REF: L0682.1 V1

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30th October 2014

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RE: 107 GRAYS INN ROAD, LONDON
ASSESSMENT OF PLANT NOISE & VIBRATION

Dear Mr Cotton,

Following our recent correspondence we are writing to you with respect to the above project, and our assessment of noise and vibration from a new installation of fixed plant equipment.

The subject of this assessment is the fourth floor plant area adjacent to, and above office accommodation.

We have considered the design standards as advised by AWW on 24th October 2014.

Our assessment is described in the following sections.

1.0 DESIGN OBJECTIVES…

The acoustic performance standards for the development are understood to be based on achievement of the British Council for Offices guidance. The BCO guidance provides a total upper noise level limit due to all sources of noise including ventilation services, and external sources.

We are of the opinion that plant noise should be considerably lower in level than the noise of the ventilation services and external noise. Our proposed criteria which is specific to the noise from the plant room is indicated in Table 1.

Location	Total Noise Limit	Proposed Plant Room Contribution	Proposed Contribution From Internal Services & External Noise
Office Accommodation	NR38	**NR27**	NR37

TABLE 1: PROPOSED NOISE LIMITS FROM PLANT ROOM EQUIPMENT

The combination of NR values is not simple as the descriptor provides knowledge of frequency content in only one of the octave bands, and which may be different for each source. The above combination of levels offers design information for a worst case.

2.0 PLANT EQUIPMENT…

The equipment installed within the plant space is understood to include air cooled condensing units. The noise output characteristics of the installed equipment is shown in Table 2 and Table 3.

Ref	Make/Model	No Off	Sound Power Level (dB re 1 pW) 1/1 Octave Band Centre Frequencies (Hz)							A
			63	125	250	500	1000	2000	4000	8000	
D1	Daikin REMQ12P8	2	--	85	81	79	75	69	63	58	80.4
D2	Daikin REMQ16P8	1	--	84	80	79	74	68	63	62	79.8

TABLE 2: SUMMARY OF SOUND POWER DATA FOR FIXED PLANT

Ref	Make/Model	No Off	Sound Pressure Level (dB re 20 µPa) at 5 m 1/1 Octave Band Centre Frequencies (Hz)							A
			63	125	250	500	1000	2000	4000	8000	
CAP	CAP0361	2	48.7	41.9	40.8	38	31.2	27.1	21.1	--	38.7

TABLE 3: SUMMARY OF SOUND PRESSURE DATA FOR FIXED PLANT

We understand that there are 3 No of the CAP0361 units but that only two of them will be in operation at any one time.

Where data is available as a sound pressure level, we have approximately converted this to a sound power level based on the equipment dimensions and measurement details, using the method described in ISO3744.

The exhaust from all the units is understood to be ducted to outside. We have included a 3 dB reduction in the total noise level of each item of equipment on the basis that the contribution from the exhaust side of the fan accounts for half of the total noise output and that it it sufficiently reduced by the ducting that it makes no contribution to the total.

We have estimated the build-up of reverberant sound within the plant space using a simple Sabine method based on the volume and the proposed room finishes. The estimated reverberation time within the plant area is described in Table 4.

Ref	Location	Reverberation Time (seconds) 1/1 Octave Band Centre Frequencies (Hz)							
		63	125	250	500	1000	2000	4000	8000
RT1	Plant Area	0.5	0.4	0.5	0.5	0.6	0.5	0.5	0.5

TABLE 4: SUMMARY OF ESTIMATED REVERBERATION TIMES

The reverberation time within the office has been assumed to be approximately 0.8 seconds in all 1/1 octave bands.

The manufacturers provide no data on the vibration characteristics of their products which can be used for design.

3.0 SEPARATING STRUCTURES…

There is one floor construction and one wall construction separating the plant area from the office space which are understood to comprise the following build ups, (Ref AWW 3257_6021_B); The locations of each construction are indicated on a marked up plan in the appendix.

