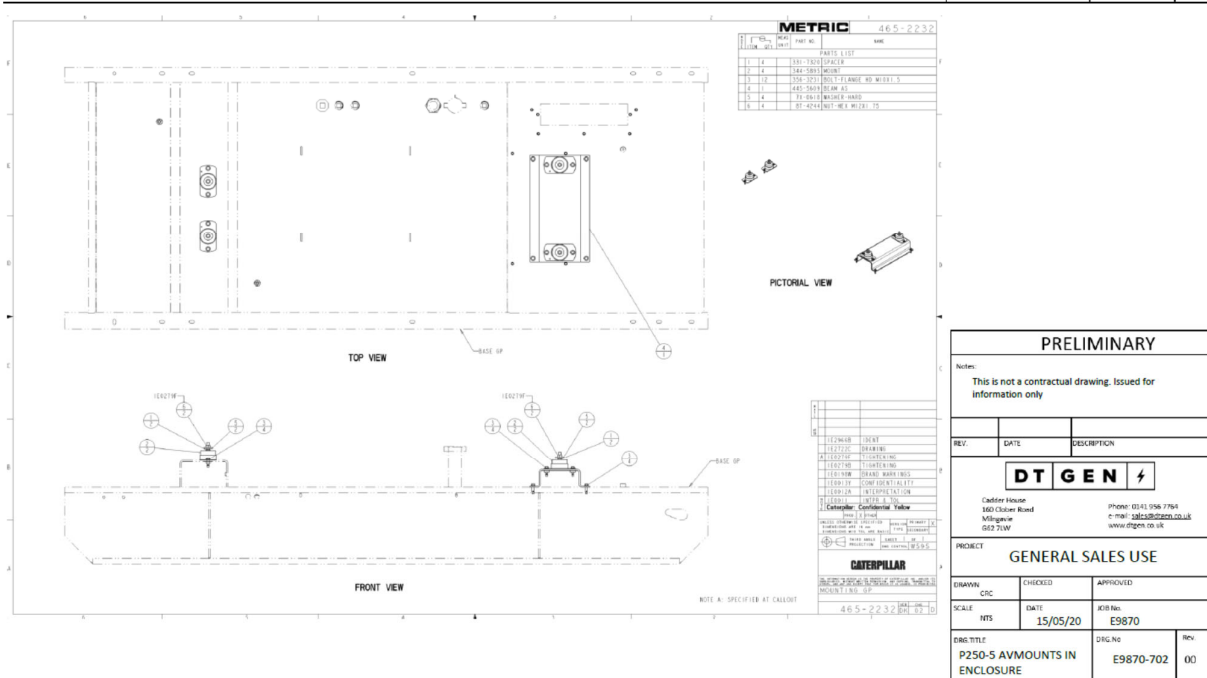
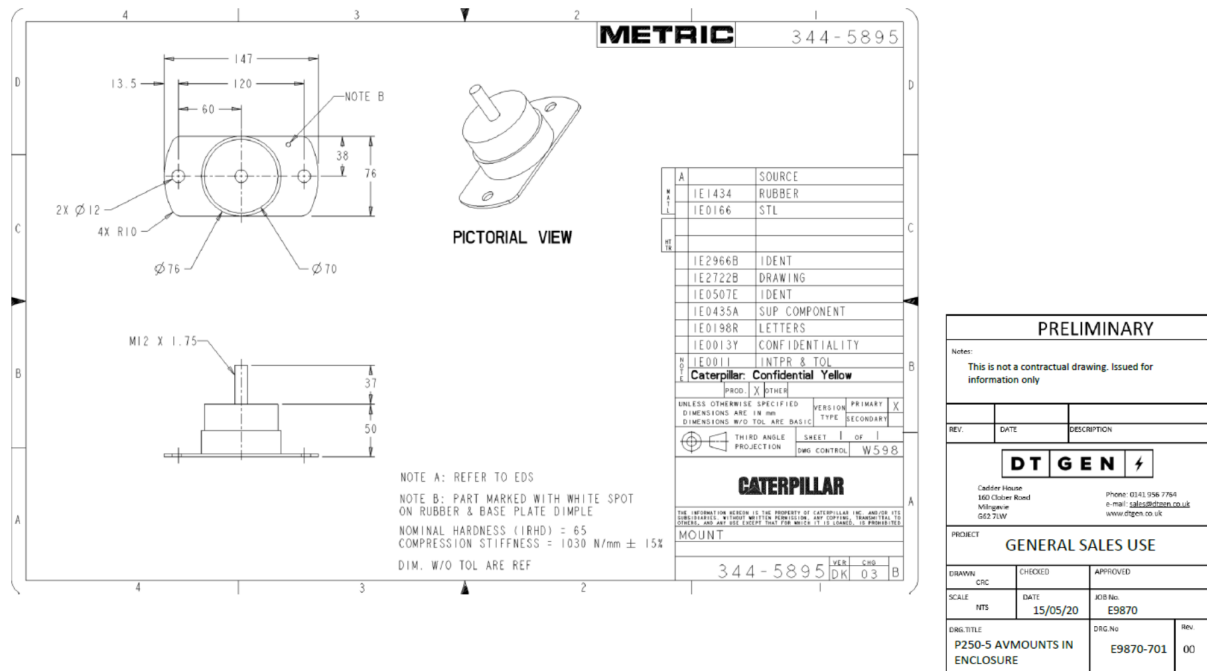
Generator Set Model		50 Hz						Ambient Capability °C
		15 m (50 ft)		7 m (23 ft)		1 m (3 ft)		
		75% Load	100% Load	75% Load	100% Load	75% Load	100% Load	
P250-S	Prime/standby	61/61	62/62	67/67	68/68	75/75	76/76	49



