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Plant Noise Criteria, Limiting Levels & Assessment Report

Blackbird Acoustics Ltd (BAL) prepared an Acoustic Assessment Report as part of the planning application, *Document reference 2124.Rep.AAR.Rev3 dated 11 April 2025*, which details results of noise surveying undertaken at site, including background L_{90} noise levels, against which plant noise emission criteria have been based. Suitable criteria are stated below based upon their measured levels and in line with industry guidance and Local Authority requirements. The proposed plant at site has been assessed and suitable limits have been calculated for atmospheric emissions along with suitable internal noise criteria. The plant has been assessed and suitable mitigation measures, as required, are stated below accordingly, to ensure the project criteria are met at the nearest receptors. This report is prepared to discharge the BREEAM Pol 05 Credit and Planning Conditions 36a (Phase 1) & 68a (Phase 2).

Plant Noise Emissions Criteria

See the aforementioned BAL report detailing the typical lowest background noise levels measured during their surveying, Manchester's requirements (Planning Conditions, i.e. -5dBA below background), and the resultant plant noise emissions criteria, which are summarised as follows in the Table below.

Table 1 – Proposed Plant Noise Emission Criteria at Receptors

Time Period	Plant Noise Emission Criterion (dBA) at Nearest Noise Sensitive Receptor (Relevant Location)				
	Existing Receptor			*Own Development (**U**nite) Receptor* All façades [1]	Emergency Plant at Receptors [2] – F - S - R/U
	Pos 1 – **F**ront (Cambridge St)	Pos 2 – **S**outh / Pub (Boundary St W)	Pos 3 – **R**ear (Chatham St)		
Daytime (07:00 – 23:00 hours)	52	39	45	45	67 / 54 / 60
Night-time (23:00 – 07:00 hours)	44	34	39	40	–

[1] *Where the nearest noise sensitive receptors to the plant locations or ventilation ductwork grilles/louvres are the windows of our own development, we have developed more relevant criteria based on guidance from applicable industry standards.*

We propose maximum emission limits that would result in acceptable internal noise levels in the bedrooms in the event of partially open windows. BS 8233 provides guidance on suitable internal noise levels. A level of -5dBA below the internal noise criterion is targeted, which ties in with the principles of the typical Pol 05 BREEAM credit, BS 4142 and Manchester's requirements.

Based on the sound reduction given by a partially open window as outlined in BS 8233:2014, internal noise levels are anticipated to be approximately 15dB lower than external noise levels. We therefore propose that cumulative noise emissions from mechanical services plant to the own development receptors should be below the levels detailed in Table 1 above (5th column).

[2] *Emergency Plant – Criterion is based upon 10dB above the existing background noise levels for routine testing of emergency and fire plant, assessed at 1 metre from the nearest receptor location. It is recommended that testing only takes place during a period which is least disturbing, e.g. 09:00 – 17:00 hours on a weekday.*

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Proposed Plant

It is understood the following items of plant are proposed:

- VRF Fan Coil Units (FCUs) internally and associated externally located condensers to serve amenity rooms
- Air Source Heat Pumps (ASHPs) for domestic hot water and heating
- Mechanical Ventilation with Heat Recovery (MVHR) units – all floor levels (PBSA)
- MVHR or Heat Recovery Units (HRUs) to amenity spaces
- Cleaner's & bin store, toilet and laundry Extract Fans (EFs)
- AOV mechanical smoke extract fans – rooftops
- Heating plantroom including pumps
- Cold water tankroom including pumps
- Emergency generator (with 'acoustic package' to limit break-out during testing)

Individual per-demise domestic servicing units (i.e. MVHR/HRU to provide ventilation) are proposed. These do not typically cause any noise impact and are very quiet. Lower floor level amenity areas will be served by ceiling mounted MVHR or HRU units, with extract fans (EF) to any WCs, kitchenettes or storerooms.

The ducted fan systems (MVHR, HRU and EF) can be readily mitigated via the inclusion of suitably selected in-line attenuators, designed to meet the above criteria, dependent on the final selection and operating speed/duty/flow rates of the fan units. Over-attenuating the fan systems will be of benefit to "take them out of the equation", so as to allow more "head room" for the other larger items of plant, e.g. condensers and ASHPs, which tend to be more difficult to attenuate. Suitable limiting levels are proposed below for each system to ensure compliance with the project requirements, as detailed in Table 1 above.

Suitably selected condenser & ASHP units can be procured, along with mitigation measures as required in order to meet the above criteria. The mitigation may be in the form of an attenuation package or kit (e.g. Ambient Acoustics), which typically achieves circa 8-9dBA reduction with inlet side attenuators and a top pod attenuator to the vertical fan discharge (~3dB for Top Pod only kits). Alternatively, a full acoustic enclosure can typically achieve circa 12dBA (10-15dBA) reduction. Night setback modes are usually available on most inverter driven units, and this can reduce source noise levels by around 3-5dBA, or even up to 15dBA, depending on the manufacturer.