Separating Floor Type 1 – Plant Space to Office

- Rockwool hardrock insulation board
- 38 mm plywood deck (or similar of equivalent mass)
- 245 mm timber joist spanning between steel beams at approximately 340 mm centres, with a joist span of c. 2300 mm
- 100 mm fibrous insulation between joists
- 2 x 12.5 mm Fireline plasterboard or equivalent directly fixed to the underside of the joist
- Lay in grid suspended ceiling suspended c. 250 mm below

Separating Wall Type 1 – Wall to office accommodation (includes single door set)

- 2 x 15 mm Soundbloc plasterboard or equivalent
- Twin 60 mm steel stud frame separated by 60 mm
- 180 mm Rockwool insulation (30 kg m^{-3})
- 1 x 18 mm Pyrok board or equivalent
- CMS Danskin liner panels

We understand the door that links the office to the plant space is a laboratory tested single door set formed of a 64 mm leaf with rebated edges and full perimeter seals. For practical purposes to limit the weight of the door and the impact on the supporting structure, we would recommend a maximum sound reduction index for the door to be 47 dB R_w and this has been assumed in our assessment.

We also understand that there are services penetrations through the separating wall which include refrigerant pipes and a supply air duct. The penetrations have been assumed to be made good so that the overall performance of the wall is maintained, and a cross talk attenuator is included within the duct work to maintain the separation offered by the wall.

To ascertain the resulting level of noise within the office areas we have estimated the sound reduction index of the various constructions. As the constructions are multi-layered providing a reliable estimation is not simple and we have used proprietary and in-house software, and also considered on-site test data for similar structures.

Our estimate of the sound insulation for the separating structures under ideal laboratory conditions is summarised in Table 5.

Ref	Estimated Laboratory Sound Reduction Index dB 1/1 Octave Band Centre Frequencies (Hz)								R_w
	63	125	250	500	1000	2000	4000	8000	
Floor 1	22	30	34	39	40	40	48	48	40
Wall 1	24	42	57	66	72	67	79	79	65

TABLE 5: SUMMARY OF ESTIMATED SOUND REDUCTION INDICES FOR SEPARATING STRUCTURES

We have calculated the resulting noise level within the accommodation based on the general principles of calculation described in BS EN ISO 12354-1:2000 *Building Acoustics - Estimation Of Acoustic Performance Of Buildings From The Performance Of Elements - Part 1: Airborne Sound Insulation Between Rooms*.

In the absence of a more accurate estimate, we have included a general tolerance for sound flanking transmission and on-site degrades due to workmanship of 5 dB.

4.0 ASSESSMENT OUTCOME…

A summary of the calculated noise levels, against the target values, and the resulting conclusions are summarised in Table 6.

Location	Description	Estimated Noise Level (NR)	Criterion (NR)	Criterion Achieved
1	Fourth Floor Office (Inc Door)	NR37	NR27	No
2	Third Floor Office	NR41	NR27	No

TABLE 6: SUMMARY OF CALCULATED NOISE LEVELS IN THE PENTHOUSE ACCOMMODATION

We can conclude from the above analysis that the target noise levels will not be satisfied due to noise from the fixed plant within the fourth floor plant space.

In our opinion the levels of plant noise that we have predicted will be noticeable and potentially disturbing to the occupants of the office.

We recommend further mitigation be considered, which is discussed in more detail in the following sections.

5.0 RECOMMENDATIONS FOR DESIGN CHANGES…

We recommend an enhancement to the performance of the separating wall and floor surrounding the 4th floor plant space.

We have investigated various methods of enhancement and can recommend the following:

Wall to 4th Floor Office
This structure is limited by the inclusion of the single access door. The specification of the door is already very high and although higher specification door sets are available we would not recommend increasing the specification due to the effects on the structure and the practicalities of operation.

Instead we are of the opinion that the access to the plant room be separated using more than one door. This could be achieved by rearranging the layout of the stair landing so that the plant room access door is within the stair lobby. Doing so would provide a non-critical space as a buffer and the specification of the plant room door and the office door could be reduced to 35 and 30 dB R_w respectively.

Alternatively, consideration could be given to providing back to back door sets to the plant room. Each door is recommended to have a laboratory measured sound reduction index of at least 35 dB R_w, and be separated by at least 100 mm. We further recommend the face of one of the doors have 25 mm open cell foam or similar installed to provide sound absorption within the formed cavity when the doors are both closed.

For comparison the level of noise expected within the office without the door, and hence due to sound transfer via the wall construction only, is NR30, with the decisive band being 63 Hz.