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: $k_{dyn} \leq 1,6 \text{ MN/m}$



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 F4: FANS

FAN-WH-L6-SF1

Sound information with acoustic jacket:

	63	125	250	500	1K	2K	4K	8K	Total	dB(A) @ 3.0	m
SWLD - Inlet	34	41	46	51	48	45	35	24	54 dB	32 dB(A)	
SWLD - Outlet	33	42	48	51	51	46	39	27	56 dB	34 dB(A)	
RW - Fan (Steel) Casing	3	8	14	20	25	30	34	35	39 dB		
SWLB	34	42	45	43	37	28	16	3	49 dB		
Breakout SPL (A) @ 3m	0	5	16	20	16	8	0	0		23 dB(A)	Breakout @ 3m
Acoustic Jacket	7	14	17	21	27	30	34	39	41 dB		
SWLB	34	39	41	40	33	25	13	0	45 dB		
Breakout SPL (A) @ 3m	0	2	11	16	12	5	0	0		19 dB(A)	Breakout @ 3m



Represented by:
ELTA FANS LTD (BUILDING SERVICES)
Tel: +44 (0)1384 275800 Fax: +44 (0)1384 275810 email: sales@eltafans.co.uk
46 Third Avenue, Pensnett Trading Estate, Kingswinford, West Midlands DY6 7US, UK
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Quotation 50K-0620-227
Fans

Project: The Factory Manchester

Date: 08/07/2020

Revision: B

Consulting Engineer: Melissa Goodman

Location	Designation	Catalogue No.	Description	Qty.	Vol. (m³/s)	Press (Pa)	Speed (r/min)	Motor Power	Motor Type	Electrical Supply	Inlet Sound Spectra(dBW)								SPL (dBA)
					63	125	250	500	1K	2K	4K	8K							
KEF02		SQU1/4-3HTS	Centrifugal Box	1	0.12	200	1450	0.25kW		400V 3ph 50Hz	62	66	70	70	66	62	57	53	51@ 3m
FAN-TH-L2-EF1		SCP710/4/6-3AC (Star speed)	Axial Plate	3	0.78	150	1114	0.75kW		400V 3ph 50Hz	68	73	73	77	76	76	75	69	62@ 3m
FAN-TH-L1-EF1		SEM150-1EC (4.8 speed)	Multiflow SEM EC	1	0.01	100	1948	0.07kW		230V 1ph 50Hz	34	41	46	51	48	45	35	24	32@ 3m
FAN-WH-L6-SF1		SLC560/4A-3AC	Axial Duct	2	1.95	150	1450	0.75kW		400V 3ph 50Hz	75	68	78	73	72	72	70	64	58@ 3m



