ACOUSTICS CENTRAL

NDPF Wrexham

Transformer Noise

20130902-0 R2

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NDPF Wrexham

Transformer Noise

20130902-0 R2

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30th August 2024

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1 Introduction

1.1 Planning permission (ref P/2024/0205) has been granted for a new primary substation and associated fencing at Building 7, Ispen Biopharm Ltd, Ash Road North, Wrexham Industrial Estate, Wrexham, LL13 9UF subject to conditions. Conditions 6 and 7 of the permission relate to the noise impact of the substation.

1.2 This report provides full details of an assessment of noise from the substation in line with the requirements of planning conditions 6 and 7. The potential impact of vibration from the substation has also been considered in line with condition 6.

1.3 The report is necessarily technical in nature, however every effort has been made to make it as clear as possible. In this regard, the Glossary of Acoustics Terms attached as Appendix A gives further explanation on relevant acoustics terminology used within the report.

2 Site Description

2.1 The proposed development site is located within Wrexham Industrial Estate off Ash Road North. The site is to be located within the existing car park of the proposed NDPF development site.

2.2 The site location is shown below:



F1 Site Location

2.3 Ash Road North runs along the western boundary of the site. Ash Road South runs along the northern boundary. To the east of site is a small wooded area and office buildings. To the south of the site are industrial uses.

2.4 The nearest dwellings to the site are located to the southeast on Erlas Lane.

3 Planning Conditions

3.1 General

3.1.1 Planning permission (ref P/2024/0205) has been granted for the "Installation of primary substation and associated fencing" at building 7, Ash Road North, Wrexham, subject to conditions. Conditions 6 and 7 consider the noise and vibration impact of the development and are reproduced below:

3.2 Condition 6

3.2.1 Condition 6 considers the impact of noise and vibration from the substation at the nearest dwellings and commercial uses. The condition is reproduced below:

Prior to the first use of any electricity substation installed in connection with the development hereby approved, an acoustic report assessing its impact upon amenity shall be submitted to, and approved in writing by, the Local Planning Authority. The report shall address the issue of noise (including low frequency noise) and vibration from the station to ensure that there is no loss of amenity to residential or commercial properties. The measures as are approved shall be fully implemented in strict accordance with the scheme prior to first use of the development and shall thereafter be retained as such.

3.3 Condition 7

3.3.1 Condition 7 sets noise limits for any and all proposed equipment to be installed as part of the development at the nearest dwellings based on the existing noise climate. The condition is reproduced below:

The rating level of any noise generated by reason of this development shall not exceed the pre-existing background level at any time. The noise levels shall be determined at nearby noise sensitive premises, and measurements and assessment shall be made in accordance with BS4142:2014 Methods for Rating and Assessing Industrial and Commercial Sound (or any Guidance revoking or re-enacting that Guidance with or without modification).

4 Noise Limits

4.1 General

4.1.1 To comply with the requirements of Condition 6 and 7 above it is necessary to set noise limits at the existing commercial and residential buildings.

4.2 Residential

BS4142:2014+A1

4.2.1 Noise limits at the nearest dwellings have been set based on guidance within BS4142:2014+A1 Methods for Rating and Assessing Industrial and Commercial Sound, and a noise survey undertaken at the site, as required by Condition 7.

4.2.2 A noise survey has previously been undertaken at the nearest noise sensitive dwellings on Erlas Road. Full details of the survey and limits set are provided within report ref 20230902-0 R1 attached as Appendix C to this report.

4.2.3 Noise limits for mechanical services plant have been set equal to the background noise level at the nearest dwellings as required by condition 7. This are reproduced below:

Location	Noise Limit, L_{Ar} dB	
	Daytime (0700-2300 only)	Night time (2300-0700)
Nearest noise sensitive properties	44	42

T1 Plant noise limits at the nearest residential properties.

4.2.4 The above limits apply to the cumulative noise emissions from all new plant items under normal operating conditions, and apply at 1 m from the outside of the windows of the worst-affected noise sensitive receptors within the vicinity of the site.

Low Frequency Noise

4.2.5 Noise from transformers is generally characterised by a low frequency noise which is often subjectively described as a "hum". BS 4142 states that it is not applicable to the assessment of low frequency noise and instead states that "Information on the assessment of low frequency noise is *given in NANR45".*

4.2.6 NANR45 provides criteria for the assessment of low frequency noise disturbance and provides a procedure for the assessment of low frequency noise complaints.

4.2.7 The procedure provided is intended for use where complaints have been received about an existing low frequency noise. The methodology allows a suitably qualified person to identify whether the noise is present within a dwelling at a level that could reasonably give rise to disturbance to some individuals. It does not necessarily follow that the presence of the noise at such a level will in fact give rise to disturbance.

4.2.8 Although the DEFRA document states that the procedure would not be reliable if used to predict the likelihood of complaints at the planning stage, when the noise source and receptors are often not yet present, we believe that it represents a good means of indicating whether a low frequency problem may occur when the substation is installed.

4.2.9 The DEFRA standard is only applicable to internal noise levels within dwellings. Due to this the performance of the building façade and ventilation system must be considered.

4.2.10 We highlight that we are aware that UK Power Networks have historically advised during CPD presentations specifically given to members of the Institute of Acoustics[1] that they look to the NANR45 standard when they are asked to review schemes with residential noise sensitive receptors that might be affected by transformer noise.

4.2.11 NANR 45 presents a criterion curve as reproduced below:

	Third-Octave Band with Centre Frequency, Hz												
	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB, L_{eq}	92	87	83	74	64	56	49	43	42	40	38	36	34

[1] IOA Central Branch presentation on 'Transformer Hum - Planning for Low Frequency Noise' (26 May 2022)

4.2.12 For noise sources present during the day-time period only, a relaxation of 5dB on the above criterion curve should be taken. For sources that are steady, i.e. not fluctuating, the criterion curve may also be relaxed by 5dB. In this regard, the guidance states:

"Fluctuating sounds are known to be more disturbing than steady sounds by an equivalent of about 5dB. The criterion curve should be relaxed by 5dB for steady sounds to take account of this."

4.2.13 The following criteria can be used to determine whether the source is considered fluctuating:

- L10 - L90 < 5: no penalty
- L10 - L90 ≥ 5: penalty of 5dB.

4.2.14 Whilst this process relates to the determination of low-frequency disturbance from an existing source (and more commonly from sources such as machinery and equipment), the general process outlined above is considered to remain relevant in terms of prediction of nuisance from proposed sources with strong low-frequency content (such as electrical substations) on occupants of a premises.

4.2.15 The substation will operate 24 hours a day and so no relaxation for daytime only operation can be taken into account, From Acoustics Central experience noise from substations is consistent and so does not fluctuate. Due to this the +5 dB relaxation for steady sources can be applied. This is consistent with UKPN advice, as discussed earlier.

4.3 Commercial Properties

4.3.1 BS 4142 only provides guidance for the assessment of noise at residential properties and so does not consider the noise limits at commercial properties which are generally considered to be less sensitive.

4.3.2 To the north of the site there is an office/reception area for a warehouse and to the east of site there are office buildings. These are considered to be the nearest commercial buildings that planning condition 6 would apply to.