We are of the opinion that it the target noise level is unlikely to be achieved in this situation unless a more massive wall construction can be used to provide improved sound insulation at low frequencies.

Floor to 3rd Floor Office / Meeting Room
We have investigated changes to the proposed separating floor construction to reduce the level of sound transferred to the office space below.

We are of the opinion that the plasterboard ceiling should not be attached to the underside of the joists directly. Instead we recommend the use of a metal frame grid to lower the ceiling level below the bottom flange of the steel work (i.e. to provide a cavity of c. 360 mm).

In addition we recommend the mass of the ceiling be increased as far as practicable and as a minimum recommend using 2 x 15 mm Fireline plasterboard.

In a situation where only airborne noise was a consideration, the use of a resilient bar or hanger would be advisable to improve the sound insulation. However in this case we would not recommend the use of a resilient bar as the resonant frequency of the ceiling would be in the range 80-100 Hz and may give rise to an appreciable level of re-radiated low frequency noise.

The final change to the design is proposed to be the inclusion of a sound insulating suspended ceiling tile, such as the Rockfon Sonar dB40 or Alaska dB40, or the CEP Acoustique dB tiles as examples.

The resulting level of noise within the office below with the proposed changes to the ceiling and suspended tile is NR26.

6.0 VIBRATION…

The vibration characteristics of the proposed equipment is not readily available. It is common for the fundamental vibration characteristics to be related to the operating speed of the fans and compressors.

The manufacturer data suggests the CAP units have an operating speed of 880 rpm (or c. 14.5 Hz). It is not clear from the data the number of blades on each fan. A six bladed fan would display a strong characteristic at c. 80 Hz.

The natural frequency of the lowest mode of vibration of the floor is estimated to be approximately 120 Hz, taking into account the span of the timber joists, the typical material properties and the loading. This is a simplified analysis on the basis the steel work is rigid and the joists are clamped into the steel flange at each end, which of course in reality is an approximation. This is a relatively high natural frequency for the lowest mode of vibration of a floor and which suggests there is some risk of interaction between the dynamics of the floor and the provision of anti-vibration mounts.

We are not able to determine the isolation characteristics of the currently proposed “big foot” mounting onto the rockwool hardrock. It is expected that the hardrock insulation would offer a similar dynamic stiffness to the Rockfloor product normally used in building designs, but this is not confirmed. It is therefore considered likely that the proposal will provide some degree of vibration

isolation at higher frequencies, however the natural frequency of the system cannot be determined and there is an inherent risk of amplification at the natural frequency of the mounting.

It is not possible to provide a detailed analysis of the vibration characteristics of the installation. We therefore recommend utilising best practice as a mean of mitigating the risk. Our recommendation is that the condensers be installed on proprietary soft anti-vibration mounts with a natural frequency well below that of the likely operating characteristics of the units and that of the floor.

As a minimum an anti-vibration mount with a static deflection of not less than 2.5 mm (10 Hz) is recommended to each of the units. This level of isolation is expected to be readily achievable with a rubber mount. Alternative means of isolation can be considered, such as mounting multiple units on a single base.

7.0 ASSESSMENT CONCLUSION…

We have undertaken a desktop assessment of the noise transfer from the 4th floor plant room to the surrounding office accommodation.

We have concluded that the proposed equipment will not achieve an acceptable level of noise within the neighbouring areas and we have proposed enhancements to the separating walls and floors to improve the outcome.

We are of the opinion that the target noise levels cannot be readily achieved within the 4th floor office space without changing the separating wall to a massive construction, and a layout change to mitigate the weakness of the link door.

We are of the opinion that the target noise level is achievable in the 3rd floor office space with the proposed change to the separating floor and provision of an enhanced ceiling tile to the office space.

In the absence of usable design information relating to the vibration characteristics of the proposed equipment we recommend installing the equipment on proprietary vibration mounts with a low natural frequency.

I trust you find this assessment provides suitable information for your needs. Please advise if you require anything further.