In addition to controlling the atmospheric and roomside noise transfer of the units, it is also important to consider the transfer of noise as vibration to any sensitive areas within the proposed building. To this end, it is advised the items of plant be mounted on suitable anti-vibration mountings, the specification of which is confirmed below.

Absorptive Soffit Linings

All unheated spaces (e.g. bin store, cycle store, generator room, tank room, etc.) will be underdrawn with mineral wool insulation, e.g. Rockwool Soffit Slab. The primary reason for its inclusion is to achieve the thermal requirements to the habitable heated spaces located above the slab on the upper floors. However, the additional benefit of this material will be to reduce the reverberant noise build-up in the spaces. The product must be open-faced or tissue-faced in order to provide the absorption, i.e. it should not be foil-faced or board-lined. Our assessments have assumed that this soffit lining is to be installed, especially to any plant rooms, and it is confirmed that noise break-through and break-out from the plantrooms should be controlled to acceptable limits with this soffit lining installed.

Nearest Receptors

Generally speaking, the worst-case scenario in terms of potential impact of plant noise on receptors, is to the windows of our own development, due to their closer proximity to the plant. Therefore other receptors (further away and/or more screened) will experience lower noise levels than those stated below and be further within the criteria. Notwithstanding, the nearest *existing* receptors are as follows, as indicated on the Architect CP's Site Elevations drawings – all receptors are lower than the floor level of the nearest proposed plant area, i.e. significantly screened:

- Manchester Metropolitan University Business School, approx. 12-storey, closest distance of separation in the worst case is approximately 20m, to the North of site, across the access road, and at least 60m from the Phase 2 Level 12 plant.
- The Union at Manchester Metropolitan University, approx. 6-storey, at least 13m to the South of site, across Boundary St W, and at least 30m from the Phase 1 Level 10 plant.
- University Barracks PBSA, approx. 3-storey, at least 19m to the South-West of site, across Cambridge Street, and at least 30m from the Phase 1 Level 7 plant.
- Cambridge House PBSA, approx. 9-storey, at least 20m to the South-West of site, across Cambridge Street, and at least 30m from the Phase 2 Level 12 plant.
- Cavendish Halls PBSA, approx. 8-storey, at least 17m to the South-East of site, across Chatham Street, and at least 30m from the Phase 1 Level 10 plant.

Therefore, ensuring compliance with the Own-Development criteria will ensure the existing receptor criteria are easily met by default.

Internal Building Services Noise Criteria

Internal noise levels due to the operation of MVHR, HRU, extract fans, FCUs, other ventilation systems and mechanical plant items serving each room should not exceed the following limits (as based upon CIBSE guidelines, the Unite Turnkey Spec (ERs) and other industry standard guidance, such as BS 8233, BCO, BB93, BS 4142, etc.).

Table 2 – Maximum Internal Noise Levels Resulting from Plant Serving any PBSA Accommodation

Room	Internal Noise Criterion (NR)
Bedrooms / Studios	25
Kitchen / Dining / Lounge	30 - 35
Bathrooms	35 - 40
Common Corridors / Circulation Areas	40

Table 3 – Maximum Internal Noise Levels Resulting from Plant Serving Other Areas (Amenity)

Room	Internal Noise Criterion (NR)
Library Pod / Meeting Room / Screening/Cinema Room	25 – 30
Library / Office / Study Room	30 – 35
Lounge / Co-Working / Common Room	35 – 40
Reception / Lobby / Foyer / Circulation / Corridor / Stairwell	35 – 40
Community Spaces / Workout Studio / Gym	35 – 45
Toilets / W-C / Store / Linen Cupboard	40 – 45
Café / Super Kitchen / Retail Units	40 – 45
Bin Store / Cycle Store	50
Plantrooms	<55

The above NR values are based upon the fan systems running at normal operational duty, i.e. 'trickle mode'. Typically, a relaxation of 5dB is allowable for fan systems when in 'boost' mode. A relaxation of 10dB is possible in overheating scenarios according to Approved Document O criteria.

Blackbird Acoustics are not responsible for any necessary roomside attenuation measures for any of the services. Therefore, the projects M&E sub-contractors and their supply chain should ensure compliance with the above criteria. Further criteria and limiting levels are detailed below for further assistance.

Ventilation Systems

Manufacturer's installation guidelines should always be followed, and the manufacturer should confirm no vibration transfer will occur through the walls/floors which would create re-radiated structure-borne noise issues.