Fläkt Woods Limited
Technical Data Sheet - [Duty 1]
JM Aerofoil

FläktGroup

Quotation Number	:	Project Code	:	BO-6381-8
Project Name	:	Customer	:	ADS Gareth Elliot
Item Reference:	:	Date:	:	Thursday, March 5, 2020

Fan Code	HT125JM/40/4/6/19
Fan Diameter / Size	1250 Size / mm
Blades	6
Fan Speed - [Duty 1]	1470 rpm
Velocity	13.9 m/s
Blade Angle	19°
Installation Type / Form of Running	D / BU (Vertical)
Fan Casing	Long

Requested Duty - [Duty 1]	17m³/s @ 500 Pa (static)
Actual Emergency Duty - [Duty 1]	17.05m³/s @ 733 Pa (static)
Outlet Dynamic Pressure	116 Pa
Accessory Losses	58 Pa

Idling Loss*	229 Pa
--------------	--------

Duty Shaft Power	24.08 kW
Max Shaft Power	24.80 kW
Total Efficiency	60.1 %

Motor Frame	180M/L [Class H]
Motor Rating	26.40 kW [IE2]
Full Load Current	48.6 A
Starting Current	329.6 A
Motor Mounting	Pad
Electrical Supply	380-420 Volts 50 Hz 3 Phase
Start Type	Enquire
Motor Winding	Standard
Enclosure	Standard All

ErP [FMEG] Rating	N 64 (ErP Compliant 2015)
ErP [FMEG] Target	N 58
FMEG Blade Angle [Range]	18° [8° - 20°]
Measurement Category	D (Total)
VSD	N
Fan + Motor Efficiency	64.7% (22.08 m³/s @ 662 Pa)
Motor Input Power (ErP)	22.57 kW

SFP value	1.53 W/(l/s) @ Requested Duty
Power from mains	26.05 kW
Energy Consumption	78138 kWh (3000 h/year)
Running Cost / Year	£9377

Air Density	1.2 kg/m³ / 20 °C / 0 m / 50% RH
Smoke Venting	300°C / 2 Hours (F300+)

Performance data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with ISO 5801 and is specifically applicable for Ducted installations. When an electronic controller is incorporated, enhanced motor noise can occur - particularly when the operating speed is well below maximum. FWL therefore recommend using an auto transformer speed controller for noise sensitive applications. Bifurcateds are Erp exempt when used continuously at >100C. They are not for use in the EEA at lower temperatures.

Acoustic data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with BS 848 Pt 2, 1985 / ISO 5136 under Ducted conditions. The LpA figure provided is the overall Inlet sound pressure level calculated at the specified distance, under spherical, free field conditions. Breakout levels stated are estimated from induct sound power levels and are provided for guidance.

Acoustic figures for adjusted running speeds have been interpolated and are for reference only.

Selection includes run / standby in series losses. Sound levels could differ to those stated, dependant on fan spacing.

This Offer is made subject to the latest version of our A100-19 Terms and Conditions, a copy of which can be made available on request.

	Sound Spectrum (Hz)								Overall	
	63	125	250	500	1k	2k	4k	8k	Lw*	LpA @ 3 m**
Inlet*	119	116	112	114	114	106	102	96	123	96
Outlet*	121	118	114	114	114	106	101	98	124	96
Breakout*	111	95	86	87	87	77	80	75	111	71

* Lw dB re 10-12W ** dBA re 2x10-5 Pa
Sound data at requested duty.

