85 to 112 Makepeace Avenue
Holly Lodge Estate, Camden

Noise Impact Assessment for replacement boiler flue

Report ref.
PJB9523/23092/V1.1

Issued to
FLOH Consulting Ltd

Prepared by
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Version	Authorised by	Remarks	Date
V1.0	PJB	First Issue	26.4.23
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1. INTRODUCTION

FLOH Consulting Ltd are undertaking works to the mechanical services at 85 to 112 Makepeace Avenue, Holly Lodge Estate, Highgate. This includes replacement of a redundant set of boiler flues and their enclosure with a new set of flues within a smaller enclosure, discharging at roof level. The London Borough of Camden have requested that a noise impact assessment be provided to demonstrate that noise emitted from the new flue is acoustically acceptable for nearby residents, namely, residents of the upper-floor flats of the building itself.

This report described the measurements, analysis and assessment undertaken to determine compliance with BS4142 guidelines for acceptability for plant noise.

2. SITE DESCRIPTION

85 to 112 Makepeace Avenue is a four-storey residential block located on the southern side of the road, at its eastern end, near Swains Lane. It has a basement plant room on the southern side, although the boiler equipment within it is not functional. Currently, temporary boiler equipment is located on the footway of Swains Lane with flues discharging toward the east (toward Highgate Cemetery).

The previous boilers had three flue pipes that routed upward along the eastern façade of the building to discharge vertically about 3m above the roof level. These flues were enclosed within a large enclosure to conceal them.

Appendix A shows drawings and photographs indicating the site location and existing plant arrangements.

3. GUIDELINES FOR ACCEPTABILITY

The site is located within the London Borough of Camden. The Camden Local Plan 2017 sets out the guidelines for acceptability for noise used in determining planning applications. Relevant extracts are shown in Figure 1.

Industrial and Commercial Noise Sources

A relevant standard or guidance document should be referenced when determining values for LOAEL and SOAEL for non-anonymous noise. Where appropriate and within the scope of the document it is expected that British Standard 4142:2014 'Methods for rating and assessing industrial and commercial sound' (BS 4142) will be used. For such cases a 'Rating Level' of 10 dB below background (15dB if tonal components are present) should be considered as the design criterion).

Table C: Noise levels applicable to proposed industrial and commercial developments (including plant and machinery)

Existing Noise sensitive receptor	Assessment Location	Design Period	LOAEL (Green)	LOAEL to SOAEL (Amber)	SOAL (Red)
Dwellings**	Garden used for main amenity (free field) and Outside living or dining or bedroom window (façade)	Day	'Rating level' 10dB* below background	'Rating level' between 9dB below and 5dB above background	'Rating level' greater than 5dB above background
Dwellings**	Outside bedroom window (façade)	Night	'Rating level' 10dB* below background and no events exceeding 57dB L_{Amax}	'Rating level' between 9dB below and 5dB above background or noise events between 57dB and 88dB L_{Amax}	'Rating level' greater than 5dB above background and/or events exceeding 88dB L_{Amax}

Figure 1: Camden Council's guidelines for acceptability for plant noise

3.1 BS 4142:2014+A1:2019 *METHODS FOR RATING AND ASSESSING INDUSTRIAL AND COMMERCIAL SOUND*

Camden's Local Plan refers directly to British Standard document BS 4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound* (BS4142). This describes methods for rating and assessing sound of an industrial and/or commercial nature, which includes sound from mechanical plant and equipment.

The principle of assessment under BS4142 is to compare sound from the source under investigation (if appropriate, with adjustments for duration and character) with the background L_{A90} (the typical minimum sound level) in the absence of the sound to be assessed. The standard's own guidance states (Section 11):

a) Typically, the greater this difference, the greater the magnitude of the impact.

b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.

c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.

d) The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

Accordingly, using BS4142 leads to different thresholds than those used in Table C of Figure 1. BS4142 indicates that, where the sound rating level is assessed to be 10 dB *above* the background sound level, this is generally taken to be a Significant Observed Adverse Effect Level (SOAEL). The Lowest Observed

Adverse Effect Level (LOAEL) occurs in a range of "sound rating level minus background sound level" between 0dB and 5 dB depending upon context. Further, the *rating level* in BS4142 already includes adjustments for noise character and no more stringent criteria should apply when a character correction is applied. Where the sound rating level is assessed to be 10 dB *below* the background sound level, Spectrum consider this to be the No Observed Adverse Effect Level (NOAEL).

Hitherto, Camden Council have applied a guideline for acceptability for plant noise of a rating level 5dB below the background level. Also, their Local Plan Policy indicates that BS4142 should be used where it is appropriate to the noise source under consideration and when determining values for LOAEL and SOAEL.

Accordingly, the relevant guideline that applies to this development is that rating level from flue discharge noise should not exceed the appropriate background noise minus 5dB. The use of character corrections as explained in Section 9 of BS4142 is discussed later within this report.

4. BACKGROUND NOISE SURVEY

$L_{A90,T}$ (background) sound level measurements were carried out during a site survey between Monday 20 and Thursday 23 March, 2023. This survey consisted of long-term, unattended noise measurements on the south east corner of the roof of 85 to 112 Makepeace Avenue, with the microphone 1m above the roof (0.5m above the roof parapet) in free field conditions.

The measurement location and photos of the equipment are included in Appendix A. Appendix B provides a graphical representation of the noise measurement data, with the results are summarised below:

Time Period	L_{A90}
Day (07:00-23:00)	41
Night (23:00-07:00)	46

Table 1: Summary of background noise data

BS 4142 states:

> *In using the background sound level in the method for rating and assessing industrial and commercial sound it is important to ensure that values are reliable and suitably represent both the particular circumstances and periods of interest. For this purpose, the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods.*

As the assessment here considers a new specific sound source, the relevant BS 4142 guidance is Section 8.2:

> *Measure the background sound level at times when the specific sound source(s) is intended to be operated.*

The guidance provided in Sections 8.1 and 8.2 of BS 4142 was observed in the background survey design. A statistical analysis of $L_{A90,T}$ levels was carried out following the example methodology provided in BS4142. The L_{A90} levels taken from the results of this process and used for assessment purposes in this report are as shown in Table1. That is, the background levels in Table 1 are considered representative of the conditions that pertain at the windows and on the balconies of the upper floor flats in the south-eastern part of the building.

5. BOILER FLUE PROPOSALS

Drawings shown the proposed new flue installation are shown in Appendix C. This shows the flue pipes exiting the existing plant room and entering a new, reduced-size casing or enclosure which follows the line of the existing chimney up to roof level. The new flues extend above this casing and discharge approximately 3m above the roof level.