4.3.3 When considering the noise impact at commercial properties it is considered appropriate to set noise limits inside rooms of the development, as external noise levels are not of concern.

4.3.4 Guidance for internal noise levels within offices are provided in various documents including BS8233:2014, British Council for Office Guide to Specification 2019 and CIBSE Guide A. Based on these guidance documents and standards as well as our experience of other buildings with similar uses the following noise limits are proposed within offices:

- Cellular offices/meeting rooms: NR35 L_{eq}
- Open plan offices/breakout spaces: NR40 L_{eq}

4.3.5 The limits above are expressed as Noise Rating Curves (NR) which is common for the assessment of mechanical services noise within offices. NR Curves are frequency dependant as they compare the noise levels at each octave bands to the NR curve. The assess NR value for the measured noise

is the lowest curve which is not exceeded in any octave band is then the measured. Due to this low frequency noise from the substation is taken into account within the proposed criteria.

4.3.6 Assuming a loss of 10 dB through a partially open windows noise limits at the façade of the offices are set at NR 45 L_{eq}. This is based on the nearest rooms within the offices are the most noise sensitive cellular offices/meeting rooms.

5 Plant Noise Assessment

5.1 General

5.1.1 To compare noise from the proposed transformers to the noise limits an atmospheric plant noise assessment has been carried out.

5.1.2 The assessment process involves calculating the noise levels from the proposed plant at the noise sensitive locations and comparing the resultant levels with the plant noise limits established in the previous section.

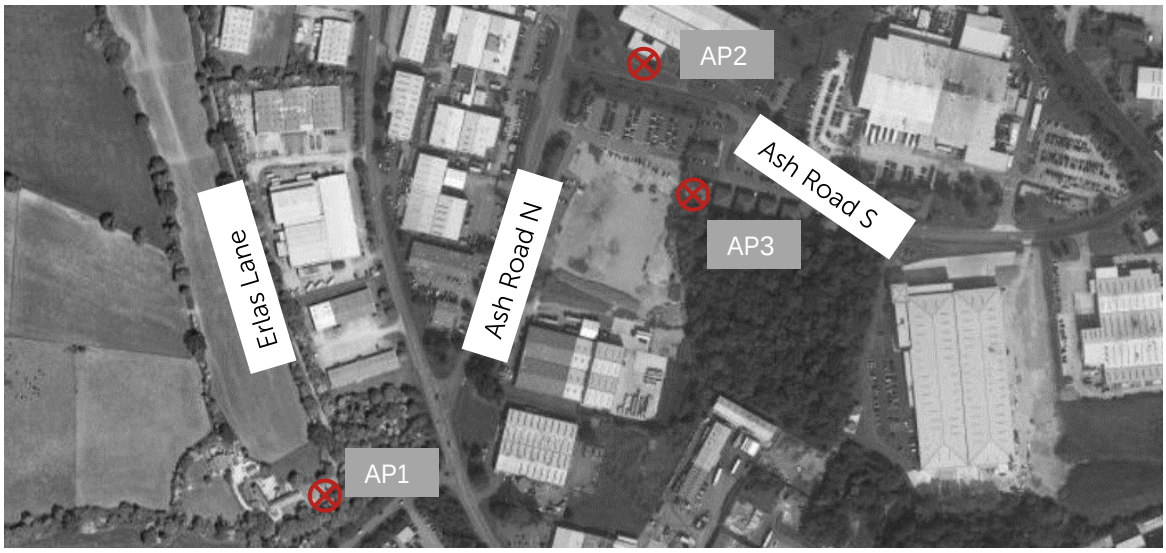
5.1.3 Our calculations take into account propagation losses such as distance and, where relevant, screening from building, roof and wall edges where these obscure the plant from direct view.

5.2 Assessment Receiver Locations

5.2.1 The closest residential premises to the transformers are located on Erias Lane to the south west of site. The closest office buildings are located off Ash Road South to the north and east of site.

5.2.2 Three assessment positions have been selected to represent the noise sensitive properties, these are described and shown below:

- AP1 – Closest dwellings on Erias Lane, approximately 400m from the development site.
- AP2 – Offices to the north of site on Ash Road South, approximately 50m from the development site
- AP3 – Closest office buildings to the east of site on Ash Road South, approximately 80m from the development site.

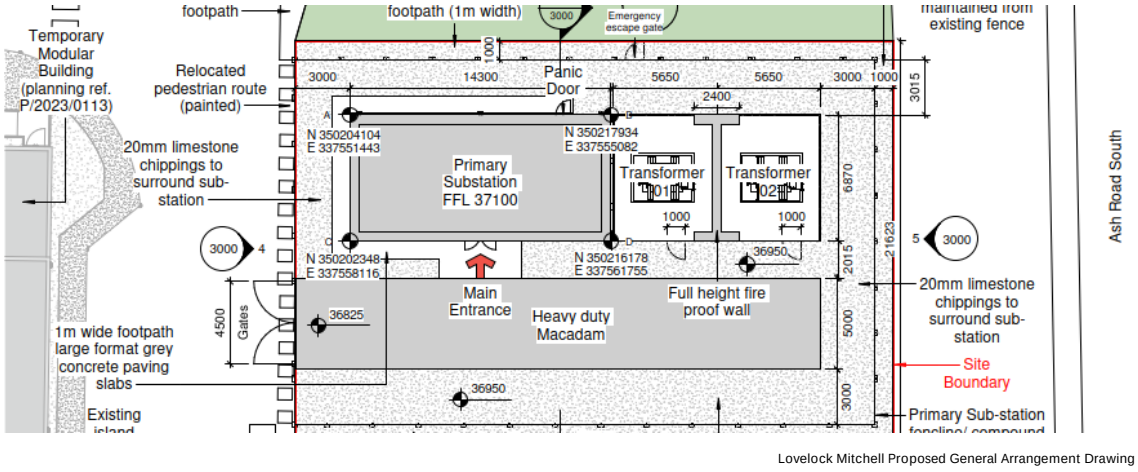


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T2 Assessment Positions

5.3 Proposed Scheme

5.3.1 It is proposed to install two new RT 10000-33 transformers at the site as shown in the layout below:



Lovelock Mitchell Proposed General Arrangement Drawing

T3 Site Layout

5.3.2 Manufacturers noise data for the transformers has been provided by the Client. The data provided is A weighted sound power levels with no frequency data. The manufacturers data is included in Appendix E and shows that each transformer has a sound power level of 75.8 dB(A).

5.3.3 Electrical substations generally generate significant noise at 100Hz and 200Hz. Other spikes in noise level can be noted at higher harmonics of 100Hz but these are generally masked by other noise sources generated by the substation.