General

The ventilation strategy within the PBSA accommodation is understood to utilise a fully integrated system (i.e. MVHR or HRU, e.g. Nuaire XBC) with extraction to remove stale air from bathrooms (and kitchens – additional MEV as required) and fresh air supply to the bedrooms (and living room areas); windows can be opened to provide rapid or purge ventilation. During those periods where windows are opened for purge / rapid ventilation, noise levels will naturally be increased internally. However, where external noise levels are prohibitive to reliance on openable windows to combat overheating, alternative mechanically assisted systems will be proposed to provide the necessary 'cooling'.

The Lower floor level amenity spaces are to have MVHR or HRU units, extracting and supplying to the spaces, ducted to the façade.

Typically, no internal noise issues arise providing the fan ductwork runs are planned and coordinated (not torturous), such that bends are minimised so as to reduce back pressure on the fan unit and regenerated noise in the ductwork, and across valves.

It should be noted, however, that there is a benefit in ensuring the above stated criteria are achieved as near as possible, i.e. do not over-attenuate the duct borne noise levels. Some acoustic issues arise within completed buildings, and most are not helped by extremely low noise levels within the rooms due to overly quiet mechanical fan systems. A certain degree of background noise is useful to offer 'masking' and aide acoustic privacy and separation between spaces.

Smaller / Residential Ventilation Systems

The domestic systems should be designed by the M&E Consultant and M&E Sub-Contractor / Supplier to achieve the internal noise level criteria (detailed in Table 4 below) within any PBSA accommodation areas during operation.

Consideration should be made to locate the fan units in cupboards or ceilings that are ideally not adjacent to, or above, bedrooms to minimise any potential future issues with noise transfer. The fan units are usually isolated internally and therefore no other resilient fixings are usually required, noting the ductwork run design comments made above.

Summary Criteria

The MVHR systems should be designed by the M&E Consultant and M&E Sub-Contractor / Supplier to achieve the following internal noise levels during operation. Manufacturer's installation guidelines should always be followed, and the manufacturer should confirm no vibration transfer will occur, so as to create re-radiated structure-borne noise issues.

Table 4 – MVHR Internal Noise Level Criteria – PBSA

Room Type	L_{eq} Criteria for Mechanical Services (MVHR, HRU and Fans) in Specific Ventilation 'Mode' (PBSA)		
	Trickle/Background	Boost	Purge (Overheating)
Bedrooms & Studios	< NR25	< NR30	< NR35 (< 40dBA L_{eq})
Living / Dining Rooms	< NR30	< NR35	< NR40
Bathrooms / Kitchens	< NR35	< NR40	< NR45

Larger / Communal Ventilation Systems

This section covers the amenity space & Central Kitchen MVHR / HRU / SF units and any bin & cycle store, cleaner's store, laundry, riser, storeroom or toilet/WC Extract Fans (EXFs).

Atmospheric Noise Emissions

Attenuators should be assessed and provided by the supplier and M&E subcontractor chain to ensure that noise from the ventilation units' inlet and outlet terminations do not exceed a level of 40dBA at 1m from each of the termination points and assessed at zero degrees, i.e. on-axis, for the MVHR/HRU/EF units. Installation of such attenuators as required to ensure noise break-out is acceptable, will also ensure that noise break-in via the systems is controlled to an acceptable level. This should be more than sufficient (given the distance losses afforded) and even assumes simultaneous worst-case night-time operation, which is unlikely. By adopting this limiting criterion, we are basically minimising any possible contribution to the noise environs from any ducted fan systems. Achievement of this limiting level will ensure the project criteria are easily met, and minimise any potential impact from any ducted fan systems. Any (top-floor) rooftop Fans have a more relaxed limit, due to the increased distance & screening losses, of 50dBA at 1m from the termination point and assessed at zero degrees, i.e. on-axis.

Roomside Noise Emissions

The ventilation systems should be designed by the M&E Consultant and M&E Sub-Contractor / Supplier to achieve suitable internal noise levels within the non-residential areas during operation, as detailed above in Table 3.

FCUs & Air Con

Any proposed Fan Coil Units (FCUs) within the spaces should also comply with the relevant criteria stated above in Tables 3 & 4 for the various modes of heating/cooling and overheating dependent on room type & location.

MAOV Smoke Extract Fans

At *least* a 20dBA reduction is typically achieved by such systems, when located on top-floor roof levels, assuming minimal losses, i.e. a separation distance of 3m, roof edge screening and $0^O/45^O$ directivity (typical to own-development windows, in the worst case). However, 2No. fans are located in Phase 1 at Level 00 Courtyard, and therefore do not benefit from roof edge screening, being overlooked by PBSA windows. Lower limiting levels will be required for these two fan systems, shown in square brackets […] below.

Suitable attenuation should be specified by a specialist for each system to achieve the below limiting levels.

Environmental Mode

If ventilation of corridors and stairwells is via the mechanical smoke extract fan systems running in an 'environmental mode', noise levels from the units should be limited to the following levels as set out below, in order to achieve the overall project criteria stated in Table 1 above.