The boilers that these flues serve are to be Hamworthy Modumax mk3 units (Unit type - 254/762). Product information about these boilers is shown in Appendix D. This provides a range of sound pressure level data 1m in front of the boiler unit during operation. Hamworthy were contacted about *flue* noise levels but were unable to provide any noise data.

Therefore, data from a similar unit manufactured by Hoval is used in this analysis. Appendix E includes their product data. This shows that the heating power output of the Hoval and Hamworthy units are similar (742 kW cf. 762 kW) and the noise level in front of the units is also similar (64 dB cf. 65 dB). Accordingly, the flue sound power level for the Hoval unit is considered to be representative of that for the Hamworthy unit. This is L_{wA} 74 dB. Maximum duty has been modelled as three boilers operating simultaneously.

6. CALCULATION PROCEDURE

6.1 DUCT LOSSES

The sound power data for flue discharge is provided as “Exhaust noise radiated from the mouth”. This is equivalent to the ‘free air’ discharge sound power level of the flue (i.e., where end reflections are already taken into account). Even so, there is a significant length of duct and a number of bends in the flue pipework between the boiler unit and the discharge above roof level.

Calculations of the duct sound power losses have been conducted following *CIBSE Guide B4: 2016 Noise and vibration control for building services systems*. The CIBSE guide allows for a number of components of attenuation, including from:

- straight ducts of various lengths, rectangular or circular in cross-section
- attenuators
- bends (elbows), right angled or curved
- branches, which may have one or more take-offs
- distribution boxes (plenums)
- terminal units, grilles, diffusers, registers.

In this case, only the duct and bend attenuation are allowed for within the analysis. This process produces the attenuated flue sound power level at discharge of L_{wA} 70 dB per flue.

6.2 ENVIRONMENTAL NOISE PROPAGATION

BS4142 states that an assessment should:

> *Determine the specific sound level by calculation alone if measurement is not practicable, for example if the source is not yet in operation. In such cases, report the method of calculation in detail and give the reason for using it.*

NOTE 1 When calculating rather than measuring sound pressure levels, it is necessary to have appropriate representative data on source sound emission, for example as a source sound power level (including source directivity), and the position of any point source(s) creating the same sound pressure levels in the environment as the real source. Often, such data are given in established calculation models, but in other cases it is necessary that they be determined in each individual case.

NOTE 2 Using a suitable method for the sound propagation from source to receiver, the sound pressure level at the assessment point can be calculated. It is necessary to relate the sound propagation to well-defined meteorological and ground conditions. Most calculation models refer to neutral or favourable sound propagation conditions, as other propagation conditions are much more difficult to predict. The acoustic impedance of the ground is also important, in particular at large distances and low source and receiver heights.

In line with these recommendations, the approach to prediction of noise associated with the proposals is as follows.

The proposed flues will discharge vertically, 3m above the roof of the building. The nearest noise-sensitive receptor locations are the windows and balconies near to the flue discharge location. As a result, the flue noise affecting different receptors at different parts of the building will be subject to differing levels of distance attenuation, screening and directivity to these sources of noise. Therefore, analysis has been undertaken to predict the noise level at the nearest receptor locations, based on the source sound power level and taking these propagation effects into account.

This is achieved using a three-dimensional numerical noise model of the flue and building using Softnoise's '*Predictor*' software. This acoustic model implements the procedures set out in ISO 9613-2:1996 "*Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation to determine noise levels*".

Figures showing elements of the numerical noise model are shown in Appendix F. The calculations include the directivity effect of a vertical discharge duct with small aperture.

6.3 RESULTING NOISE LEVEL – DAYTIME AND NIGHT-TIME OPERATION

The results of this analysis show that the highest predicted flue noise level from the operation of three boilers at maximum duty outside the most-affected receptor location is L_{Aeq} 40 dB.

Even so, it is important to note that the heating system capacity is designed to accommodate the maximum heating load demand, which occurs during the daytime. The demand for heating varies throughout the day and night according to the heating and hot water requirements of occupants across the estate. Information provided by FLOH Consulting indicates the expected variation in demand for heating throughout the day.

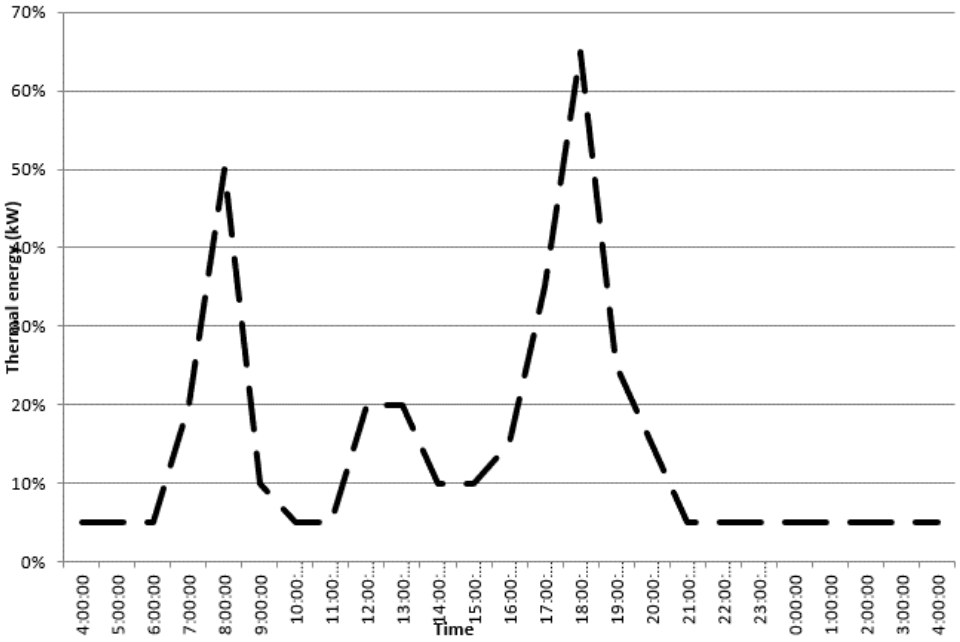


Figure 3: Typical boiler load profile

The figure indicates that there is a greatly reduced load on the system overnight. In particular, the heat load could be provided by a single boiler at night-time. Therefore, system controls will ensure that the heating supply matches the demand and, as a result, boiler flue noise levels will reduce overnight. Reducing from 3 operational boilers to only 1 boiler will result in a 5 dB reduction in overall noise levels.