Description	Qty	Nett Unit Price	Price
Fan			
HT125JM/40/4/6/19	2		
Accessories			
- Set of Mounting Feet (3)	1		
Spring Anti Vibration Mounts (set of 6)	1		
74919 - Matching Flange	2		
AS041002 - Flex connector c/w 2 clips (less Flanges)	2		
91344 - Air Operated Damper - Horizontal	1		
EA901012 Inverter IP20	2		
Estimated Despatch : 8 Weeks			
TOTAL PRICE (Fan / Accessories / Controls)			
Optional Controllers & Sensors		Optional Accessories	
 IDDXF54 - 3/3 - Inverter [EA901027]			

Website:

Tel: Fax:

Email: Simon.Plummer@flaktwoods.com

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Printed on 11 January 2021

Page 1 of 18

Selection Engine: 3.1.3.43a(1)(UK.3.6.0)(e)



Fläkt Woods Limited
Technical Data Sheet - [Duty 1]
JM Aerofoil

FläktGroup

Quotation Number	:	Project Code	:	BO-6381-9
Project Name	:	Customer	:	ADS Gareth Elliot
Item Reference:	:	Date:	:	Thursday, March 5, 2020

Fan Code	HT140JM/40/4/9/22
Fan Diameter / Size	1400 Size / mm
Blades	9
Fan Speed - [Duty 1]	1470 rpm
Velocity	20.2 m/s
Blade Angle	22°
Installation Type / Form of Running	D / BU (Vertical)
Fan Casing	Long
Requested Duty - [Duty 1]	31m³/s @ 500 Pa (static)
Actual Emergency Duty - [Duty 1]	31.11m³/s @ 964 Pa (static)
Outlet Dynamic Pressure	245 Pa
Accessory Losses	245 Pa
Idling Loss*	457 Pa
Duty Shaft Power	62.4 kW
Max Shaft Power	64.3 kW
Total Efficiency	60.3 %
Motor Frame	250S/M [Class H]
Motor Rating	66.0 kW [IE2]
Full Load Current	120 A
Starting Current	616 A
Motor Mounting	Pad
Electrical Supply	380-420 Volts 50 Hz 3 Phase
Start Type	Enquire
Motor Winding	Standard
Enclosure	Standard All
ErP [FMEG] Rating	N 65 (ErP Compliant 2015)
ErP [FMEG] Target	N 58
FMEG Blade Angle [Range]	22° [8° - 22°]
Measurement Category	D (Total)
VSD	N
Fan + Motor Efficiency	67.2% (36.03 m³/s @ 1174 Pa)
Motor Input Power (ErP)	62.9 kW
SFP value	2.14 W/(l/s) @ Requested Duty
Power from mains	66.47 kW
Energy Consumption	199405 kWh (3000 h/year)
Running Cost / Year	£23929
Air Density	1.2 kg/m³ / 20 °C / 0 m / 50% RH
Smoke Venting	300°C / 2 Hours (F300+)

Performance data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with ISO 5801 and is specifically applicable for Ducted installations. When an electronic controller is incorporated, enhanced motor noise can occur - particularly when the operating speed is well below maximum. FWL therefore recommend using an auto transformer speed controller for noise sensitive applications. Bifurcateds are Erp exempt when used continuously at >100C. They are not for use in the EEA at lower temperatures.

Acoustic data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with BS 848 Pt 2, 1985 / ISO 5136 under Ducted conditions. The LpA figure provided is the overall Inlet sound pressure level calculated at the specified distance, under spherical, free field conditions. Breakout levels stated are estimated from induct sound power levels and are provided for guidance.

Acoustic figures for adjusted running speeds have been interpolated and are for reference only.

Selection includes run / standby in series losses. Sound levels could differ to those stated, dependant on fan spacing.

This Offer is made subject to the latest version of our A100-19 Terms and Conditions, a copy of which can be made available on request.

	Sound Spectrum (Hz)								Overall	
	63	125	250	500	1k	2k	4k	8k	Lw*	LpA @ 3 m**
Inlet*	107	107	104	106	105	104	101	98	114	90
Outlet*	111	109	105	107	107	104	103	99	116	91
Breakout*	101	86	77	80	80	75	82	76	101	66

* Lw dB re 10-12W ** dBA re 2x10-5 Pa
Sound data at requested duty.