Atmospheric

The system must be designed not to exceed the following limits when running in environmental mode, which should include the times when higher fan speeds will be required in high heat gain periods:

Daytime – 60dBA @ 1m at 0^o (on-axis) [40dBA]
Night-time – 55dBA @ 1m at 0^o (on-axis) [35dBA]

To Common Corridor Areas

We would advise the design of the smoke extract shaft systems (when operating in environmental mode) should achieve a level of NR35-40 when assessed within the residential common corridor areas, i.e. 1m from the AOV louvre in the worst case (top floor) corridor.

Noise problems have previously been encountered due to wind generated noise from such shafts. Therefore, it is recommended the outlet design prevents such noise nuisance. In addition, noise from the motors controlling the louvres has also been problematic on past projects and we therefore recommend the motors are sufficiently isolated.

Emergency Mode

During emergency modes the proposed smoke fans (supply & extract – duty/standby) will run at much higher speeds, thus resulting in high operating noise levels. However, the systems must be designed not to exceed +10dB above background when operating during emergency modes and during routine emergency maintenance testing.

Atmospheric

To this end, a limit of 75dBA @ 1m at 0^o (on-axis) [55dBA] from the atmospheric outlet of the exhaust discharge point should be achieved.

To Common Corridor Areas

The project's M&E sub-contractors and their supply chain should ensure that roomside noise levels from the emergency smoke extract ventilation systems do not exceed NR55 at 1 metre from the AOV louvre in any common corridor. They should also confirm that the fire alarm will be audible during the fans' operation.

Noise problems have previously been encountered due to wind generated noise from such shafts. Therefore, it is recommended the outlet design prevents such noise nuisance. In addition, noise from the motors controlling the louvres has also been problematic on past projects and we therefore recommend the motors are sufficiently isolated.

Vibration Isolation

Each item of mechanical services plant will require appropriate treatment in order to ensure vibration transfer to the building structure (which may then cause a re-radiated noise issue) is controlled to acceptable levels. We therefore present the following advice.

Isolators / AVMs

We would advise that any Condenser units and ASHPs be isolated from the supporting structure by means of neoprene in-shear isolators with a 10mm static deflection. The units should either be mounted on a concrete plinth or mounted on bigfoot frames.

Where there are cased fans located across the development, such as MVHR, HRU and extract fans, these should be isolated using neoprene in-shear isolators or hangers with neoprene turrets with a 6-10mm static deflection dependent on duty.

Any pumps located within plantrooms should be isolated with a concrete inertia base and neoprene in-shear isolators with a minimum static deflection of 10mm.

Any cold-water booster pump sets and sprinkler pump sets should be isolated via caged steel springs with a restraining device and minimum static deflection of 25mm.

The generator should be isolated via caged steel springs with a restraining device and minimum static deflection of 25mm.

The smoke extract fans should be isolated via open steel springs with a restraining device and minimum static deflection of 20mm. All cased fans shall have the specified isolators internally beneath the fan/motor frame and be additionally isolated externally with neoprene pads having 2mm (min) deflection.

Pipework Isolation

The use of flexible connectors as an interface between plant and associated pipework cannot be considered as adequate vibration isolation. Their use as thermal and shock compensators is well known, but even under nominal line pressures the connectors become acoustically rigid. It is, therefore, recommended that all active pipework should be isolated on resilient mountings/hangers up to the plant room structural penetration.

Thereafter oversized brackets having neoprene inserts would be advisable, generally for larger "live" pipework, but also for smaller "live" pipework where friction losses exceed 280Pa/m.

If flexible connectors are also required, they should be located in the horizontal plane and be of the double bellows type.

Ductwork Flexible Connections

All ductwork connections to fans and air handling units should be flexible and at least 75mm long. These should be constructed from sound barrier mat having a minimum superficial density of at least 5kg/m^2. These connections should be straight but not rigid, with no offset, in order to prevent turbulence.

Electrical Connections

It is important that isolated equipment is not mechanically shorted by the installation of conduit or cable trays, etc., which are rigidly connected to the structure. Electrical connections to plant should, therefore, be made via a looped flexible conduit. The loop should form a diameter of 300mm or more.

ASHP & Condenser Assessment

The following Mitsubishi Air Source Heat Pumps (ASHPs) and Daikin Comfort Cooling Outdoor Condenser units (which serve the fan coil units and air conditioning systems proposed to the comms rooms and amenity spaces & offices, etc.) are proposed at the development.