Accordingly, specific sound level of the flue during the night-time will be $L_{Aeq,T}$ 35 dB.

7. ASSESSMENT OF NOISE IMPACT

7.1 RATING LEVEL

In Section 9.1, BS4142 states:

> *Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, add a character correction to the specific sound level to obtain the rating level.*
>
> *NOTE 1 Sound with prominent impulses has been shown to be more annoying than continuous types of sound (without impulses or tones) with the same equivalent sound pressure level.*
> *NOTE 2 The rating level is equal to the specific sound level if there are no such features present or expected to be present.*

We can be confident that boiler flue noise, which is continuous and not level-varying, contains none of the impulse characteristics described in Note 1.

Spectrum have carried out measurements of boiler flue noise on previous occasions. Figure 2, below, shows the 1/3rd octave band spectra for a sample of these measurements, with the measured levels normalised to the same overall sound pressure level. This tends toward a conclusion that there is no significant tonal element from flue noise. This corresponds to the subjective judgement of flue noise undertaken by Spectrum's consultants, that is, flue noise is not distinguishably tonal but rather, is broadband and non-descript.

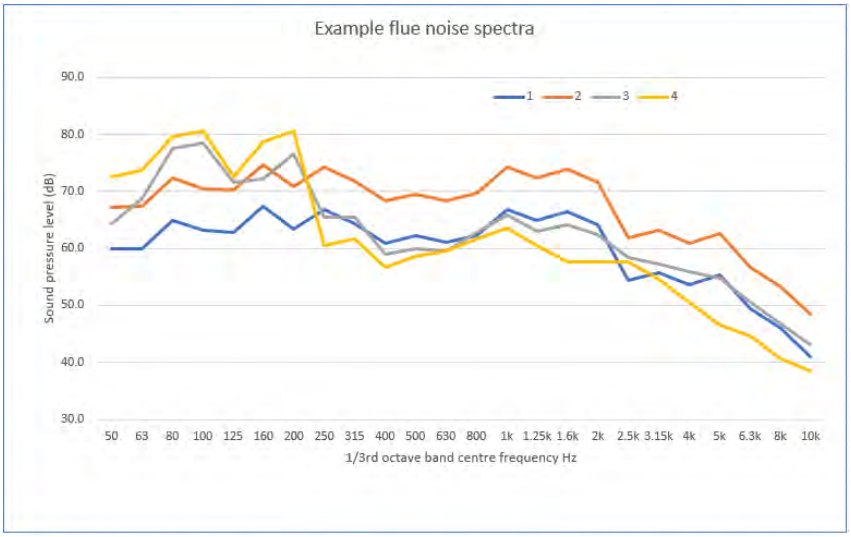


Figure 2: Example flue noise spectra

Accordingly, in this case, the rating level is equal to the specific sound level and the noise criterion that applies is that flue noise should be at least 5 dB below the background $L_{A90,}$ 1m from the nearest noise sensitive location.

7.2 ASSESSMENT

Paragraph 6.3, above, states that the predicted specific sound level from flue noise outside the most affected receptor is L_{Aeq} 40 dB. This occurs at the southern-most residential window at third floor level of the eastern façade of the building, as shown in Appendix C. This sound level occurs during the daytime when all 3 boilers operating at 100% duty and compares to a daytime L_{A90} of 46 dB.

Paragraph 6.3 also indicates that controls on the operation of the boilers will ensure only 1 boiler operates during the night-time resulting in a specific sound level from flue noise outside the most affected receptor is L_{Aeq} 35 dB. This compares to a night-time L_{A90} of 41 dB

Section 7.1 confirms that the character of the flue noise is such that the rating level is equal to the specific sound level. As a result, for both daytime and night-time operation, the sound rating level of the boiler flue noise will be 6 dB below the L_{A90} (background) noise.

Therefore, for both daytime and night-time operation, the BS4142 assessment is a 'LOAEL' condition. This complies with Camden Council's noise guidelines for the operation of mechanical plant.

7.3 CONTEXT

BS4142 states:

> *The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs. An effective assessment cannot be conducted without an understanding of the reason(s) for the assessment and the context in which the sound occurs/will occur. When making assessments and arriving at decisions, therefore, it is essential to place the sound in context.*

The factors described in BS4142 in relation to context, such as the absolute level of sound, the character of the residual sound and receptor sensitivity have been considered and do not affect the outcome of the assessment set out in Section 7.2 above.

8. CONCLUSION

The analysis indicates that the proposed new boiler flues to be installed at Holly Lodge Estate will comply with the noise level guidelines provided by Camden Council for both daytime and night-time operation. Accordingly, the noise impact of these proposals will be acceptable low.

APPENDIX A

Site location plan showing noise monitoring location and photos of current plant installation

A3

N

Makepeace Mansions

Existing flue termination and noise monitoring location as viewed from north

MAKEPEACE AVENUE

SWAINS LANE

Noise monitoring location

TEMPORARY BOILER PLANT

EXT-ERNAL AREA

PLANT ROOM

Existing flue enclosure as viewed from south east

El Sub Sta

113 to 130

131 to 148

149 to 164

57 to 84

85 to 112

Court View

FLOH
W floh.consulting
A 66 Wentworth Street
London
E1 7BB

Client	LONDON BOROUGH OF CAMDEN
Architect	–
Project	HOLLY LODGE, PLANT REPLACEMENT WORKS