5.3.4 To take account of the low frequency noise generated by the substation a typical third octave band spectra has been taken from Paper Number 23, Proceedings of Acoustics 2011 "Low-frequency and Total Characteristics of Transformer Noise" attached to this report as Appendix D. The "typical transformer noise spectrum" provided within the paper is reproduced below:

Typical Transformer Noise Spectrum, dB												
Freq	50	63	80	100	125	160	200	250	315	400	500	630
L_{eq}	58	60	60	79	60	56	75	61	72	73	69	65
Freq	800	1k	1250	1600	2k	2500	3150	4000	5000	6300	8000	10000
L_{eq}	58	57	51	49	46	44	41	42	44	42	42	58

T4 Typical Transformer Noise Spectrum

5.3.5 The spectrum above shows a 19 dB increase at 100Hz compared to 80 Hz and 19 dB increase at 200 Hz compared to 160 Hz. This is as expected from Acoustics Central's consultants experience

with other large scale electrical transformers. The spectra has been utilised in our assessment by shifting it to match the overall 75.8dBA sound power level as noted by the manufacturer.

5.4 Residential Assessment Results

BS 4142 assessment

5.4.1 By utilising the methodology set out above the calculated noise levels at AP1 are shown below. These are the specific noise levels and so do not include a penalty correction as this will be applied at the receptor.

Assessment Position	Noise Limit, dB(A)	Calculated specific noise level, dB(A)
AP1	42	14

T5 BS 4142 Assessment results

5.4.2 The calculated noise level at the dwellings is 28 dB(A) below the existing background noise levels. Due to this it is expected that any low frequency character from the transformers will not be noticeable at the dwellings and so no acoustic penalties are required.

5.4.3 Based on the above the requirements of condition 7 are considered to be achievable without any mitigation.

NANR 45 assessment

5.4.4 The calculated external low frequency noise levels from the units, between 50 Hz and 160 Hz are shown below along with the NANR 45 criteria (including the +5 dB relaxation for steady state noise):

	Third-Octave Band with Centre Frequency, L_{eq} (dB)												
	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
NANR 45	97	92	88	79	69	61	54	48	47	45	43	41	39
Substation Noise	-	-	-	-	-	-	-	-2	0	0	19	0	-4

DEFRA NANR45 Criterion Curve

5.4.5 The results above show that the transformers are 24 dB below the criteria at its worst case frequency of 100Hz and so meets the criteria. It is noted that the calculated levels above are external and so noise levels within rooms, where NANR 45 is to be applied, would be lower than those shown above.

5.4.6 Based on the above residential noise requirements condition 6 are considered to be achievable on site without any mitigation.

5.5 Office Assessment Results

5.5.1 The calculated external noise levels at the proposed offices, compared to the criteria are shown in the table below:

Assessment Position	Noise Limit, NR, dB	Calculated noise level, NR, dB
AP2	45	37
AP3	45	31

T6 Office Assessment results (External)

5.5.2 The calculated noise levels are 8 dB to 14 dB below the noise limits and so meets the criteria.

5.5.3 It is noteworthy that the noise level predicted at 100Hz at AP2 is 42 dB which is below the 43 dB NANR45 criteria for within dwellings at night. Whilst NANR45 is not a relevant standard for assessing low frequency noise in commercial properties, as it is significantly more onerous than required, meeting the criteria is a clear demonstration that the resultant noise levels are acceptable.

5.5.4 Based on the above, the commercial noise requirements for condition 6 are considered to be achievable without any mitigation.

5.5.5 Calculation sheets are available for all of the assessments undertaken above on request.

6 Vibration

6.1 Condition 6 requires an assessment of vibration from the transformer. No vibration data has been provided for the transformer and so a full assessment cannot be undertaken. The transformer must be installed as per the manufacturer's instructions to control vibration.

6.2 It is noted that transformers do not have any moving parts which would generate any vibration and are generally installed on rubber mounts which would further reduce the transmission of any potential vibration. The substation is located 50m from the nearest commercial receptor. At this distance vibration is not considered to be significant.

7 Conclusion

7.1 Planning permission has been granted for a new primary substation and associated fencing at Building 7, Ispen Biopharm Ltd, Ash Road North, Wrexham Industrial Estate, Wrexham, LL13 9UF subject to conditions. Conditions 6 and 7 of the condition relate to the noise impact of the substation.

7.2 Assessments have been undertaken to calculate the noise impact of the proposed transformers on the nearest dwellings and offices as required by the conditions. The assessments have shown that suitable noise levels are achieved at the nearest noise sensitive locations without the need for any mitigation and so the noise requirements of the conditions are achievable on site.

7.3 The likelihood of significant vibration from the transformers has also been considered in line with Condition 6. As the nearest sensitive receptors from the transformers are approximately 50m away vibration is not considered to be likely to be significant.

7.4 We therefore suggest that condition 6 and 7 should be discharged with regards to the proposed transformers.

Appendix A

Glossary of Acoustics Terms – Noise Levels

Single Figures and Spectra

Generally speaking, the human ear is capable of hearing noise within the frequency range 20Hz to 20kHz. To make handling of data more meaningful and manageable, the range is often divided into 'bands', each of which covers a specific part.

For most acoustics applications, either octave or third-octave bands are used. Each band has a specific centre frequency which is used to identify it. When reported, the band centre frequency is given, along with the associated noise level, e.g. 63dB L_{eq} at 500Hz.

Noise levels can also be reported as single figure values where all energy contained within the measured frequency range is summed to provide a single figure. However, as the human ear does not hear noise at different frequencies with equal loudness, a weighting curve is often applied to levels before summing to account for this fact.

The most common curve is the A-weighting curve, and its use is denoted by including the letter 'A' with either the index e.g. 63dB L_{Aeq}, or with the decibel suffix (if the index is described elsewhere), e.g. 63dBA. 'B' and 'C' weighting curves may also be applied, depending on the application. A 'Z' is used to indicate a single figure where no weighting has been applied, e.g. 63dB L_{Zeq}.

Noise Level Indices

Noise level measurements can be made and reported in a variety of indices. The index is reported using the letter L to indicate Level, followed by, for example, abbreviations to represent the specifics of the index, and time intervals where applicable. The most commonly used are given below.

$L_{eq,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{eq,T}$ value is the sound pressure level in decibels of a continuous steady sound that within a specified time interval, T, has the same mean-squared sound pressure as a sound that varies with time. It is often used as a descriptor of the ambient noise climate, and commonly seen as a single A-weighted figure $L_{Aeq,T}$.

L_{max}, (dB) - Maximum Sound Pressure Level

The L_{max} value is the highest recorded sound pressure level in decibels averaged across a specified time constant during a noise measurement of certain duration. Two time constants are used, Fast and Slow, where the time constants are 0.125s and 1s respectively. The time constant is denoted in the index, $L_{max,F}$ for Fast and $L_{max,S}$ for Slow. It is often used to identify transient events that have a high-level relative to the ambient noise climate, and commonly seen as a single A-weighted figure L_{Amax}.

$L_{10,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{10,T}$, value is the sound pressure level in decibels that is exceeded for 10% of a given time interval, T. It is often used as a measurement of noise from transportation sources such as road and rail. It is commonly seen as a single A-weighted figure $L_{A10,T}$.

$L_{90,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{90,T}$, value is the sound pressure level in decibels that is exceeded for 90% of a given time interval, T. It is often used as a descriptor of the background noise climate, and commonly seen as a single A-weighted figure $L_{A90,T}$.