Description	Qty	Nett Unit Price	Price
Fan			
HT140JM/40/4/9/22	2		
Accessories			
Set of Mounting Feet (3)	1		
Spring Anti Vibration Mounts (set of 6)	1		
74920 - Matching Flange	2		
AS041004 - Flex connector c/w 2 clips (less Flanges)	2		
91343 - Air Operated Damper - Horizontal	2		
EA901070 Inverter IP54	2		
Estimated Despatch : 12 Weeks			
TOTAL PRICE (Fan / Accessories / Controls)			
Optional Controllers & Sensors		Optional Accessories	

Website:

Email: Simon.Plummer@flaktwoods.com

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Selection Engine: 3.1.3.43a(1)(UK.3.6.0)(e)



Fläkt Woods Limited
Technical Data Sheet - [Duty 1]
JM Aerofoil

FläktGroup

Quotation Number	:	BO-6381-10
Project Name	:	ADS Gareth Elliot
Item Reference:	:	SEF-WH-08-01&02
	:	Thursday, March 5, 2020

Fan Code	HT63JM/25/2/3/28
Fan Diameter / Size	630 Size / mm
Blades	3
Fan Speed - [Duty 1]	2910 rpm
Velocity	19.6 m/s
Blade Angle	28°
Installation Type / Form of Running	D / BU (Vertical)
Fan Casing	Long
Requested Duty - [Duty 1]	6m³/s @ 300 Pa (static)
Actual Emergency Duty - [Duty 1]	6.12m³/s @ 454 Pa (static)
Outlet Dynamic Pressure	231 Pa
Accessory Losses	116 Pa
Idling Loss*	136 Pa
Duty Shaft Power	7.86 kW
Max Shaft Power	8.08 kW
Total Efficiency	53.4 %
Motor Frame	112M [Class H]
Motor Rating	8.25 kW [IE2]
Full Load Current	15.5 A
Starting Current	99.42 A
Motor Mounting	Pad
Electrical Supply	380-420 Volts 50 Hz 3 Phase
Start Type	DOL
Motor Winding	Standard
Enclosure	Standard All
ErP [FMEG] Rating	N 58 (ErP Compliant 2015)
ErP [FMEG] Target	N 58
FMEG Blade Angle [Range]	20° [12° - 28°]
Measurement Category	D (Total)
VSD	N
Fan + Motor Efficiency	56.9% (5.23 m³/s @ 571 Pa)
Motor Input Power (ErP)	5.25 kW
SFP value	1.47 W/(l/s) @ Actual Duty
Power from mains	9 kW
Energy Consumption	27013 kWh (3000 h/year)
Running Cost / Year	£3242
Air Density	1.2 kg/m³ / 20 °C / 0 m / 50% RH
Smoke Venting	300°C / 2 Hours (F300+)

Performance data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with ISO 5801 and is specifically applicable for Ducted installations. When an electronic controller is incorporated, enhanced motor noise can occur - particularly when the operating speed is well below maximum. FWL therefore recommend using an auto transformer speed controller for noise sensitive applications. Bifurcateds are Erp exempt when used continuously at >100C. They are not for use in the EEA at lower temperatures.

Acoustic data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with BS 848 Pt 2, 1985 / ISO 5136 under Ducted conditions. The LpA figure provided is the overall Inlet sound pressure level calculated at the specified distance, under spherical, free field conditions. Breakout levels stated are estimated from induct sound power levels and are provided for guidance.

Acoustic figures for adjusted running speeds have been interpolated and are for reference only.

Selection includes run / standby in series losses. Sound levels could differ to those stated, dependant on fan spacing.

This Offer is made subject to the latest version of our A100-19 Terms and Conditions, a copy of which can be made available on request.

	Sound Spectrum (Hz)								Overall	
	63	125	250	500	1k	2k	4k	8k	Lw*	LpA @ 3 m**
Inlet*	111	108	106	100	93	90	87	84	114	82
Outlet*	113	110	107	100	93	91	89	86	116	83
Breakout*	103	89	81	75	68	64	70	62	103	61

* Lw dB re 10-12W ** dBA re 2x10-5 Pa
Sound data at actual duty.