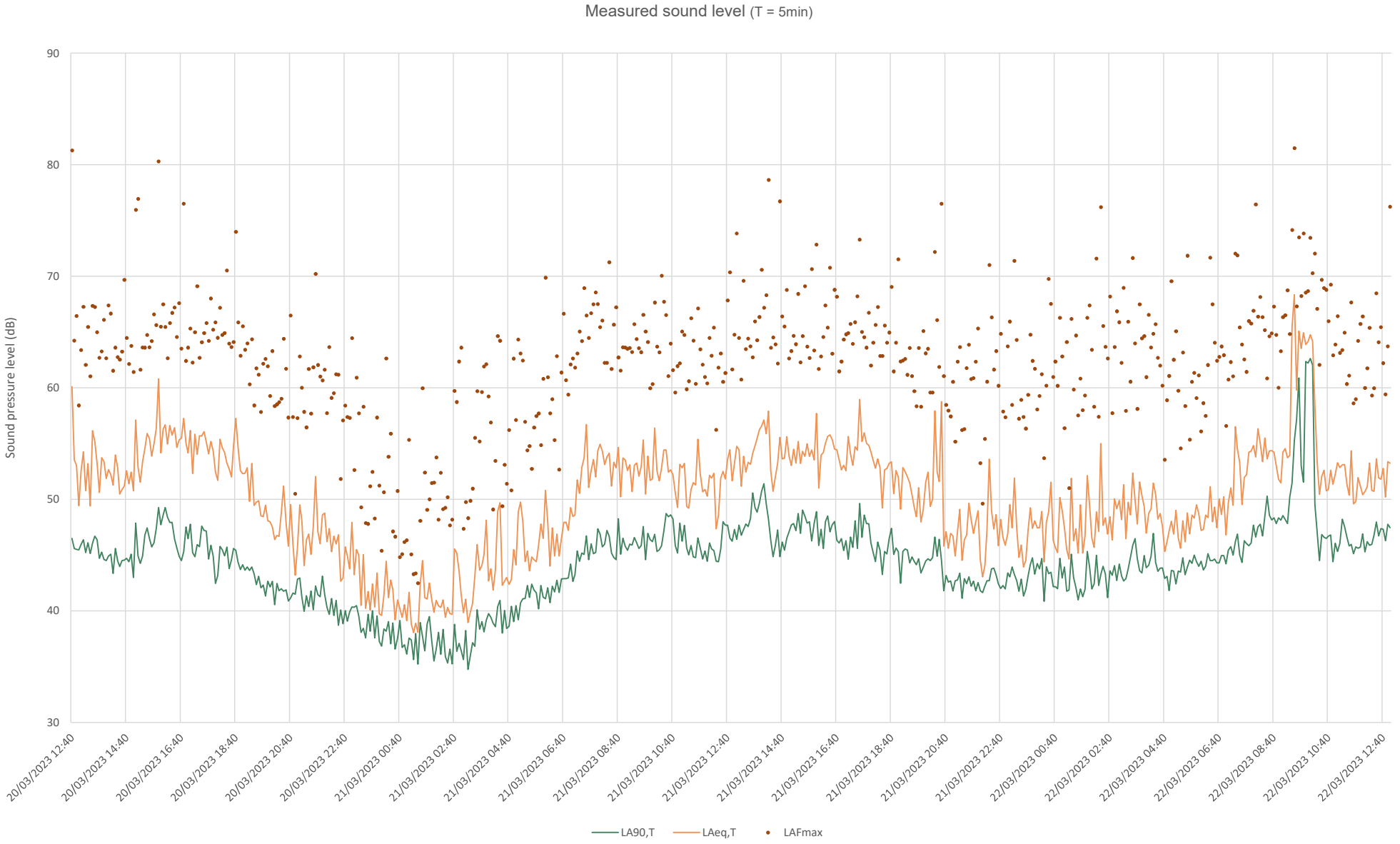
Drawing title: ESTATE BLOCK PLAN

Drawn	Date made	Scale	Check	Status	FLOH ref
MF	NOV '22	1:500	AM	SKETCH	F2142

Project	Originator	Zone	Level	Type	Disc.	Service	Number	Rev
HL	FLOH	XX	XX	DR	M	PR	SK10	–

APPENDIX B

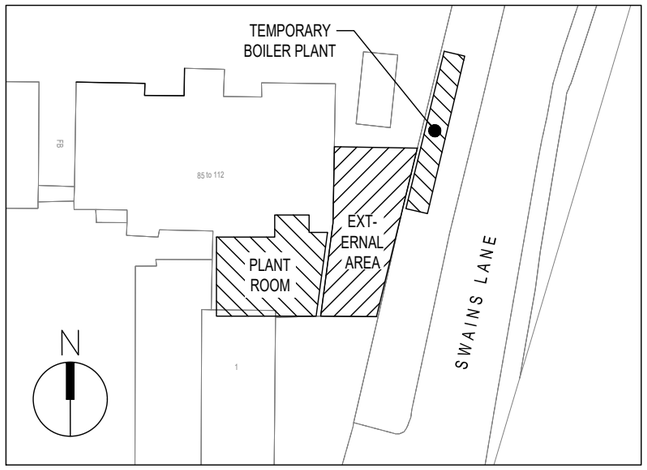
Chart showing results of noise monitoring on the roof of 85 to 112 Makepeace Avenue


Measured sound level (T = 5min)
Sound pressure level (dB)
90
80
70
60
50
40
30
20/03/2023 12:40
20/03/2023 14:40
20/03/2023 16:40
20/03/2023 18:40
20/03/2023 20:40
20/03/2023 22:40
21/03/2023 00:40
21/03/2023 02:40
21/03/2023 04:40
21/03/2023 06:40
21/03/2023 08:40
21/03/2023 10:40
21/03/2023 12:40
21/03/2023 14:40
21/03/2023 16:40
21/03/2023 18:40
21/03/2023 20:40
21/03/2023 22:40
22/03/2023 00:40
22/03/2023 02:40
22/03/2023 04:40
22/03/2023 06:40
22/03/2023 08:40
22/03/2023 10:40
22/03/2023 12:40
LA90,T
LAeq,T
LAFmax