Appendix B

Document Naming and Version Control Policy

All documents are issued with a unique number which comprises the principle 8-digit project and 1-digit subsection numbers, for example 20151203-0, and a reference indicting iteration of document type, for example R1 for Report 1, M2 for Memorandum 2 etc.

All documents employ version control through the use of a unique version number. The version numbers employ two levels of hierarchy, and use the format illustrated below:

V 1 . 2

Major Minor

Major

A major revision occurs when the report is revised to reflect significant changes in design strategy. For example, wide scale changes to building footprint or general arrangements, changes to principle construction type (e.g. masonry to lightweight), reselection of mechanical services plant etc. A change in strategy that takes place within the same RIBA work stage for example will prompt a major revision to a document.

Minor

A minor revision occurs when the report is revised to reflect minor changes to the design implementation. For example a change in the type of natural vent, extract fan, surface finish etc. to be used, on the project. Minor revisions will also occur when there is a change in wording of the report text.

Reporting

The Document History and Version Control table on the second page of each report identifies the versions through which the document has moved, along with the date, author that produced the version, and a description of its purpose or change.

Electronic File Naming

Reports issued electronically use the following format:

2012xxxx	-	x	Rx	Noise Assessment Report	v1.0	yyyy.mm.dd.pdf
Project Number		Subsection	Report Number	Report Name	Version	Date File Extension

Appendix C

Noise Survey Report

ACOUSTICS CENTRAL

NDPF Wrexham

Noise Survey Report

20230902-0 R1

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NDPF Wrexham

Noise Survey Report

20230902-0 R1

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27th October 2023

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Attachments

20230902-0 R1 SCH1
Measured Noise Levels

Appendix A
Glossary of Acoustics Terms

Appendix B
Document Naming and Version Control Policy

1 Introduction

1.1 Planning permission is sought for a new pharmaceutical facility in Wrexham Industrial Estate, Wrexham. As part of the development it is proposed to install various mechanical services items.

1.2 Acoustics Central have been instructed to undertake a noise survey and plant noise assessment for the proposed development.

1.3 This report sets out the methodology and results of an environmental noise survey undertaken at the development site, along with noise limits for the mechanical services items in line with the Councils Noise Limits. A mechanical services noise impact assessment will be required when full details of the equipment are available to demonstrate that the noise limits set in this report are achievable on site.

1.4 The report is necessarily technical in nature, however every effort has been made to make it as clear as possible. In this regard, the Glossary of Acoustics Terms attached as Appendix A gives further explanation on relevant acoustics terminology used within the report.

2 Site Description

2.1 The proposed development site is located within Wrexham Industrial Estate off Ash Road North. The current site is an empty plot.

2.2 The site location is shown below:



F1 Site Location

2.3 Ash Road North runs along the western boundary of the site. Ash Road South runs along the northern boundary. To the east of site is a small wooded area and office buildings. To the south of the site are industrial uses.

2.4 The nearest dwellings to the site are located to the southeast on Erlas Lane.

3 Guidance and Standards

3.1 National Planning Policy Framework

3.1.1 The National Planning Policy Framework (NPPF)[1] sets out the Government's planning policies for England and how these are expected to be applied.

3.1.2 Paragraph 174 states:

Planning policies and decisions should contribute to and enhance the natural and local environment by (...) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of (...) noise pollution.

3.1.3 Paragraph 185 states:

Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:

- a) mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life
- b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

3.1.4 NPPF paragraph 185 refers to the Noise Policy Statement for England, details of which are set out in the following section.

Noise Policy Statement for England[2]

3.1.5 The Noise Policy Statement for England (NPSE) seeks to clarify the underlying principles and aims in existing policy documents, legislation and guidance that relate to noise. The statement applies to all forms of noise, including environmental noise, neighbour noise and neighbourhood noise.

3.1.6 The statement sets out the long-term vision of the government's noise policy, which is to *"promote good health and a good quality of life through the effective management of noise within the context of policy on sustainable development"*.

3.1.7 The NPSE adopts established concepts from toxicology that are currently being applied to noise effects. The concept details noise level thresholds, at which the effects of an exposure may be classified into a specific category. The classification categories as detailed within NPSE are as follows:

- No Observed Effect Level (NOEL) - the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;

[1] National Planning Policy Framework – Ministry of Housing, Communities and Local Government, September 2023
[2] https://www.gov.uk/government/publications/noise-policy-statement-for-england

- Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse effects on health and quality of life can be detected; and
- Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse effects on health and quality of life occur.

3.1.8 The first aim of the NPSE is to avoid significant adverse effects on health and quality of life, taking into account the guiding principles of sustainable development. The second aim considers situations where effects are established between the LOAEL and SOAEL. In such circumstances, all reasonable steps should be taken to mitigate and minimise the effects. However, this does not mean that such adverse effects cannot occur. The third aim seeks to improve health and quality of life, where possible, through the pro-active management of noise, whilst also taking account of the guiding principles of sustainable development.

3.1.9 It is recognised that the SOAEL does not have a single objective noise-based level that is applicable to all sources of noise in all situations; therefore the SOAEL is likely to be different for different sources, receptors and at different times of the day.

Planning Practice Guidance[3]

3.1.10 Planning practice guidance on noise attempts to clarify the thresholds set out above. To this end, the table below taken from the guidance summarises the noise exposure hierarchy, based on the likely average response.

[3] https://www.gov.uk/guidance/noise--2

Response	Examples of Outcomes	Increasing Effect Level	Action
No Observed Effect Level (NOEL)			
Not present	No Effect	No Observed Effect	No specific measures required
No Observed Adverse Effect Level (NOAEL)			
Present and not intrusive	Noise can be heard, but does not cause any change in behaviour, attitude, or other physiological response. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.	No Observed Adverse Effect	No specific measures required
Lowest Observed Adverse Effect Level (LOAEL)			
Present and intrusive	Noise can be heard and causes small changes in behaviour, attitude or other physiological response, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a small actual or perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level (SOAEL)			
Present and disruptive	The noise causes a material change in behaviour, attitude or other physiological response, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Present and very disruptive	Extensive and regular changes in behaviour, attitude or other physiological response and/or an inability to mitigate effect of noise leading to psychological stress, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Unacceptable Adverse Effect	Prevent

T1 Summary of the noise exposure hierarchy, based on the likely average response

3.2 BS4142:2014 +A1:2019

3.2.1 Atmospheric noise emissions from new items of mechanical services plant will need to be adequately controlled to minimise disturbance. It is relevant to refer to British Standard BS4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound.

3.2.2 The standard defines a method for quantifying noise levels from a specific sound source at a noise sensitive location, applying acoustic feature corrections as necessary to define a 'rating level' ($L_{Ar,Tr}$), and comparing this rating level with the prevailing background level (L_{A90}). Section 11 of the standard (*Assessment of the impacts*) states the following:

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

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

- *"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."*

3.2.3 Based on this guidance Acoustics Central considers that a noise limit 5 dB above the existing background noise is representative of the Lowest Observed Adverse Effect Level (LOAEL).