Table 5 – Proposed QTon ASHPs & Daikin Condensers and their Locations & References – Phase 1

Unit Type / Ref	No. Off & Location	Make-Model / Serving
QTON/1Z/10/01-07	7No. – Level 10 Roof	Mitsu Q-Ton ESA30E-25 (ASHP – DHW LoPr)
QTON/1Z/23/01-03	3No. – Level 23 Roof	Mitsu Q-Ton ESA30E-25 (ASHP – DHW HiPr)
VRF/1Z/07/001	Level 07 Ext. Plant Compound	Daikin RXYA10A (Gym)
VRF/1Z/10/001	Level 10 Ext. Plant Compound	Daikin REYA28A9 (16+12) – 64dBA SPL Cooling
VRF/1Z/10/002	Level 10 Ext. Plant Compound	Daikin REYA8A9
VRF/1Z/10/003	Level 10 Ext. Plant Compound	Daikin REYA18A9
VRF/1Z/10/004	Level 10 Ext. Plant Compound	Daikin REYA16A9
VRF/1Z/10/005	Level 10 Ext. Plant Compound	Daikin REYA14A9
OU/1Z/00/001-002	2No. – Level 00 External *	Daikin RZAG100NV1 (DX – Duty/Standby, 24-7)

* Provision for Retail tenant's plant in Level 00 External plantroom – allowance made in calculations for future cumulative impact. Tenant's plant to achieve 45dBA Leq daytime and 40dBA night-time. Condensers or ASHPs are likely to require full acoustic kits or enclosures, and use of night setback "low noise" modes during the night-time.

Table 6 – Proposed QTon ASHPs & Daikin Condensers and their Locations & References – Phase 2

Unit Type / Ref	No. Off & Location	Make/Model (Type)
QTON/2Z/12/01-08	5No.+ 3No. – Level 12 Roofs	Mitsu QTon ESA30E-25 (ASHP – DHW LoPr)
QTON/2Z/29/01-03	3No. – Level 29 Roof	Mitsu QTon ESA30E-25 (ASHP – DHW HiPr)
VRF/2Z/01/001-007	7No. - Level 01 MEP Courtyard	Daikin RXYSA12A (horizontal discharge)
VRF/2Z/12/001	Level 12 Roof Plant 1	Daikin REYA14A9
VRF/2Z/12/002	Level 12 Roof Plant 1	Daikin REYA8A9
VRF/2Z/12/003	Level 12 Roof Plant 1	Daikin REYA22A9 (12+10) – 63dBA SPL Cooling
VRF/2Z/12/004	Level 12 Roof Plant 1	Daikin REYA22A9 (12+10) – 63dBA SPL Cooling
VRF/2Z/12/005	Level 12 Roof Plant 1	Daikin REYA18A9
VRF/2Z/12/006	Level 12 Roof Plant 2	Daikin REYA16A9 (Gym)
VRF/2Z/12/007	Level 12 Roof Plant 2	Daikin RXYSA8A (Gym)
OU/2Z/00/001-004	4No. – Level 01 External *	Daikin RZAG100NV1 (DX – Duty/Standby, 24-7)

* Provision for Community tenant's plant in Level 01 External plantroom – allowance made in calculations for future cumulative impact. Tenant's plant to achieve 45dBA Leq daytime and 40dBA night-time. Condensers or ASHPs are likely to require full acoustic kits or enclosures, and use of night setback "low noise" modes during the night-time.

Noise data has been received from the manufacturers of the Mitsubishi Q-Ton ESA30EH units. The octave band sound pressure levels of the units (at 1m distance and 1.5m height) are detailed as follows:

Table 7 – Manufacturer's Noise Levels – Q-Ton

Operational Mode	Parameter	Sound Level (dB) at Octave Band Centre Frequency (Hz)								dBA
		63	125	250	500	1k	2k	4k	8k	
Normal / Summer / Rated	Lp at 1m	68	56	51	54	51	48	44	41	56
High / Winter / Heating		73	64	60	58	60	54	52	47	63
Silent Mode		64	51	46	44	45	41	39	34	49

Mitsubishi Heavy Industry have confirmed the Q-Ton units can operate in 'Silent Mode', which can be scheduled via the controller. In Silent Mode, the sound output is reduced by approximately 7-14 dBA. This Mode reduces the duty/output of the units, i.e. throttles the performance, but it is understood this should be acceptable for night-time operation given the reduced operational load (only serving hot water) during this period. Hot Water peak operating periods likely to be 05:00-10:00 & 17:00-23:00 hours.

Sound level data has been obtained from the suppliers of the VRV condenser units (Daikin), as shown below.