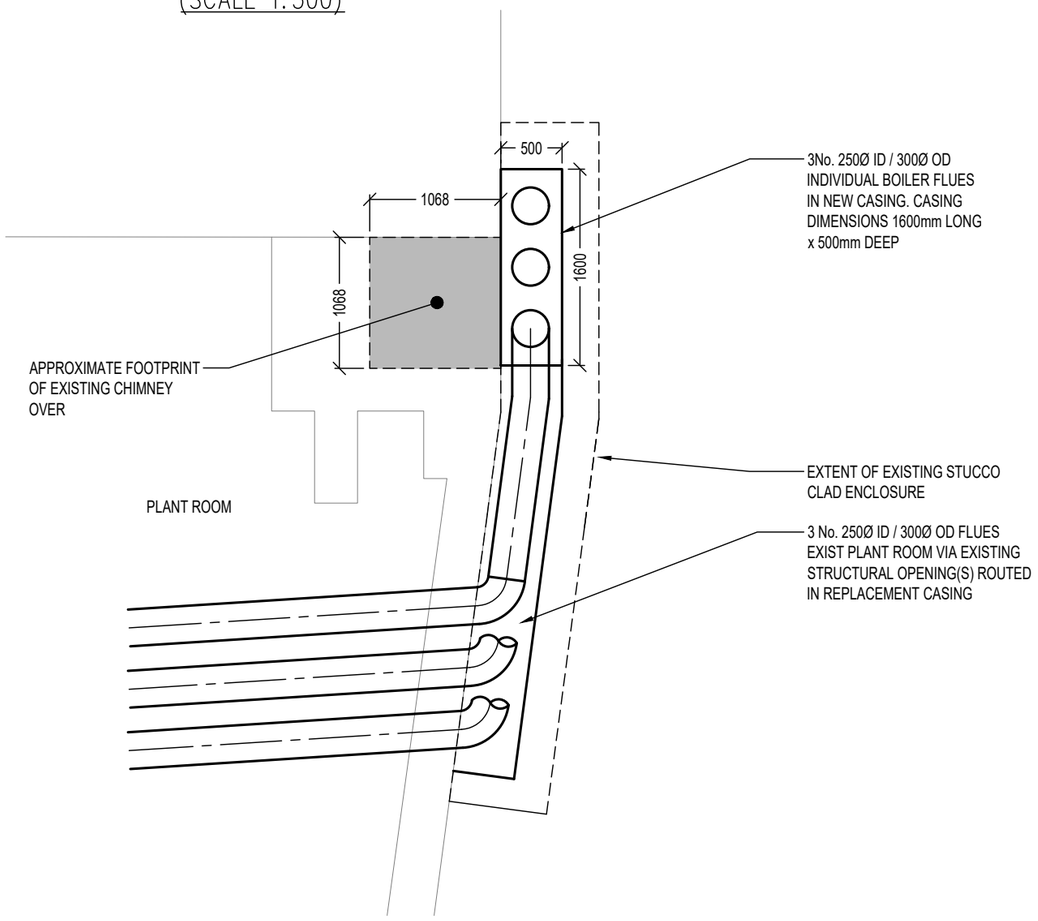
APPENDIX C

Drawings showing the proposed new flue installation

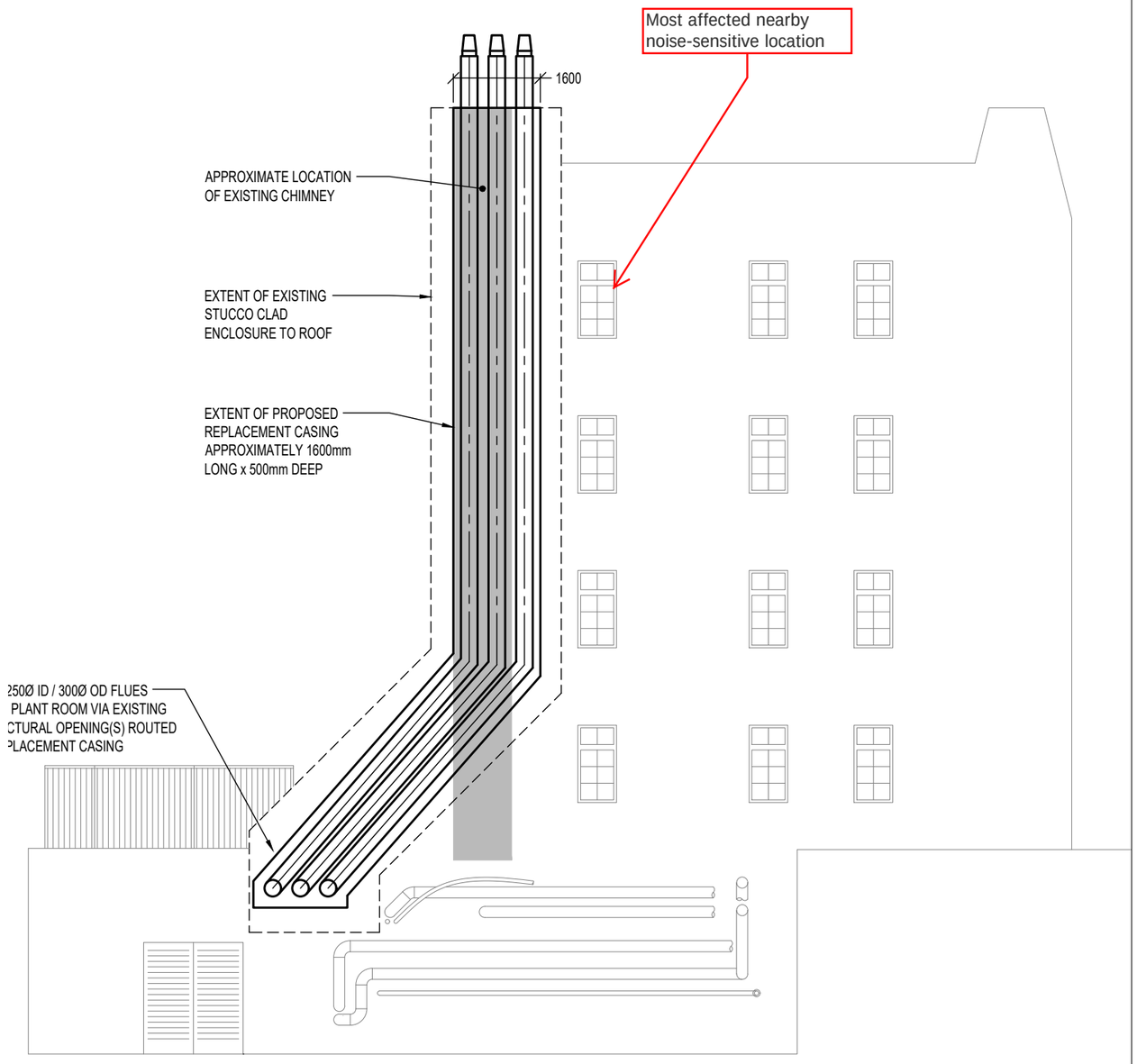
A3



LOCATION PLAN
(SCALE 1:500)



PLAN DETAIL
(SCALE 1:50)



EXTERNAL ELEVATION DETAIL
(SCALE 1:100)

FLOH
W floh.consulting
A 66 Wentworth Street
London
E1 7BB

Client	LONDON BOROUGH OF CAMDEN
Architect	–
Project	HOLLY LODGE, PLANT REPLACEMENT WORKS

Drawing title
MECHANICAL ENGINEERING SERVICES
FLUE CONFIGURATION OPTIONS
OPTION 3 – REUSE EXISTING ROUTE
W/REPLACEMENT CASING

Drawn	Date made	Scale	Check	Status	FLOH ref
MF	NOV '22	1:50	AM	SKETCH	F2142

Project	Originator	Zone	Level	Type	Disc.	Service	Number	Rev
HL	FLOH	XX	XX	DR	M	PR	SK03	–