3.3 Local Planning Policy

3.3.1 Paul Campini at Wrexham Council has confirmed that the Council's standard noise limit will apply to mechanical services items installed on the site. This is reproduced below:

The rating level of any noise generated by reason of development shall not exceed the pre-existing background level at any time. The noise levels shall be determined at nearby noise sensitive premises, and measurements and assessment shall be made in accordance with BS4142:2014 Methods for Rating and Assessing Industrial and Commercial Sound.

3.3.2 Based on the guidance above noise limits from mechanical services items installed on site will be designed to not exceed the current background noise levels at the nearest dwellings.

4 Environmental Noise Survey

4.1 General

4.1.1 To quantify the noise levels at the nearest dwellings, an attended environmental noise survey was carried out, commencing at 22:00 on 17th November 2023 and concluding at 02:00 on 18th November 2023. The timing of the survey was selected to ensure that the quietest times of the day and night time periods were measured.

4.1.2 The survey instrumentation, methodology and reporting of results have been carried out following guidance contained within British Standard 7445-1:2003 - 'Description and measurement of environmental noise - Part 1: Guide to quantities and procedures',

4.1.3 Noise measurements were made at a single measurement location as illustrated in the following figure and described below:

- MP1 – Free field measurement position located 1.5m above local ground level on Erlas Road. Measurements made at this position to be best representative of the background noise levels at the nearest dwellings on Erlas Road.



Imagery @2023 Airbus, Bluesky, Bluesky, Infoterra Ltd & COWI A/S, CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Tchnologies, Map Data @2023

F2 Measurement location

4.1.4 Noise measurements were made with the equipment detailed in the following table.

Item	Manufacturer	Type
Sound Level Analyser	NTi Audio	XL2-TA
Microphone	NTi Audio	MC230
Pre-Amp	NTi Audio	MA220
Acoustic Calibrator	NTi Audio	CAL200

T2 Equipment used during attended noise survey.

4.1.5 The sound level analyser presented in the above table conforms to the Type 1 specification as given in BS EN 61672-1:2003 - 'Electroacoustics - Sound level meters - Part 1: Specifications'. The calibrator presented in the above table conforms to the Class 1 specification as specified in IEC 60942:2003 – 'Electroacoustics - Sound calibrators'.

4.2 Calibrations

4.2.1 The measurement instrumentation, including sound level analyser, preamplifier, microphone and calibrator has undergone traceable calibration by either a competent laboratory or the equipment manufacturer within the last two years. The calibration certificates for the above equipment can be provided on request.

4.2.2 A field calibration check was undertaken on the noise measurement equipment before and after the survey to ensure a consistent and acceptable level of accuracy is maintained. No significant drift was noted to have occurred.

4.2.3 Noise data was recorded over consecutive 15-minute periods in all relevant indices, including L_{Aeq}, L_{A90}, and $L_{AMax,F}$. See attached Appendix A for an explanation of noise units used.

4.2.4 Octave band data for each of the above indices was also recorded at all positions, the filters for which met the requirements of BS EN 61260:1996, Class 1.

4.3 Weather Conditions

4.3.1 The weather conditions during the survey period were cool and dry with clear skies and no breeze.

4.4 Measurement Results

4.4.1 The noise climate at the nearest dwellings, and measurement position, was noted to be dominated by mechanical services located on the adjacent industrial estate. Occasional vehicle movements on the estate were also audible.

4.4.2 The attached schedule 20230902-0 R1 SCH1 presents the noise levels measured at MP1.

4.4.3 A summary of the representative background noise levels measured is presented in the table below. As the noise measurements were made over a short term the minimum results are considered to be representative of the background noise levels:

Location	Minimum $L_{A90,15min}$	
	Daytime (0700-2300 only)	Night time (2300-0700)
MP1	44	42

T3 Measured minimum L_{A90}.

4.5 Limits

4.5.1 Using the measured noise levels and requirements set out in Section 3, the following plant noise emission limits are to apply at the nearest noise sensitive premises:

Location	Noise Limit, L_{Ar} dB	
	Daytime (0700-2300 only)	Night time (2300-0700)
Nearest noise sensitive properties	44	42

T4 Plant noise limits at the nearest residential properties.

4.5.2 The above limits apply to the cumulative noise emissions from all new plant items under normal operating conditions, and apply at 1 m from the outside of the windows of the worst-affected noise sensitive receptors within the vicinity of the site.

5 Conclusion

5.1 Planning permission is sought for a new pharmaceutical facility in Wrexham Industrial Estate, Wrexham. As part of the development it is proposed to install various mechanical services items.

5.2 This report has set out the methodology and results of an environmental noise survey undertaken at the development site and sets noise limits for the proposed plant in line with the requirements of the local Council.

5.3 A full assessment of the mechanical services items, demonstrating compliance with the limits set in this report will be required when the equipment has been selected.

20230902-0 R1 SCH1

Title	Measured Noise Levels
Project	NDPF Wrexham
Date	27th October 2023

Start Time	$L_{Aeq, 15min}$	$L_{Amax, fast}$	$L_{A90, 15min}$
22:05	49	75	45
22:20	46	52	44
22:35	45	50	44
22:50	45	58	44
23:05	46	51	44
23:20	45	52	44
23:35	45	51	43
23:50	46	58	44
00:05	45	54	43
00:20	45	58	42
00:35	45	50	43
00:50	45	51	44
01:05	46	51	43
01:20	45	51	43
01:35	45	52	43
01:50	45	56	43

T5 Measured Noise Levels

Appendix A

Glossary of Acoustics Terms – Noise Levels

Single Figures and Spectra

Generally speaking, the human ear is capable of hearing noise within the frequency range 20Hz to 20kHz. To make handling of data more meaningful and manageable, the range is often divided into 'bands', each of which covers a specific part.

For most acoustics applications, either octave or third-octave bands are used. Each band has a specific centre frequency which is used to identify it. When reported, the band centre frequency is given, along with the associated noise level, e.g. 63dB L_{eq} at 500Hz.

Noise levels can also be reported as single figure values where all energy contained within the measured frequency range is summed to provide a single figure. However, as the human ear does not hear noise at different frequencies with equal loudness, a weighting curve is often applied to levels before summing to account for this fact.

The most common curve is the A-weighting curve, and its use is denoted by including the letter 'A' with either the index e.g. 63dB L_{Aeq}, or with the decibel suffix (if the index is described elsewhere), e.g. 63dBA. 'B' and 'C' weighting curves may also be applied, depending on the application. A 'Z' is used to indicate a single figure where no weighting has been applied, e.g. 63dB L_{Zeq}.

Noise Level Indices

Noise level measurements can be made and reported in a variety of indices. The index is reported using the letter L to indicate Level, followed by, for example, abbreviations to represent the specifics of the index, and time intervals where applicable. The most commonly used are given below.

$L_{eq,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{eq,T}$ value is the sound pressure level in decibels of a continuous steady sound that within a specified time interval, T, has the same mean-squared sound pressure as a sound that varies with time. It is often used as a descriptor of the **ambient noise climate**, and commonly seen as a single A-weighted figure $L_{Aeq,T}$.