Description	Qty	Nett Unit Price	Price
Fan			
HT63JM/25/2/3/28	2		
Accessories			
AS021108 - Set of Mounting Feet (2)	1		
AS035484 - Spring Anti Vibration Mounts (set)	1		
DA074915 - Matching Flange	2		
AS040630 - Flex connector c/w 2 clips (less Flanges)	2		
414475 - Air Operated Damper - Horizontal	1		
EA901007 Inverter IP20	2		
Estimated Despatch : 6 Weeks			
TOTAL PRICE (Fan / Accessories / Controls)			
Optional Controllers & Sensors	Optional Accessories		
 IDDXF54 - 3/3 - Inverter [EA901023]			

Website:

Email: Simon.Plummer@flaktwoods.com

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Selection Engine: 3.1.3.43a(1)(UK.3.6.0)(e)



Fläkt Woods Limited
Technical Data Sheet - [Duty 1]
JM Aerofoil

FläktGroup

Quotation Number	:	BO-6381-11
Project Name	:	ADS Gareth Elliot
Item Reference:	:	SEF-TH-05-05&06
	:	Thursday, March 5, 2020

Fan Code	HT63JM/25/2/3/28
Fan Diameter / Size	630 Size / mm
Blades	3
Fan Speed - [Duty 1]	2910 rpm
Velocity	19.6 m/s
Blade Angle	28°
Installation Type / Form of Running	D / BU (Vertical)
Fan Casing	Long
Requested Duty - [Duty 1]	6m³/s @ 300 Pa (static)
Actual Emergency Duty - [Duty 1]	6.12m³/s @ 454 Pa (static)
Outlet Dynamic Pressure	231 Pa
Accessory Losses	116 Pa
Idling Loss*	136 Pa
Duty Shaft Power	7.86 kW
Max Shaft Power	8.08 kW
Total Efficiency	53.4 %
Motor Frame	112M [Class H]
Motor Rating	8.25 kW [IE2]
Full Load Current	15.5 A
Starting Current	99.42 A
Motor Mounting	Pad
Electrical Supply	380-420 Volts 50 Hz 3 Phase
Start Type	DOL
Motor Winding	Standard
Enclosure	Standard All
ErP [FMEG] Rating	N 58 (ErP Compliant 2015)
ErP [FMEG] Target	N 58
FMEG Blade Angle [Range]	20° [12° - 28°]
Measurement Category	D (Total)
VSD	N
Fan + Motor Efficiency	56.9% (5.23 m³/s @ 571 Pa)
Motor Input Power (ErP)	5.25 kW
SFP value	1.47 W/(l/s) @ Actual Duty
Power from mains	9 kW
Energy Consumption	27013 kWh (3000 h/year)
Running Cost / Year	£3242
Air Density	1.2 kg/m³ / 20 °C / 0 m / 50% RH
Smoke Venting	300°C / 2 Hours (F300+)

Performance data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with ISO 5801 and is specifically applicable for Ducted installations. When an electronic controller is incorporated, enhanced motor noise can occur - particularly when the operating speed is well below maximum. FWL therefore recommend using an auto transformer speed controller for noise sensitive applications. Bifurcateds are Erp exempt when used continuously at >100C. They are not for use in the EEA at lower temperatures.

Acoustic data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with BS 848 Pt 2, 1985 / ISO 5136 under Ducted conditions. The LpA figure provided is the overall Inlet sound pressure level calculated at the specified distance, under spherical, free field conditions. Breakout levels stated are estimated from induct sound power levels and are provided for guidance.

Acoustic figures for adjusted running speeds have been interpolated and are for reference only.

Selection includes run / standby in series losses. Sound levels could differ to those stated, dependant on fan spacing.

This Offer is made subject to the latest version of our A100-19 Terms and Conditions, a copy of which can be made available on request.

	Sound Spectrum (Hz)								Overall	
	63	125	250	500	1k	2k	4k	8k	Lw*	LpA @ 3 m**
Inlet*	111	108	106	100	93	90	87	84	114	82
Outlet*	113	110	107	100	93	91	89	86	116	83
Breakout*	103	89	81	75	68	64	70	62	103	61

* Lw dB re 10⁻¹² W
** dBA re 2x10⁻⁵ Pa
Sound data at actual duty.