APPENDIX D

Product data for Hamworthy Modumax mk3 units

Hamworthy

Heating *at work.*

Wessex ModuMax mk3

- Floor standing
- Condensing modular boiler
- Compact & lightweight
- 90°C maximum flow temperature

UP TO **40°C** ΔT

15 MODELS, OUTPUTS 97 - 762KW

up to 95% Gross Seasonal Efficiency

Nat Gas LPG

up to 15:1 Turndown

10 Yr Heat Exchanger Warranty

ErP Part L Compliant

BIM Objects

9 MODELS

147-762 kW OUTPUT

Technical data & dimensions

Models WM147/147H, WM147/294V, WM147/441V, WM196/196H, WM196/392V, WM196/588V, WM254/254H, WM254/508V, WM254/762V
147, 196 and **254kW** modules

	Wessex ModuMax mk3 boiler model	Units	147/147H	147/294V	147/441V	196/196H	196/392V	196/588V	254/254H	254/508V	254/762V
	No. of modules		1	2	3	1	2	3	1	2	3
Energy	Building regulations Part L seasonal efficiency	% gross	94.8	94.8	94.8	93.9	93.9	93.9	95.0	95.0	95.0
	BS EN 15502 seasonal efficiency	% gross	95.2	95.2	95.2	94.1	94.1	94.1	95.3	95.3	95.3
	Boiler output 80/60°C, NG & LPG	kW	142.8	285.6	428.4	191.6	383.2	574.8	239.8	479.6	719.4
	Boiler output 50/30°C, NG & LPG	kW	147.4	294.8	442.2	196.3	392.6	588.9	254.4	508.7	763.1
	Boiler input (gross) - maximum, NG	kW	163	326	489	219	428.7	657	275	550	825
	Boiler input (gross) - maximum, LPG	kW	159.5	319.1	478.6	214.4	428.7	643.1	269.2	538.3	807.5
	Boiler input (nett) - maximum, NG & LPG	kW	146.8	293.6	440.3	197.2	394.4	591.6	247.6	495.3	742.9
	Boiler output - minimum 80/60°C, NG & LPG	kW	28.7	28.7	28.7	38.6	38.6	38.6	48.4	48.4	48.4
Water	Water content	litres	22	44	66	22	44	66	22	44	66
	System design flow rate @ 40°C ΔT rise	l/s	0.9	1.8	2.7	1.2	2.4	3.6	1.5	3	4.5
	Water side pressure loss @ 40°C ΔT rise	mbar	36	36	36	62	62	62	100	100	100
	System design flow rate @ 30°C ΔT rise	l/s	1.2	2.4	3.6	1.6	3.2	4.8	2	4	6
	Water side pressure loss @ 30°C ΔT rise	mbar	60	60	60	120	120	120	180	180	180
	System design flow rate @ 20°C ΔT rise	l/s	1.8	3.6	5.4	2.4	4.8	7.2	3	6	9
	Water side pressure loss @ 20°C ΔT rise	mbar	145	145	145	246	246	246	395	395	395
	System design flow rate @ 11°C ΔT rise	l/s	3.3	6.6	9.9	4.3	8.6	12.9	5.4	10.8	16.2
	Water side pressure loss @ 11°C ΔT rise	mbar	500	500	500	850	850	850	1300	1300	1300
	Minimum water pressure	barg	Dependent on differential temperature – see page 25								
	Maximum water pressure	barg	10	10	10	10	10	10	10	10	10
	Maximum flow temperature setting	°C	90	90	90	90	90	90	90	90	90
Gas	Gas flow rate, NG (G20) - maximum	m^3/hr	15.5	31	46.5	20.9	41.8	62.7	26.2	52.4	78.6
	Gas flow rate, LPG (G31) - maximum	m^3/hr	6	12	18	8.1	16.2	24.3	10.1	20.2	30.3
	Nominal inlet pressure, NG (LPG) - maximum	mbar	20 (37)	20 (37)	20 (37)	20 (37)	20 (37)	20 (37)	20 (37)	20 (37)	20 (37)
	Maximum gas inlet pressure NG (LPG)	mbar	25 (45)	25 (45)	25 (45)	25 (45)	25 (45)	25 (45)	25 (45)	25 (45)	25 (45)
Flue	Approx. flue gas volume @ 15°C, 8.75-9.25% CO_2	m^3/hr	214	428	642	279	558	837	354	708	1062
	Maximum flue gas temperature @ 80/60°C	°C	78	78	78	83	83	83	82	82	82
	Pressure at boiler flue connection	Pa mbar	150 1.5	150 1.5	150 1.5	150 1.5	150 1.5	150 1.5	150 1.5	150 1.5	150 1.5
	Dry NOx emission (0% excess oxygen, dry air free) - NG	mg/kWh	37.7	37.7	37.7	39.9	39.9	39.9	38.8	38.8	38.8
	Dry NOx emission (0% excess oxygen, dry air free) - LPG	mg/kWh	69.3	69.3	69.3	68.6	68.6	68.6	39.9	39.9	39.9
Connection	Water flow/return connections	inches	G2½" male	G2½" male	G2½" male	G2½" male	G2½" male	G2½" male	G2½" male	G2½" male	G2½" male
	Gas inlet connection pipe thread size	inches	R1¼" male	R1¼" male	R1¼" male	R1¼" male	R1¼" male	R1¼" male	R1¼" male	R1¼" male	R1¼" male
	Nominal flue diameter (I/D)	mm	150	250	250	150	250	250	150	250	250
	Condensate trap connection(s) (O/D)	mm	32	32	32	32	32	32	32	32	32
Electrics	Electrical supply		230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz	230V 1Ph 50Hz
	Power consumption - maximum boiler modulation	W	240	480	720	240	480	720	240	480	720
	Start current (per module)	Amp	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
	Run current (per module)	Amp	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
	Approx shipping weight	kg	226	452	678	226	452	678	226	452	678
	Noise emission @1m @maximum modulation	Max dB (A)	65	65	65	65	65	65	65	65	65
	Noise emission @1m @minimum modulation	Min dB (A)	47	47	47	47	47	47	47	47	47