L_{max}, (dB) - Maximum Sound Pressure Level

The L_{max} value is the highest recorded sound pressure level in decibels averaged across a specified time constant during a noise measurement of certain duration. Two time constants are used, Fast and Slow, where the time constants are 0.125s and 1s respectively. The time constant is denoted in the index, $L_{max,F}$ for Fast and $L_{max,S}$ for Slow. It is often used to identify transient events that have a high-level relative to the ambient noise climate, and commonly seen as a single A-weighted figure L_{Amax}.

$L_{10,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{10,T}$, value is the sound pressure level in decibels that is exceeded for 10% of a given time interval, T. It is often used as a measurement of noise from transportation sources such as road and rail. It is commonly seen as a single A-weighted figure $L_{A10,T}$.

$L_{90,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{90,T}$, value is the sound pressure level in decibels that is exceeded for 90% of a given time interval, T. It is often used as a descriptor of the **background noise climate**, and commonly seen as a single A-weighted figure $L_{A90,T}$.

Appendix B

Document Naming and Version Control Policy

All documents are issued with a unique number which comprises the principle 8-digit project and 1-digit subsection numbers, for example 20151203-0, and a reference indicting iteration of document type, for example R1 for Report 1, M2 for Memorandum 2 etc.

All documents employ version control through the use of a unique version number. The version numbers employ two levels of hierarchy, and use the format illustrated below:

V 1 . 2

Major Minor

Major

A major revision occurs when the report is revised to reflect significant changes in design strategy. For example, wide scale changes to building footprint or general arrangements, changes to principle construction type (e.g. masonry to lightweight), reselection of mechanical services plant etc. A change in strategy that takes place within the same RIBA work stage for example will prompt a major revision to a document.

Minor

A minor revision occurs when the report is revised to reflect minor changes to the design implementation. For example a change in the type of natural vent, extract fan, surface finish etc. to be used, on the project. Minor revisions will also occur when there is a change in wording of the report text.

Reporting

The Document History and Version Control table on the second page of each report identifies the versions through which the document has moved, along with the date, author that produced the version, and a description of its purpose or change.

Electronic File Naming

Reports issued electronically use the following format:

2012xxxx	- x	Rx	Noise Assessment Report	v1.0	yyyy.mm.dd.pdf
Project Number	Subsection Report Number		Report Name	Version	Date File Extension

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Appendix D

Paper Number 23, Proceedings of Acoustics 2011, Low-frequency and Tonal Characteristics of Transformer Noise.

Low-frequency and Tonal Characteristics of Transformer Noise

Michael Gange

Senior Engineer, Renzo Tonin & Associates, Sydney, Australia

ABSTRACT

Electricity substations and their associated transformers are necessary for community power needs. In NSW these substations are often located in rural areas where background noise is low. Noise 'hum' from the transformers can be an issue for residents located nearby to the substation, and the tonal and low-frequency nature of the noise can add to the annoyance. The NSW Industrial Noise Policy applies penalties for these noise characteristics when assessing such sources. This paper analyses noise measurements of substations in rural areas. One-third octave band noise measurements were conducted both close up to the transformers, and also in the residential community. The measurement results show that although tonal and low frequency characteristics might be evident close up to the transformers, these characteristics dissipate over distance and the INP penalties do not necessarily apply at the residential receiver.

INTRODUCTION

The electricity used by households and businesses in NSW is generated at power stations then transmitted through high voltage transmission lines to substations. The substation performs the task of stepping down the voltage suitable for domestic and commercial distribution. There are approximately 91 large zone substations in NSW and many more smaller distribution substations.

Since substations are often located in rural areas, the nearest residential receivers are commonly isolated dwellings on large lots. Background noise is therefore usually very low due to the lack of other industrial development and low levels of traffic noise. Occasionally medium density residential areas on the edge of towns abut the substation land holding.

Since transformers generate noise emissions with a distinct tone at a relatively low frequency, it is sometimes assumed that these characteristics will also be evident at the residential receiver, to the point that a tonality penalty and/or a low-frequency penalty is automatically applied during an assessment. Particularly when utilising noise modelling say during the planning phase of a substation, the tones and harmonics the substation source are strongly evident in the predicted results at the receiver.

However, since tonality is assessed by determining the emergence of a particular tone above the noise level of the adjacent frequency bands, the background noise in an area plays a significant part in determining whether a noise source will be tonal or not. Even where the tone of a substation may still be somewhat audible, it may be that the tone has 'blended' enough with the background noise so that the tone is no longer inherently annoying.

This paper analyses the results of noise measurements conducted in rural areas, in the vicinity of substations, with the aim of determining typical distances from substations beyond which tonal and low-frequency penalties would no longer apply according to the INP.

ELECTRICITY SUBSTATION TRANSFORMERS

Zone substations typically contain at least two step-down transformers. These transformers operate with a distinct 'hum' which is generated by the periodic mechanical deformation of the transformer core and the winding coils, under the influence of fluctuating electromagnetic flux. The vibration of the core is at twice the frequency of the alternating magnetic flux. Since the line supply frequency is 50Hz, the noise emissions from these transformers are typically characterised by tonal spikes at 100Hz, and also at the 200Hz and 400Hz harmonic frequencies.



Figure 1 Typical substation transformer

During a transformer's operation, the vibrations from its core and windings get transmitted to the transformer tank surface through air-borne transmission (the air surrounding the core), and by structure-borne transmission at points where the mounting of the core structure is attached to the tank. The vibrating tank surface eventually radiates noise into the exterior air.

Some of the other sources of noise associated with transformer operation, such as cooling fans and pumps, are usually negligible contributors to the far-field noise.

NSW INDUSTRIAL NOISE POLICY

General Criteria

The NSW Industrial Noise Policy (INP) is generally used for setting noise goals in substation noise assessments in NSW.

The assessment procedure for the Industrial Noise Policy has two components:

- Controlling intrusive noise impacts in the short term for residences
- Maintaining noise level amenity for particular land uses for residences and other land uses.

In setting the project specific noise levels, the more stringent of the intrusive and amenity criteria is adopted. In general, the intrusive criterion tends to be the controlling criterion for substations as there is often little other industrial development in the regional areas where the substation is located.

Penalties for Low-frequency and Tonal Sources

Where a noise source contains certain characteristics (i.e. if it has an inherently tonal, low frequency, impulsive or intermittent character), then it can cause greater annoyance than other noise at the same level. According to the INP an adjustment of 5dBA for each annoyance aspect, up to a total of 10dBA, is to be added to the measured value to penalise the noise for the additional annoyance caused.

The INP provides definitive procedures for determining whether a penalty or adjustment should be applied for increased annoyance.

Tonal noise is defined as noise containing a prominent frequency and characterised by a definite pitch. A one-third octave (or narrow band analysis) is required and a 5dBA penalty is applied to the measured or predicted level when the level of one-third octave band exceeds the level of the adjacent bands on both sides by:

- 5dB or more if the centre frequency of the band containing the tone is above 400 Hz
- 8dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive
- 15dB or more if the centre frequency of the band containing the tone is below 160 Hz.

Low frequency noise is defined as noise containing major components within the low frequency range of 20Hz – 250Hz. Low frequency noise is considered to be evident where the difference between the measured A and C weighted levels is 15dB or more, and another 5dBA penalty may be applied.