Yours sincerely,
For Red Twin Limited

Ian Matthews CEng MEng MIOA AMIMechE
Director
Chartered Engineer

8.0 APPENDIX A – PLANS…

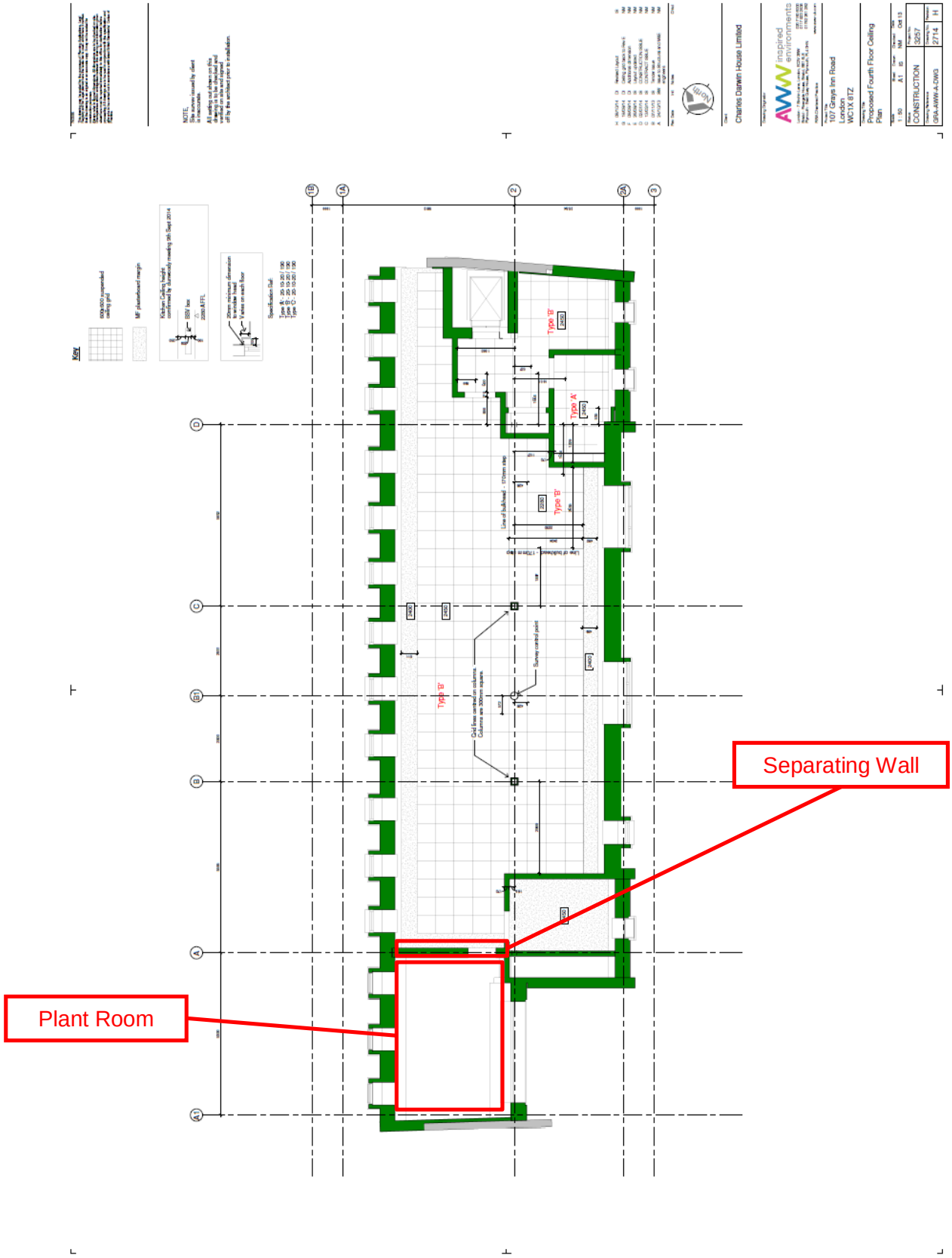


FIGURE 1: 4TH FLOOR GENERAL ARRANGEMENT (NOT TO SCALE)