APPENDIX E

Product data for Hoval 1300D boilers

3.4 Technical information UltraGas® (800D-1300D)

Type			(800D)	(900D)	(1000D)	(1150D)	(1300D)
• Nominal output 80/60 °C with natural gas [1]		kW	87-742	87-834	87-926	208-1060	122-1206
• Nominal output 40/30 °C with natural gas [1]		kW	97-800	97-900	97-1000	233-1150	136-1300
• Nominal output 80/60 °C with propane [3]		kW	139-728	139-820	139-910	169-1048	169-1184
• Nominal output 40/30 °C with propane [3]		kW	154-800	154-900	154-1000	185-1150	185-1300
• Nominal load with natural gas [1]		kW	89-754	89-848	89-942	214-1082	125-1226
• Nominal load with propane [3]		kW	144-754	144-848	144-942	175-1084	175-1228
• Working pressure heating maximum/minimum		bar	6.0/1.0	6.0/1.0	6.0/1.0	6.0/1.0	6.0/1.0
• Test pressure		bar	9.0	9.0	9.0	9.0	9.0
• Working temperature maximum		°C	90	90	90	90	90
• Boiler water content		l	822	774	751	1098	1058
• Minimum water flow		l/h	0	0	0	0	0
• Boiler weight (without water content, incl. casing)		kg	1844	1944	1982	2554	2606
• Boiler efficiency at full load at 80/60 °C (related to net calorific value NCV/gross calorific value GCV)		%	98.3/88.6	98.3/88.6	98.3/88.6	98.3/88.6	98.3/88.6
• Boiler efficiency at partial load 30% (according to EN 303) (related to net calorific value NCV/gross calorific value GCV)		%	108,1/97.4	108.0/97.3	108.0/97.3	108,1/97.4	108.0/97.3
• Standard efficiency (according to DIN 4702 part 8)	40/30 °C	%	109.8/98.9	109.8/98.9	109.8/98.9	109.9/99.0	109.9/99.0
(related to net calorific value NCV/gross calorific value GCV)	75/60 °C	%	107.3/96.7	107.3/96.7	107.3/96.7	107.4/96.8	107.4/96.8
• Stand-by loss at 70 °C		Watt	1500	1500	1500	2000	2000
• Standard emission rate	Nitrogen oxides	mg/kWh	43	42	41	48	48
• Content of CO_2 in the exhaust gas maximum/minimum output		%	9.0/8.8	9.0/8.8	9.0/8.8	9.0/8.8	9.0/8.8
• Dimensions			see table of dimensions				
• Connections	Flow/return	DN	DN 125/ PN 6	DN 125/ PN 6	DN 125/ PN 6	DN 150/ PN 6	DN 150/ PN 6
	Gas	inches	2″	2″	2″	2″	2″
	Flue gas Ø inside	mm	356	356	356	356	356
• Gas flow pressure minimum/maximum							
Natural gas E/LL		mbar	17.4-80	17.4-80	17.4-80	17.4-80	17.4-80
Propane		mbar	37-57	37-57	37-57	37-57	37-57
• Gas connection value at 0 °C/1013 mbar:							
Natural gas E (Wo = 15.0 kWh/m³) NCV = 9.97 kWh/m³		m³/h	75.4	84.9	94.3	108.5	122.7
Natural gas LL (Wo = 12.4 kWh/m³) NCV = 8.57 kWh/m³		m³/h	88	98.9	109.9	126.5	143,1
Propane (NCV = 25.9 kWh/m³)		m³/h	29.1	32.7	36.4	41.9	47.3
• Operation voltage		V/Hz	230/50	230/50	230/50	230/50	230/50
• Control voltage		V/Hz	24/50	24/50	24/50	24/50	24/50
• Minimum/maximum electrical power consumption		Watt	60/890	60/1164	60/1490	62/1440	62/2060
• Stand-by		Watt	18	18	18	18	18
• IP rating (integral protection)		IP	20	20	20	20	20
• Sound power level							
- Heating noise (EN 15036 part 1) (room air dependent)		dB(A)	74	76	78	75	78
- Exhaust noise is radiated from the mouth (DIN 45635 part 47)		dB(A)	74	75	76	72	75
• Sound pressure level heating noise (depending on installation conditions)[2]		dB(A)	64	66	68	65	68
• Condensate quantity (natural gas) at 40/30 °C		l/h	70.9	79.7	88.5	101.9	115.2
• pH value of the condensate		pH	approx. 4.2	approx. 4.2	approx. 4.2	approx. 4.2	approx. 4.2
• Flue gas system: requirements, values							
Temperature class			T120	T120	T120	T120	T120
Flue gas mass flow		kg/h	1252	1408	1564	1799	2035
Flue gas temperature at nominal output and operation 80/60 °C		°C	71	71	72	71	72
Flue gas temperature at nominal output and operation 40/30 °C		°C	48	47	49	47	49
Volume flow rate combustion air		Nm³/h	933	1050	1166	1342	1518
Feed pressure total at the combustion air/flue gas pipe		Pa	60	60	60	60	60
Maximum draught/depression at flue gas outlet		Pa	-50	-50	-50	-50	-50

[1] Data related to NCV. The boiler series is tested for EE/H-settings. With a factory setting of the Wobbe coefficient of 15.0 kWh/m³ operation at a Wobbe coefficient of 12.0 up to 15.7 kWh/m³ is possible without new settings.

[2] See also notes at “Engineering”.

[3] Data related to NCV. UltraGas® (250D-700D) can also be operated with propane.