Table 8 – Manufacturer's Noise Levels – Daikin VRV-5 Heat Recovery Units

Unit	Mode	Parameter	Sound Level (dB) at Octave Band Centre Frequency (Hz)								dBA
			63	125	250	500	1k	2k	4k	8k	
REYA10	Cooling	Lp at 1m	55	62	57	55	54	46	48	38	58
	Heating		64	63	60	55	52	49	48	39	58
REYA12	Cooling	Lp at 1m	60	65	59	57	55	52	52	41	61
	Heating		68	63	60	57	57	54	52	45	62
REYA14	Cooling	Lp at 1m	59	58	54	55	51	51	47	45	58
	Heating		65	64	60	60	54	51	52	45	61
REYA16	Cooling	Lp at 1m	66	63	59	60	55	50	50	49	61
	Heating		68	65	63	64	57	55	55	46	65
REYA18	Cooling	Lp at 1m	63	63	56	57	55	56	56	48	62
	Heating		67	68	61	62	56	55	56	48	64

Tables 9 – Daikin REYA12 Unit – Manufacturer's Noise Data – Explanation of Low Noise Modes

Model	Sound Power Level (dBA)		Sound Pressure Level (dBA)	
	Cooling	Heating	Cooling	Heating
REYA12	82	83	61	62

Duty	Mode	Sound Levels				Difference from Mode before			
		Cooling		Heating		Cooling		Heating	
		SWL (dBA)	SPL (dBA)	SWL (dBA)	SPL (dBA)	SWL (dBA)	SPL (dBA)	SWL (dBA)	SPL (dBA)
100%	Nom	82	61	83	62	-	-	-	-
90%	LN1	79	58	80	58	3	3	3	4
75%	LN2	76	55	77	55	3	3	3	3
60%	LN3	73	52	74	52	3	3	3	3
45%	LN4	70	49	71	49	3	3	3	3
30%	LN5	67	46	68	46	3	3	3	3
Diff	Nom-LN5	15	15	16	15			Avg = -3dB	/mode

Each step down in Low Noise Mode realises a -3dBA reduction, with a maximum reduction of -15dBA from 100% down to LN5, 30%. The same 'average' patterns are exhibited in the data for the other Models, i.e. -3dB per LN mode and -15dBA to lowest mode.

Generally speaking, the small DX split units (RZAG – Comms Room) are much quieter and do not contribute as much to the overall noise emissions, as well as operating in a duty/standby arrangement, i.e. one out of the pair is operating at any one time. Noise data obtained from the manufacturer's datasheet for the smaller Daikin units are as follows:

Table 10 – Manufacturer's Noise Levels – Smaller Daikin Units

Unit	Mode	Parameter	Sound Level (dB) at Octave Band Centre Frequency (Hz)								dBA
			63	125	250	500	1k	2k	4k	8k	
RZAG100NV1	Cooling	Lp at 1m	47	39	38	40	36	31	21	20	41
RXYA10A	Cooling	Lp at 1m	55	62	57	55	54	46	48	38	58
RXYSA8A	Cooling	Lp at 1m	63	61	58	57	51	48	44	42	58
RXYSA12A	Cooling	Lp at 1m	68	65	59	56	56	50	47	40	60

Decorative screens are proposed to each plant area, which will assist in hiding the plant visually, thus reducing the psychological impact of the plant. Plant on the top-floor levels benefit from significant roof edge screening to the own-development windows on the floors below. Where plant areas are overlooked by Receptors, there is no benefit in making the screen solid or louvred, as noise will by-pass the screening.

All units are inverter driven and noise levels reduce in line with duty/load, as can be seen from the above reductions in noise levels at various percentage duties. As a worst case scenario, we have assumed the highest source noise levels in our worst case daytime calculations, and Low Noise mode for night-time operation. The real-life scenario is likely to be considerably lower/quieter in reality due to the inverter driven nature of the units.

As stated previously, the additional distance (windows much further than own-development windows), screening (most existing receptors are lower than the proposed plant floor levels), and directivity (i.e. off-axis) losses afforded to the off-site Receptors will further reduce the predicted levels (as compared to the own-development windows, example calcs below), ensuring much lower noise levels at their façades, easily complying with the Local Authorities requirements. Therefore the Own-development calculations are considered worst-case.

Our calculation method for predicting noise levels from the proposed plant at the nearest noise-sensitive receptors, based on the information above, is summarised below.

- Source Term (SPL)
- Distance attenuation
- Directivity losses
- Screening/barrier losses (e.g. from building roof edge or screens)
- Reflection corrections (e.g. confined compounds)
- Insertion losses of louvres / kits / enclosures (if applicable/required)

A multitude of calculations have been undertaken from *all* the plant areas to the *various* nearest receptors (*both* existing *and* own-development) with the resultant predicted noise levels outside the windows of the receptors compared to the project criteria, as stipulated in Table 1 above. The main parameters giving rise to 'losses' in the calculations are the distance loss (source to receptor) and roof edge or barrier screening losses (where significantly more than line-of-sight screening is generally achieved as most Receptors are lower than the relevant roof plant area, especially to Existing Receptors).