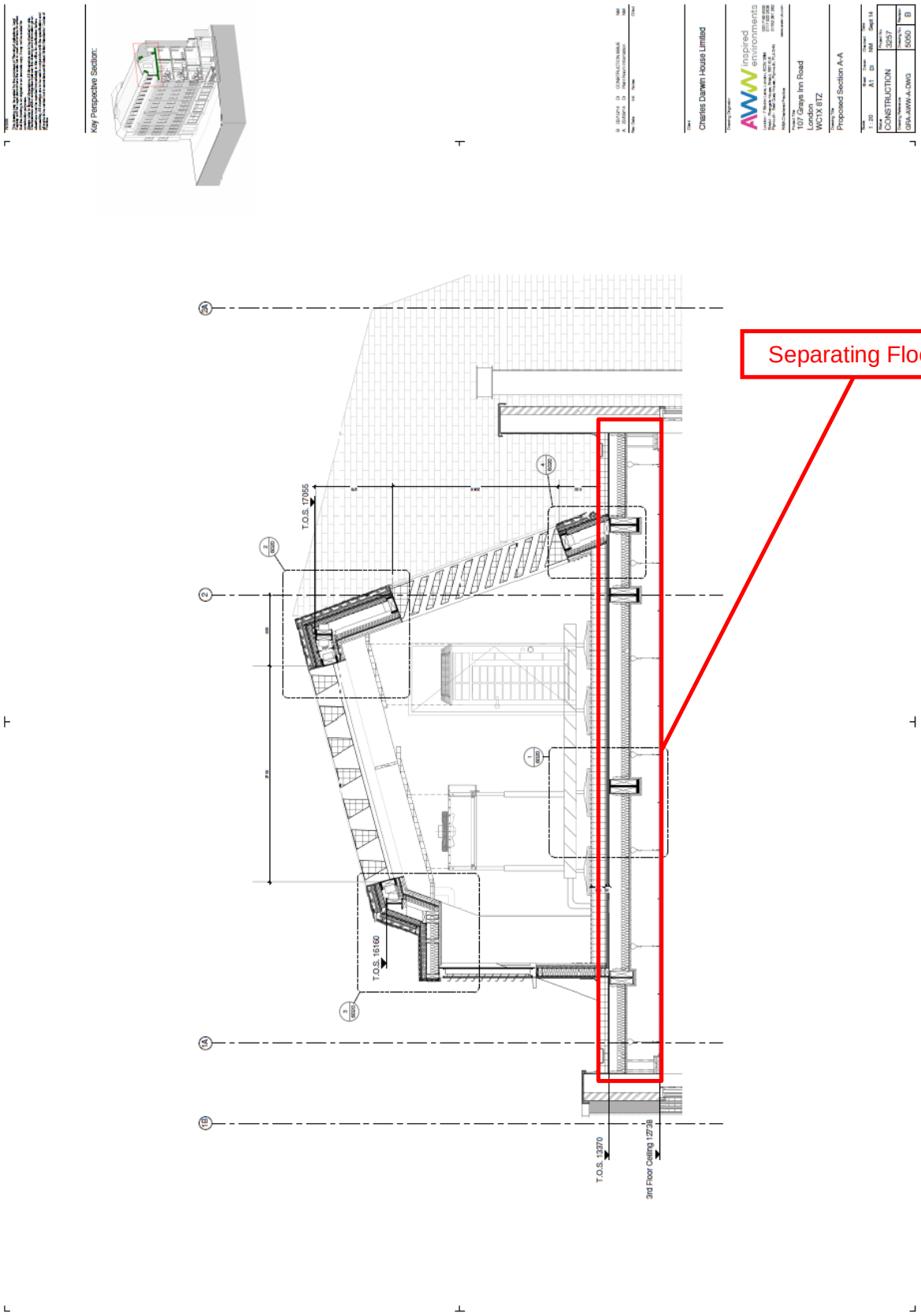


FIGURE 2: 4TH FLOOR PLANT ROOM SECTION INDICATING SEPARATING FLOOR STRUCTURE (NTS)