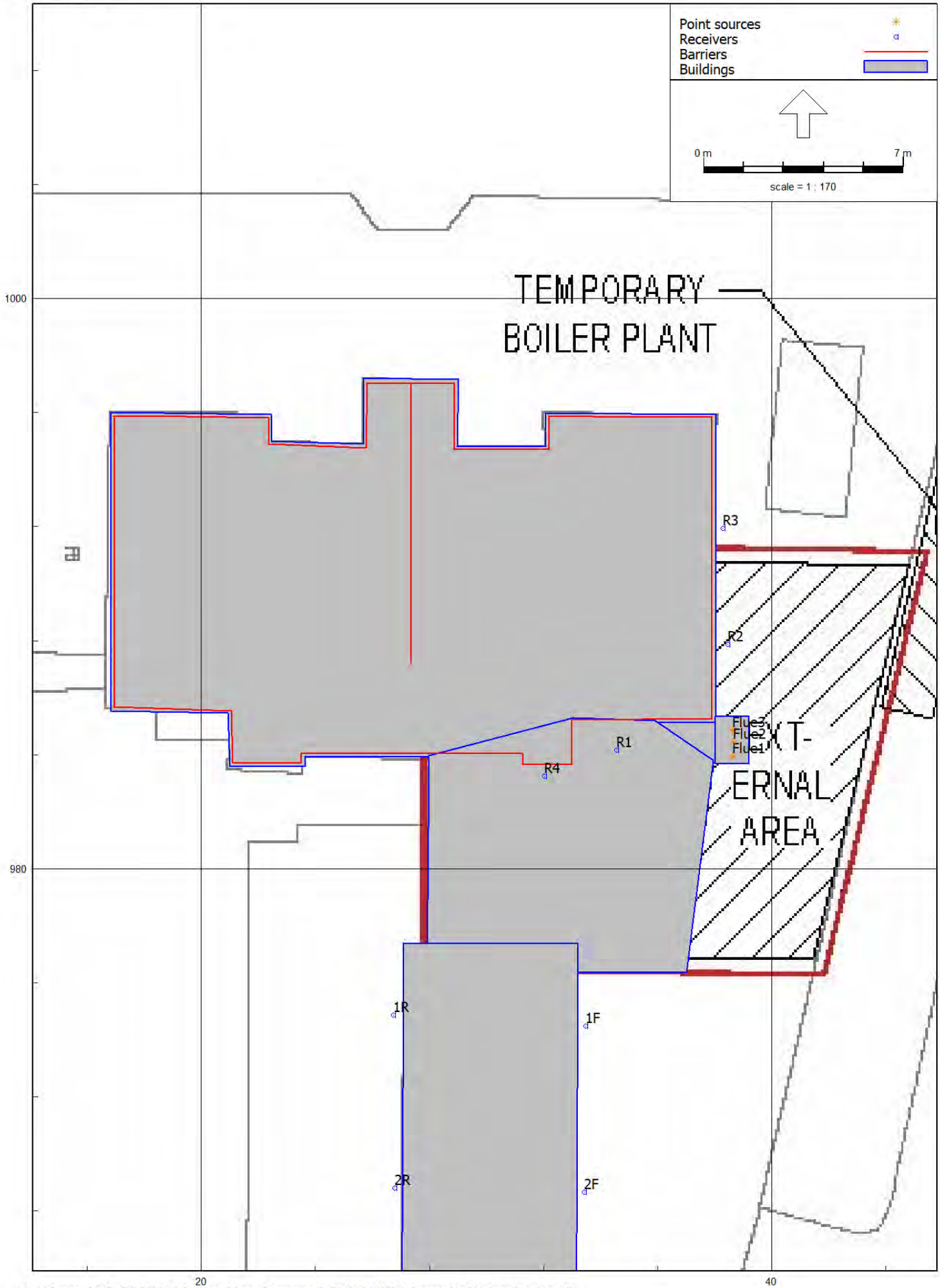
• Boiler flow resistance see diagrams.

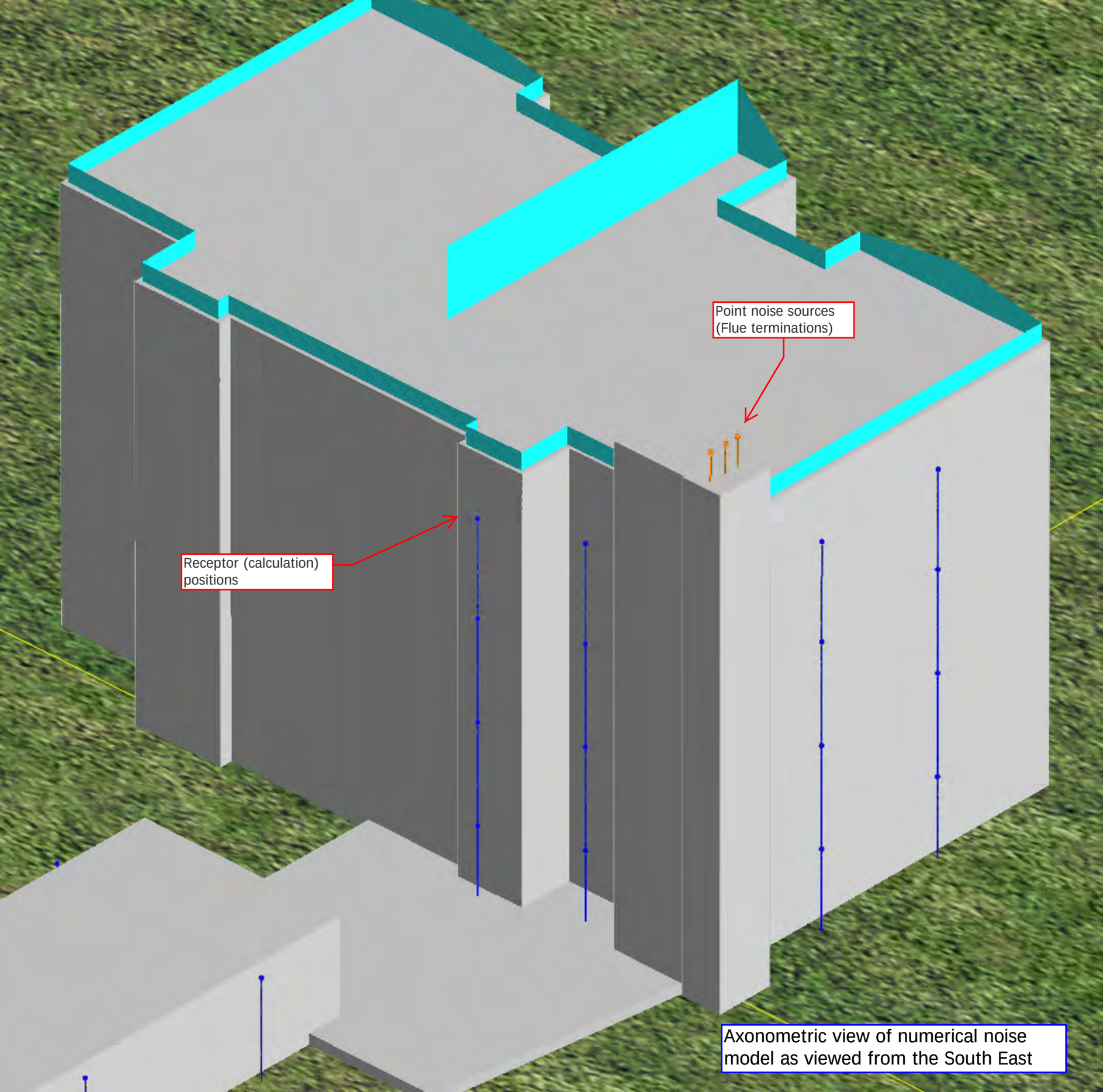
APPENDIX F

Figures showing elements of the numerical noise model

Plan of numerical noise model
Holly Lodge Estate

Spectrum Acoustics, UK





Axonometric view of numerical noise model as viewed from the South East

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