MEASURED TRANSFORMER NOISE LEVELS

Near Field Noise Levels

Australian Standard 60076.10.1-2009 "*Power transformers – Determination of sound levels*" is the current standard for quantifying noise levels from transformers. The procedure in this standard calls for noise levels to be measured at a series of points around the tank of the transformer.

One-third octave band noise measurements have been conducted in accordance with the standard for the near field noise levels presented in this paper. A typical noise spectrum for these near field measurements is presented in Figure 2. The tone at 100Hz is distinct, being two times the electrical supply line frequency. There is also significant energy at the 200Hz and 400Hz harmonic frequencies.

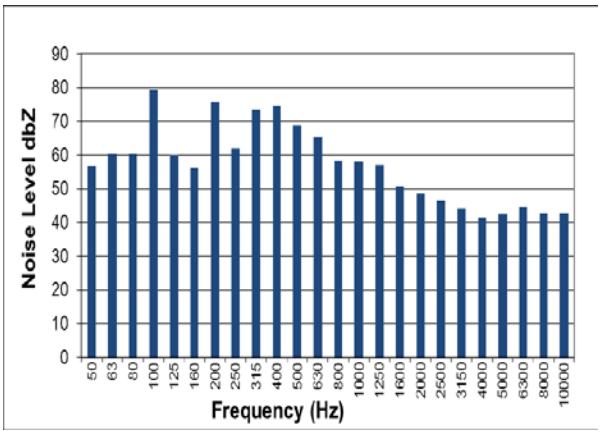


Figure 2. Typical Transformer Noise Spectrum

Noise Levels in the Community

The following three case studies are examples of where residences are affected by audible substation noise. Noise measurements have been conducted late at night at the residential boundaries in a low background noise environment to quantify noise emission levels and to determine whether tonal or low frequency characteristics exist. In each case, noise measurements have also been conducted close up to the transformers in the switchyard to quantify the character of the source.

Case 1

The substation was located in a rural area surrounded by grassy fields and farmland, and is approximately 2km from the main highway. Background noise levels were around 30dBA, although slightly less than 30dBA at some residential locations.

The graph in Figure 3 presents a comparison of measured noise levels both close up to the transformer in the substation, at the substation boundary, and at the residential boundary. The results are in one-third octave bands to enable analysis of tonality.

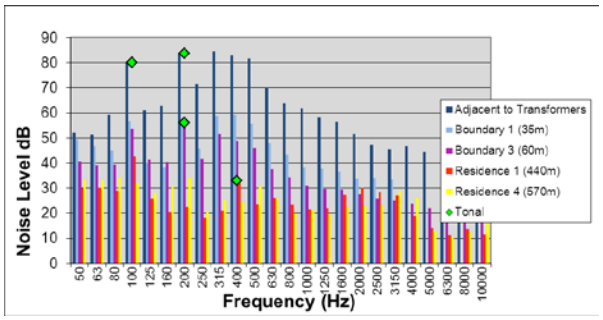


Figure 3. Measured Noise Levels (Case 1)

As shown by the arrowed notations, the following conclusions can be drawn for Case 1 according to the annoyance test procedures outlined in the INP

- Close up to the transformers, noise emissions are clearly tonal, with the obvious tones being at 100Hz, and at the 200Hz harmonic.
- Noise is still considered tonal at both the boundary locations (35m and 60m away), however the tones are only evident at 200Hz, but no longer at 100Hz.
- At the residential boundary 440m away, tonality was determined at 400Hz, but not at 100Hz or 200Hz
- At the residential boundary 570m away, noise from the substation was not considered tonal according to the INP procedures

Comparison of the A-weighted and C-weighted overall noise levels confirmed that a penalty for low frequency noise would not need to be applied at any residence.

Case 2

The substation was located in an area with farmland and some industry, and is approximately 400m from the main highway. Background noise levels were between 30 - 32dBA at night and truck traffic from the highway was audible at night.

The graph in Figure 4 presents a comparison of measured noise levels both close up to the transformer in the substation, at the substation boundary, and at the residential boundary.

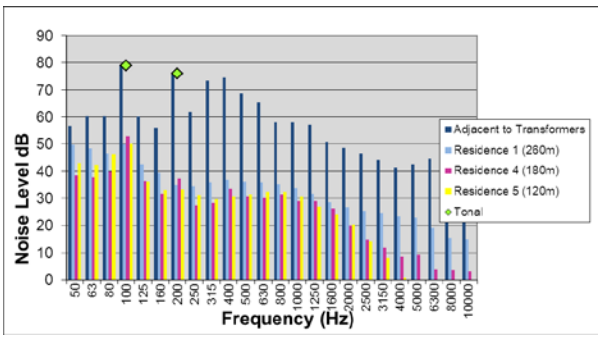


Figure 4. Transformer Noise (Case 2)

The following conclusions can be drawn for Case 2:

- Close up to the transformers, noise emissions are clearly tonal, with the obvious tones being at 100Hz and 200Hz.
- Noise is not considered tonal according to the INP at residences 120m, 180m or 260m away in any frequency.

Comparison of the A-weighted and C-weighted overall noise levels confirmed that a penalty for low frequency noise would not need to be applied at any residence.

Case 3

The substation was located in a rural residential with no industry. The nearest main road was approximately 1km away, and the nearest highway many kilometres away. Background noise levels were less than 30dBA at night.

The graph in Figure 5 presents a comparison of measured noise levels both close up to the transformer in the substation, at the substation boundary, and at the residential boundary.

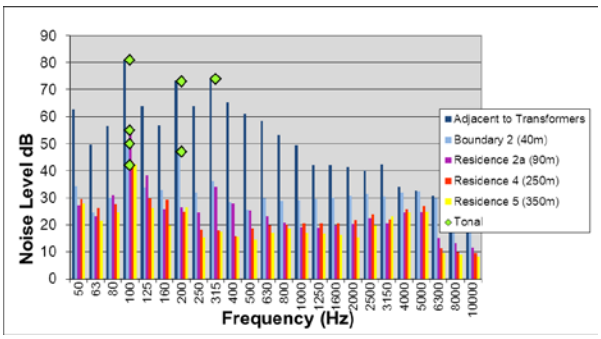


Figure 5. Transformer Noise (Case 3)

The following conclusions can be drawn for Case 3:

- Close up to the transformers, noise emissions are tonal at 100Hz, 200Hz and 315Hz.
- Tonality still exists at 100Hz at 40m and 90m. It is not calculated at 250m but is just triggered at 350m.

Comparison of the A-weighted and C-weighted overall noise levels confirmed that a penalty for low frequency noise would not need to be applied at any residence.

AUDIBILITY VERSUS INP PENALTIES

At each residential measurement location referenced in this paper, transformer hum could be described as being 'clearly audible' within the ambient noise. However, according to the INP procedures, penalties for tonality would not apply at all locations.

Table 1 summarises where tonality is evident for each case scenario, according to the INP procedures.