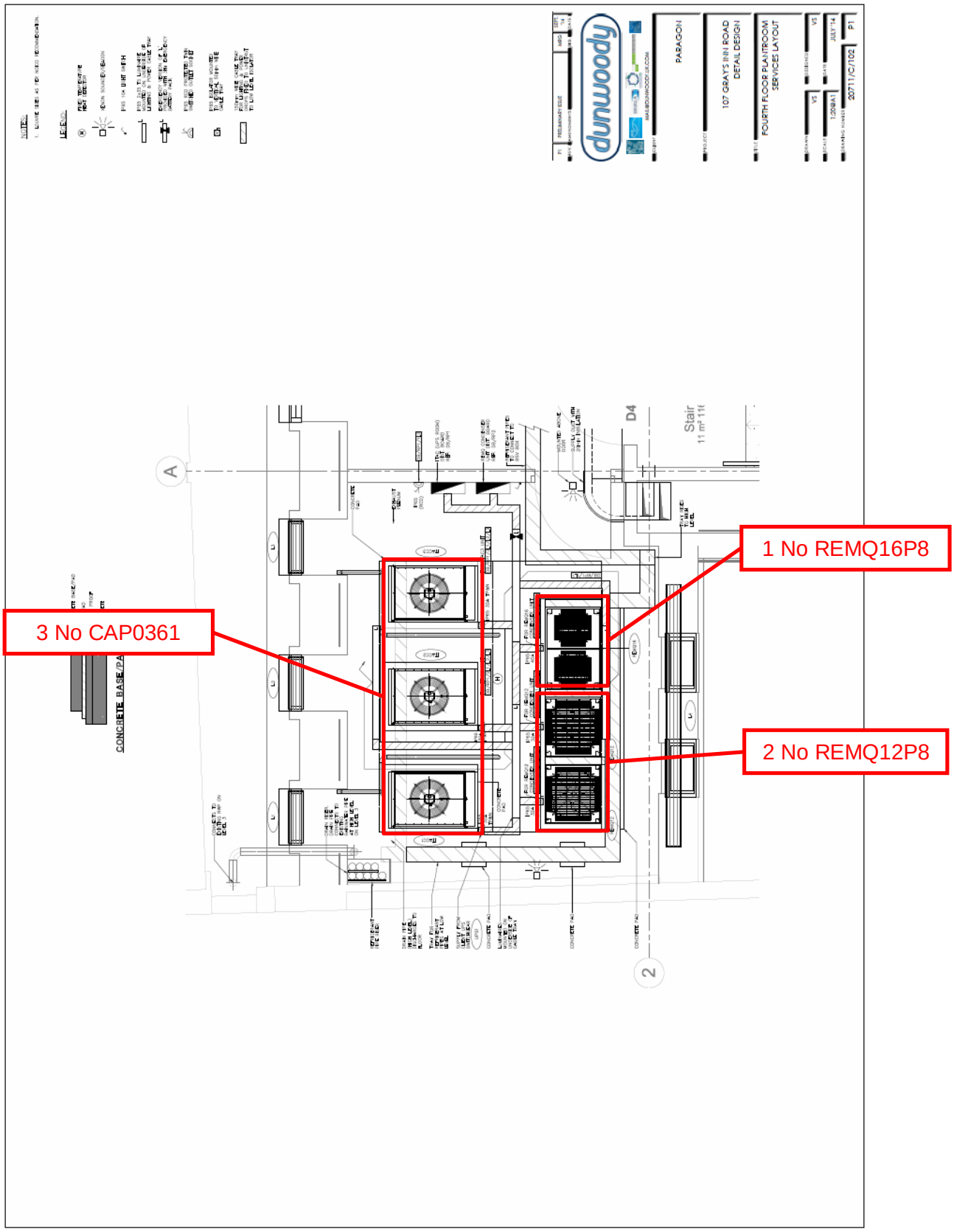


FIGURE 3: 4TH FLOOR PLANT INDICATIVE EQUIPMENT LAYOUT

9.0 MANUFACTURERS DATA…

UNIFLAIR™ TECHNICAL DATA

PROJECT REF	:	**Server Room - City of London**
CLIENT REF	:	**Dunwoody**
AREA REF	:	**Server Room**
DATA SHEET REF	:	**QC7475r1t**
UNIT TYPE	:	**Direct expansion air cooled**
MODEL SELECTED	:	**SDAC0351 A**