A few example calculations are shown below in Tables 9 & 10– all the other calculations, from other plant areas to other receptors, follow the same principles:

Table 11 – Example Calculation (simplified) of Ph2 Lvl29 3x ASHPs (no mitigation) to PBSA windows below (roof edge screened)

Parameter	Octave-band Noise Level (dB) at Octave-band Centre Frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8k	
3x QTon, Lp @ 1m	77	69	65	63	64	59	56	52	68
Distance Loss (~7m)	-17	-17	-17	-17	-17	-17	-17	-17	
Reflections (rear wall)	3	3	3	3	3	3	3	3	
Screening Loss (building edge)	-8	-9	-12	-14	-17	-20	-20	-20	
Resultant Noise Level at Receiver	56	46	39	35	33	25	22	18	38.5

Table 12 – Example Calculation (simplified) of Ph2 Lvl 01 Courtyard to PBSA

Parameter	Octave-band Noise Level (dB) at Octave-band Centre Frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8k	
RZAG100, Lp @ 1m	47	39	38	40	36	31	21	20	41
RZAG100, Lp @ 1m	47	39	38	40	36	31	21	20	41
7x RXYSA12, Lp @ 1m w Full Ac Kit *	73	69	62	53	52	47	46	39	59
Total Lp	73	69	62	54	52	47	46	39	60
Distance Loss (5 to 15m) [avg]	-18	-18	-18	-18	-18	-18	-18	-18	
Reflections (compound)	3	3	3	3	3	3	3	3	
Screening Loss (none)	0	0	0	0	0	0	0	0	
Resultant Noise Level at Receiver	58	54	47	39	37	32	31	24	44.5

* See Mitigation section below for details.

The calculations undertaken are considered very much worst-case though;

- They utilise the “full” 100% duty, worst case mode source levels, whereas in reality the inverter driven operation ensures the units reduce their output as the Load dictates, which in turn reduces the noise levels emitted.
- Some degree of directivity losses will inevitably be afforded as well, but have not been taken into account.
- Some degree of screening/barrier losses may be afforded as well in some cases – by building corners, screening, etc. – but none have been taken into account (other than roof edges where applicable, i.e. top-floor areas.
- They allow a 3dB increase in noise due to reflection effects, although not all units are that ‘confined’.
- They do not consider any low noise/reduced duty reductions in noise, which are likely given the units are inverter driven and will ramp down dependent on duty – at least a 3dB+ reduction is anticipated in these situations.
- The units’ night setback or “low noise” modes should be utilised, if practicable, to help further reduce any potential impact when in operation, and switched off entirely when not in operation, unless required for maintenance reasons (e.g. frost cycle).
- The calculations are undertaken to the Own-Development windows in the worst-case. As mentioned, noise levels at the more critical existing receptors will be considerably lower due to the increased distance (other side of roads) and screening losses (receptors generally lower than plant areas).

In reality, the resultant noise levels at the receptor are likely to be less than those stated above and therefore more comfortably within the criteria. Nonetheless, calculations indicate the Courtyard and “middle” floor louder units require *some* form of mitigation applied to them (see section below for further details) in order to meet the project criteria under the worst case operation. This is because of lower natural losses (i.e. screening and distance/directivity) due to the closer proximity to sensitive windows (directly overlooked by own-development).

Calculations for the Comms Room (RZAG) units [quiet], Gym units at Lvl 7 Ph1 & Lvl12 PR 2 Ph2 [quiet and not overlooked] and the top floor Q-Tons at Lvl 23 Ph1 & Lvl 29 Ph2 [not overlooked, roof edge screened] are all acceptable and within criteria without any additional mitigation.

Mitigation

Due to the Courtyard areas (i.e. Ph2 Level 01 podium) being directly overlooked by the proposed PBSA windows, mitigation measures are necessary to the larger units serving amenity spaces (NB the smaller comms units are acceptable). These units should be fitted with full acoustic attenuation kits (e.g. Ambient Acoustics or similar), including side inlet and top pod attenuators, which achieve the following minimum losses;

Table 13 – Full Acoustic Kit Attenuation Losses

Minimum Losses from Acoustic Kit (dB) at Octave Band Centre Frequency (Hz)								dBA
63	125	250	500	1k	2k	4k	8k	
3	4	5	11	13	11	9	9	9

If the units are all in one enclosure (rather than spread out), the performance should achieve 14dBA. In addition, the above mentioned units should be limited to a 'low noise mode' (i.e. LN2, 75%) during the night-time periods during lower loads, for which an additional 6dBA is realised as a reduction in the source noise levels (ref Table 7b).

The "middle" roof floor levels (i.e. Ph1 Lvl 10 and Ph2 Lvl 12) are overlooked by the Tower elements of each phase and therefore altering the screen to be acoustically-rated will not have any effect. The largest units (the Q-Ton ASHPs) are noisiest and in order to meet the project criteria, these units should be fitted with Top Pod only acoustic attenuation kits (e.g. Ambient Acoustics or similar), which achieve the following minimum losses;

Table 14 – 'Top Pod' (only) Kit Attenuation Losses

Minimum Losses from Top Pod Kit (dB) at Octave Band Centre Frequency (Hz)								dBA
63	125	250	500	1k	2k	4k	8k	
1	2	2	3	6	6	6	4	3

In addition, the Q-Ton units should enter their 'Silent Mode' whenever possible (i.e. during the night-time periods during lower loads) to help minimise any potential impacts, for which a significant -14dBA is realised as a reduction in the source noise levels (ref Table 5).