Description	Qty	Nett Unit Price	Price
Fan			
HT63JM/25/2/3/28	2		
Accessories			
AS021108 - Set of Mounting Feet (2)	1		
AS035484 - Spring Anti Vibration Mounts (set)	1		
DA074915 - Matching Flange	2		
AS040630 - Flex connector c/w 2 clips (less Flanges)	2		
414475 - Air Operated Damper - Horizontal T	1		
EA901007 Inverter IP20	2		
Estimated Despatch : 6 Weeks			
TOTAL PRICE (Fan / Accessories / Controls)			
Optional Controllers & Sensors		Optional Accessories	
 IDDXF54 - 3/3 - Inverter [EA901023]			

Website:

Email: Simon.Plummer@flaktwoods.com

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Selection Engine: 3.1.3.43a(1)(UK.3.6.0)(e)



Fläkt Woods Limited
Technical Data Sheet - [Duty 1]
JM Aerofoil

FläktGroup

Quotation Number	:	BO-6381-12
Project Name	:	ADS Gareth Elliot
Item Reference:	:	SEF-TH-05-03&04
Date:	:	Thursday, March 5, 2020

Fan Code	HT63JM/25/2/3/28
Fan Diameter / Size	630 Size / mm
Blades	3
Fan Speed - [Duty 1]	2910 rpm
Velocity	19.6 m/s
Blade Angle	28°
Installation Type / Form of Running	D / BU (Vertical)
Fan Casing	Long
Requested Duty - [Duty 1]	6m³/s @ 300 Pa (static)
Actual Emergency Duty - [Duty 1]	6.12m³/s @ 454 Pa (static)
Outlet Dynamic Pressure	231 Pa
Accessory Losses	116 Pa
Idling Loss*	136 Pa
Duty Shaft Power	7.86 kW
Max Shaft Power	8.08 kW
Total Efficiency	53.4 %
Motor Frame	112M [Class H]
Motor Rating	8.25 kW [IE2]
Full Load Current	15.5 A
Starting Current	99.42 A
Motor Mounting	Pad
Electrical Supply	380-420 Volts 50 Hz 3 Phase
Start Type	DOL
Motor Winding	Standard
Enclosure	Standard All
ErP [FMEG] Rating	N 58 (ErP Compliant 2015)
ErP [FMEG] Target	N 58
FMEG Blade Angle [Range]	20° [12° - 28°]
Measurement Category	D (Total)
VSD	N
Fan + Motor Efficiency	56.9% (5.23 m³/s @ 571 Pa)
Motor Input Power (ErP)	5.25 kW
SFP value	1.47 W/(l/s) @ Actual Duty
Power from mains	9 kW
Energy Consumption	27013 kWh (3000 h/year)
Running Cost / Year	£3242
Air Density	1.2 kg/m³ / 20 °C / 0 m / 50% RH
Smoke Venting	300°C / 2 Hours (F300+)

Performance data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with ISO 5801 and is specifically applicable for Ducted installations. When an electronic controller is incorporated, enhanced motor noise can occur - particularly when the operating speed is well below maximum. FWL therefore recommend using an auto transformer speed controller for noise sensitive applications. Bifurcateds are Erp exempt when used continuously at >100C. They are not for use in the EEA at lower temperatures.

Acoustic data has been derived from tests carried out in a Flakt Woods laboratory, in accordance with BS 848 Pt 2, 1985 / ISO 5136 under Ducted conditions. The LpA figure provided is the overall Inlet sound pressure level calculated at the specified distance, under spherical, free field conditions. Breakout levels stated are estimated from induct sound power levels and are provided for guidance.

Acoustic figures for adjusted running speeds have been interpolated and are for reference only.

Selection includes run / standby in series losses. Sound levels could differ to those stated, dependant on fan spacing.

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	Sound Spectrum (Hz)								Overall	
	63	125	250	500	1k	2k	4k	8k	Lw*	LpA @ 3 m**
Inlet*	111	108	106	100	93	90	87	84	114	82
Outlet*	113	110	107	100	93	91	89	86	116	83
Breakout*	103	89	81	75	68	64	70	62	103	61

* Lw dB re 10⁻¹² W
Sound data at actual duty.