Return air	**dry bulb temperature**	**22±2 °C**
	relative humidity	**50±10 %rh (not controlled)**
Ambient temperature		**30 °C**
Total cooling capacity at coil		**12.5 kW**
Sensible cooling capacity at coil		**11.7 kW**
Net sensible cooling capacity		**10.6 kW**
Sensible heat ratio		**0.94**
No. of cooling circuits (each unit)		1
No. of compressors		1
Compressor type		Rotary scroll
Refrigerant type		R410A
Compressor power absorbed		3.4 kW
Air pattern		**downflow**
Air volume		0.9 m³/s
External static pressure		20 Pa
No. of motors		2
No. of fans		2
Fan type		direct driven forward curved centrifugal
Fan motor power absorbed		1.1 kW
Filter efficiency		EU4
Heating type		None
Heating capacity		N.A. kW
Humidifier type		N.A.
Humidifier capacity		N.A. kg/h
Power supply (V/Ph/Hz)		400/3+N/50
Unit run current		11.7 Amps
Full load current		15.6 Amps
Dimensions	width	850 mm
	depth	450 mm
	height	2090 mm*
	weight	160 kg
Sound pressure level (Free field)	dB(A)	47.3 @ 2m

Please note that all sound levels are measured 1.0m above floor level. Downflow unit levels are based on normal working conditions supplying air to a 300mm deep floor and exclude the effect of floor grilles.
** includes height of base stand (350mm), supplied loose*
Data subject to measurement tolerances prescribed in EN 14511 and EN ISO 3744 standards
Uniflair has a policy of continuous innovation and reserves the right to amend data without prior notice.

UNIFLAIR™ TECHNICAL DATA

AREA REF	:	**Server Room**
DATA SHEET REF	:	**QC7475r1t cont'd**
CONDENSER(S) SELECTED	:	**1 x CAP0361**
Matching room unit model	:	SDAC0351

All data relate to each individual condenser

Max air volume (@ 100% fan speed)		0.92 m³/s
Direction of airflow		vertical with leg kit option
Type of fan		axial
Number of fans		1
Fan speed		880 rpm
Total power absorbed		0.15 kW
Condenser coil		
Total internal volume		4.1 dm³
Number of circuits		1
Electrical supply (1Ph+N,50Hz)		230 V
Unit run current		0.6 Amps
Dimensions*	width	1180 mm
	depth	750 mm
	height	750 mm
(*Figures for unit with leg kit for vertical air discharge)		
Weight		42 kg
Minimum recommended clearances (vertical discharge)		
	Side	1.0 m
	Top	4.0 m

Sound Pressure Levels (dB(A) @ 5m in free field conditions)

	Fan Speed	
(Vertical discharge)	100%	47.9 dB(A)
	70%	41.6 dB(A)
	56%	37.6 dB(A)
	43%	32.1 dB(A)

Please note that all sound levels are measured 1.0m above ground level.

Information regarding inter-connecting pipework sizes is contained in the Uniflair Engineering Data

No inter-connecting wiring is required between room units and condensers.
Condenser power supply must be taken from nearest convenient local source, not from room unit.

Uniflair has a policy of continuous technological innovation and reserves the right to amend product data at all times. Prior notice may not be possible in all circumstances.