Alternatively, the units (where necessary, as above) could be enclosed via 150mm acoustic louvres to the inside face of the decorative screen panels (including the grille 'roof' of the compounds), if layout and space permits. The specification of which should comprise standard 150mm deep acoustic louvres (e.g. Caice SS 150, IAC SL-150 or similar), capable of achieving the following insertion losses;

Table 15 – 150mm Deep Acoustic Louvre Losses

Minimum Static Insertion Loss from 150mm Acoustic Louvre (dB) at Octave Band Centre Frequency (Hz)								R_w (dB)
63	125	250	500	1k	2k	4k	8k	
3	4	6	10	12	13	13	14	11

All of the above is on the basis of:

- Condensers & ASHPs will be running at full load during office (and daytime) hours only, i.e. hours of occupancy for the amenity, greatest solar heat gain, hot water load, etc. Although they should operate at actual required duties where possible (as the units are inverter driven).
- Night setback 'Quiet' or 'Low Noise' mode should be utilised to all units (condensers & ASHPs) to help minimise any potential impact from noise emissions during the night-time period, typically reducing levels by 3-14dBA.

Predicted noise levels at existing receptors can meet the Local Authority's criteria providing the systems are setup to utilise 'set-back' modes on some of the ASHPs and Condensers during the night-time period. Utilising the Low-Noise Mode (LN2, 75%) for the Daikin VRF units (-6dBA) [Ph2 Lvl 1] and the Silent Mode for the Q-Ton ASHPs (-14dBA) [esp. Ph1 Lvl 10 & Ph2 Lvl 12].

The proposed plant should be considered acceptable providing the mitigation measures detailed above are adopted. The calculations indicate the predicted levels at the nearest receptors in the worst case operation mode should be in line with the requirements of the Local Authority utilising Low Noise Modes and some degree of acoustic enclosure to some of the louder the units on the "middle" rooftop and Courtyard plant levels.

Noise Transfer Assessment

Acoustic Ceiling to PBSA Bedrooms below ASHP/Condenser Rooftop Plant Areas

In order to reduce the amount of noise transmission across the roof structure between the rooftop plant and any PBSA accommodation below, a slightly upgraded 'acoustic ceiling' is recommended to the soffit of the rooms beneath the rooftop plant areas – all as per Cartwright Pickard's RCP Drawings.

We therefore propose the following roof structure construction is adopted, which incorporates the anti-vibration measures (see above for further details) along with the proposed roof structure and the advised acoustic ceiling. The ceiling within these rooms should comprise the following construction;

- Anti-vibration measures (see above), including Big Foot system and spring/rubber mounts, as required
- Thermal insulation, etc. as required
- Minimum 225mm cast in-situ concrete flat slab
- MF ceiling with 25mm mineral wool insulation in void
- 1No. layer of 15mm BG SoundBloc (dense) board or similar

Summary

Our assessment is summarised in this section as follows. Predicted plant noise emissions should comply with both the requirements of Manchester and BREEAM, at both the nearest existing residential receptors and proposed own-development windows, providing the following mitigation measures are adopted;

- Any Back-of-House or Plantrooms are to have a Rockwool insulation soffit lining, which should be open-faced or tissue-faced to provide the necessary acoustic (and thermal) performance.
- A slightly upgraded acoustic ceiling is proposed to PBSA accommodation below any Rooftop plant areas.
- Atmospheric noise from any EF / MVHR / HRU termination point should be limited to 40dBA L_{eq} when measured at 0 degrees on-axis at 1 metre. Top-Floor Rooftop fans should be limited to 50dBA @ 1m.
- Smoke extract fans should generally be limited to 75dBA at 1m externally [55dBA for Ph1 Lvl 00] and NR55 internally in Emergency Mode – by specialist design.
- M&E Sub-Contractor and supply chain to specify suitable internal attenuators to ducted systems, as required, to ensure the internal noise criteria are achieved.
- Appropriate anti-vibration measures have been proposed for each item of plant, but generally with 10 - 20mm static deflection.
- In the worst case, some of the ASHPs & Condensers (Courtyard and "middle" floors – overlooked) require some form of acoustic attenuation kits. Full acoustic kits (-9dBA) are required to the Amenity condensers within the Courtyard of Phase 2, and Levels 10 & 12 Q-Ton ASHPs require a Top Pod only kit (-3dBA).
- All ASHPs and Condensers units should utilise their "low noise" night setback mode to minimise emissions during the night-time period.