** dBA re 2x10⁻⁵ Pa

Description	Qty	Nett Unit Price	Price
Fan			
HT63JM/25/2/3/28	2		
Accessories			
AS021108 - Set of Mounting Feet (2)	1		
AS035484 - Spring Anti Vibration Mounts (set)	1		
DA074915 - Matching Flange	2		
AS040630 - Flex connector c/w 2 clips (less Flanges)	2		
414475 - Air Operated Damper - Horizontal	1		
EA901007 Inverter IP20	2		
Estimated Despatch : 6 Weeks			
TOTAL PRICE (Fan / Accessories / Controls)			
Optional Controllers & Sensors	Optional Accessories		
 IDDXF54 - 3/3 - Inverter [EA901023]			

Website:

Email: Simon.Plummer@flaktwoods.com

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Selection Engine: 3.1.3.43a(1)(UK.3.6.0)(e)



Fläkt Woods Limited
Technical Data Sheet - [Duty 1]
JM Aerofoil

FläktGroup

Quotation Number	:	BO-6381-13
Project Name	:	ADS Gareth Elliot
Item Reference:	:	SEF-TH-05-01&02
	:	Thursday, March 5, 2020

Fan Code	HT125JM/40/4/6/15
Fan Diameter / Size	1250 Size / mm
Blades	6
Fan Speed - [Duty 1]	1470 rpm
Velocity	11.3 m/s
Blade Angle	15°
Installation Type / Form of Running	D / BU (Vertical)
Fan Casing	Long

Requested Duty - [Duty 1]	13.8m³/s @ 500 Pa (static)
Actual Emergency Duty - [Duty 1]	13.83m³/s @ 710 Pa (static)
Outlet Dynamic Pressure	76 Pa
Accessory Losses	38 Pa

Idling Loss*	207 Pa
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Duty Shaft Power	17.78 kW
Max Shaft Power	19.20 kW
Total Efficiency	61.2 %

Motor Frame	180M/L [Class H]
Motor Rating	26.40 kW [IE2]
Full Load Current	48.6 A
Starting Current	329.6 A
Motor Mounting	Pad
Electrical Supply	380-420 Volts 50 Hz 3 Phase
Start Type	Enquire
Motor Winding	Standard
Enclosure	Standard All

ErP [FMEG] Rating	N 63 (ErP Compliant 2015)
ErP [FMEG] Target	N 58
FMEG Blade Angle [Range]	18° [8° - 20°]
Measurement Category	D (Total)
VSD	N
Fan + Motor Efficiency	64.4% (22.08 m³/s @ 659 Pa)
Motor Input Power (ErP)	22.57 kW

SFP value	1.38 W/(l/s) @ Requested Duty
Power from mains	19.14 kW
Energy Consumption	57416 kWh (3000 h/year)
Running Cost / Year	£6890

Air Density	1.2 kg/m³ / 20 °C / 0 m / 50% RH
Smoke Venting	300°C / 2 Hours (F300+)

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Selection includes run / standby in series losses. Sound levels could differ to those stated, dependant on fan spacing.

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	Sound Spectrum (Hz)								Overall	
	63	125	250	500	1k	2k	4k	8k	Lw*	LpA @ 3 m**
Inlet*	115	112	109	112	111	104	98	92	120	94
Outlet*	117	113	110	112	111	104	97	93	120	94
Breakout*	107	90	82	85	84	75	76	70	107	68

* Lw dB re 10⁻¹² W
** dBA re 2x10⁻⁵ Pa

Sound data at requested duty.

Description	Qty	Nett Unit Price	Price
Fan			
HT125JM/40/4/6/15	2		
Accessories			
Set of Mounting Feet (3)	1		
Spring Anti Vibration Mounts (set of 6)	1		
74919 - Matching Flange	2		
AS041002 - Flex connector c/w 2 clips (less Flanges)	2		
91344 - Air Operated Damper - Horizontal	1		
EA901012 Inverter IP20	2		
Estimated Despatch : 6 Weeks			
TOTAL PRICE (Fan / Accessories / Controls)			
Optional Controllers & Sensors	Optional Accessories		
 IDDXF54 - 3/3 - Inverter [EA901027]			

Website:

Tel: Fax:

Email: Simon.Plummer@flaktwoods.com

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