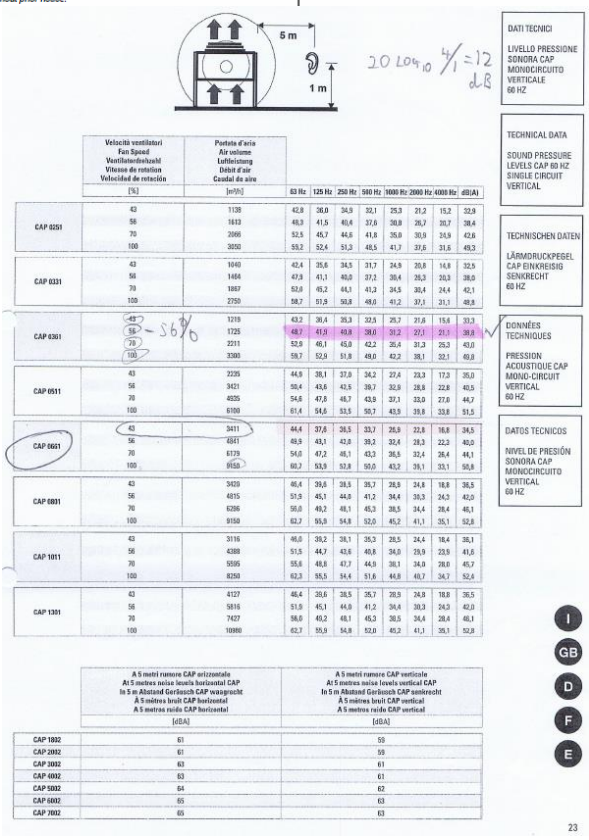


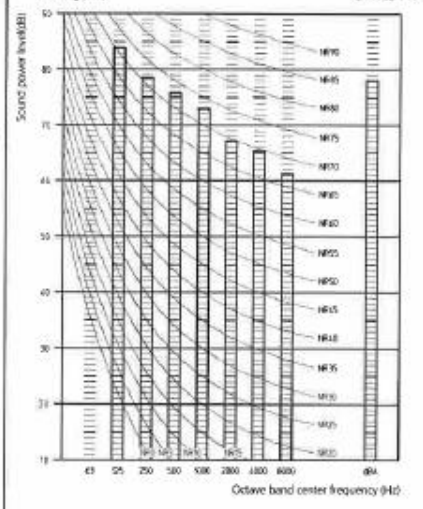
FIGURE 4: UNIFLAIR TECHNICAL DATA (CAP0361)

12 Sound data

12 - 2 Sound Power Spectrum

12

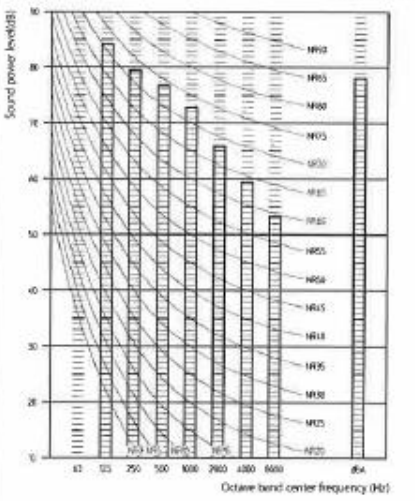
REMQ8P9 3TW29117-1



NOTES

1 dBA = A-weighted sound power level (A-scale according to IEC)
2 Reference acoustic intensity 0dB = 10E-6μW/m².
3 Measured according to ISO 3744

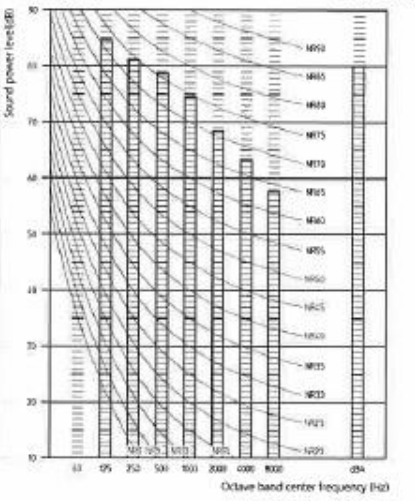
REMQ10P8 3TW29127-1



NOTES

1 dBA = A-weighted sound power level (A-scale according to IEC)
2 Reference acoustic intensity 0dB = 10E-6μW/m².
3 Measured according to ISO 3744

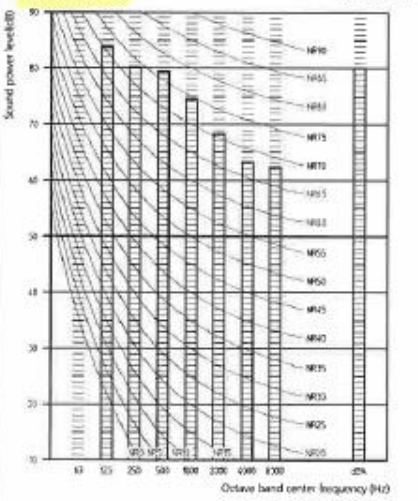
REMQ12P8 3TW29137-1



NOTES

1 dBA = A-weighted sound power level (A-scale according to IEC)
2 Reference acoustic intensity 0dB = 10E-6μW/m².
3 Measured according to ISO 3744

REMQ14,16P8 3TW29147-1



NOTES

1 dBA = A-weighted sound power level (A-scale according to IEC)
2 Reference acoustic intensity 0dB = 10E-6μW/m².
3 Measured according to ISO 3744

FIGURE 5: DAIKIN TECHNICAL DATA