Table 1. Application of INP Tonality Penalty

Case	Receiver Distance	INP Penalty Applicable	Audibility of substation 'hum'
1	440m	Yes, tonal at 400Hz	Clearly audible
	570m	No	Clearly audible
2	260m	No	Clearly audible
	180m	No	Clearly audible
	120m	No	Clearly audible
3	90m	Yes, tonal at 100Hz	Clearly audible
	250m	No	Clearly audible
	350m	Yes, tonal at 100Hz	Clearly audible

Where a penalty for tonality is not required to be applied, the INP's 'background + 5dB' intrusiveness criterion is the remaining instrument for limiting noise impacts.

CONCLUSION

When acoustic engineers are planning for new substation installations in accordance with the NSW Industrial Noise Policy, the set of measured data in this paper suggests that:

- Where background noise levels are around 30dBA at night, application of the tonality penalty is appropriate for residences within about 500m of the transformers if the aim is simply to comply with the INP.
- Transformer hum can be clearly audible at a residential location without the INP procedures necessarily identifying that noise as being tonal. For additional protection of residences, particularly where background noise levels are below 30dBA at night, application of the tonality penalty for all receivers in the surrounding area may be appropriate, generating a more conservative outcome and additional mitigation measures so that that audible noise from the substation is reduced.
- Where receivers are exposed to existing traffic or industrial noise, or where background noise levels are greater than 30dBA, the INP penalty for tonality may not be triggered even for residences within a few hundred meters of the transformers.
- According to the INP procedures, an additional penalty for low-frequency noise is not warranted for substation installations.

REFERENCES

Australian Standard 60076.10.1-2009 "*Power transformers – Determination of sound levels*", Standards Australia, Sydney.

Jane Ann Verner, *Sound Tutorial*, March 2006

NSW Environment Protection Authority 2000, *Industrial Noise Policy*, EPA, Sydney.

Ravish S. Masti, Wim Desmet, Ward Heylen *Influence of core laminations upon power transformer noise,* K.U. Leuven, Department of Mechanical Engineering, Division PMA, Celestijnenlaan 300B, B-3001 Leuven, Belgium.

Appendix E

Manufacturers Noise Data

KOLEKTOR ETRA	TRANSFORMER TEST REPORT TRANSFORMATOR PRÜFPROTOKOLL	
Transformer: Transformator:	RT 10000-33	Ser. No.: Fertigungsnummer: 85105

9.0 DETERMINATION OF SOUND LEVEL - Sound intensity method
BESTIMMUNG DES SCHALLPEGELS - Schallintensitäts- Messverfahren - BS EN 60076-10:2016

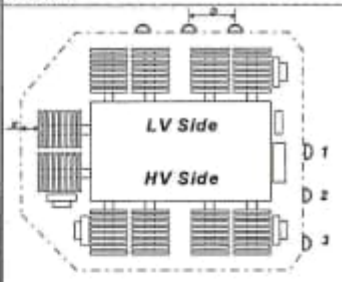
At rated voltage, ONAN, distance 1,0 m	**bei der Nennspannung, ONAN, Abstand 1,0 m**
Without fans!	**ohne Lüfter!**

Supply winding; Einspeise Wicklung: **LV / US** | Tap position: Stufe: **9** | Frequency: Frequenz: 50 Hz

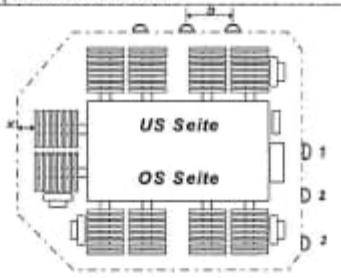
	h = 1/2			
	L_{IAi}	L_{pAi}		
	[dB(A)]	[dB(A)]		
1	46,3	48,8		
2	50,9	52,5		
3	48,0	50,6		
4	49,2	51,0		
5	50,5	52,1		
6	51,3	54,0		
7	51,0	54,4		
8	49,2	51,3		
9	47,9	50,1		
10	46,5	49,5		
11	43,4	48,0		
12	49,7	50,9		
13	47,8	49,8		
14	52,3	53,6		
15	50,7	52,6		
16	51,1	52,8		
17	47,4	50,1		
18	51,9	57,8		
19	48,7	51,8		
20	46,7	50,6		
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Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pAi}}$	52,3	[dB(A)]
Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IAi}}$	49,5	[dB(A)]
Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	2,7	[dB(A)]
Microphone spacing	Mikrofonabstand	Δr	50	[mm]
Average A-weighted sound intensity level	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{IA}	49,5	[dB(A)]
Guaranteed	**Garantierter**	L_{IA}	--	[dB(A)]
Measurement distance	Abstand	X	1,0	[m]
Length of the prescribed contour	Länge des Messpfade	l_m	20	[m]
Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
Area of the effective surface	Flächeninhalt der Messfläche	S	66	[m²]
A-weighted sound power level	**A-bewerteter Schallleistungspegel**	L_{WA}	67,7	[dB(A)]
Guaranteed	**Garantierter**	L_{WA}	≤ 68	[dB(A)]

NOTE:



BEMERKUNG:



1,2,3, .. m. points D = 1m Height of the radiating surface: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3	1,2,3, .. Messpunkt D = 1m höhe: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3
Calculation formula:	Berechnungsformel:
$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0,1L_{IAi}}\right]$ $\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$ $L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$	$S = (h + X) \times l_m$ $Sv\{(24{,}2 \times 23{,}8 \times 17{,}6) + (22 \times 20 \times 16{,}8)\}$ $Sv_1 = 1016\ m^2$ $Sv_2 = 3314\ m^2$ $\Delta r\ 50\ mm - ONAN$ $\Delta r\ 12mm - ONAF$

KOLEKTOR ETRA

TRANSFORMER TEST REPORT
TRANSFORMATOR PRÜFPROTOKOLL

Transformer: / Transformator:	RT 10000-33	Ser. No.: / Fertigungsnummer:	85105

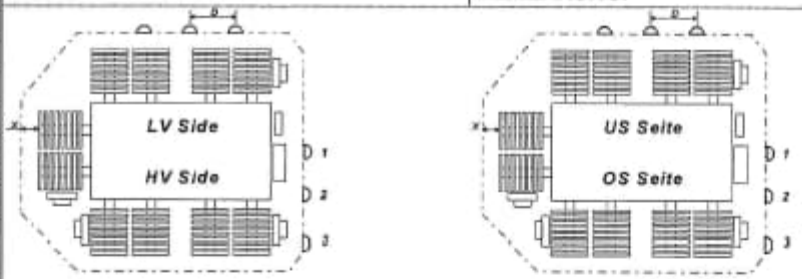
At 110% voltage, ONAN, distance 1,0 m	bei der 110% Spannung, ONAN, Abstand 1,0 m
Without fans!	ohne Lüfter!

Supply winding; Einspeise Wicklung:	LV / US	Tap position: Stufe:	9	Frequency: Frequenz:	50 Hz

	h = 1/2			
	L_{IAi}	L_{pAi}		
	[dB(A)]	[dB(A)]		
1	58,5	61,5		
2	64,6	66,0		
3	61,3	65,8		
4	68,5	69,6		
5	72,8	73,7		
6	70,1	70,9		
7	66,9	69,1		
8	63,6	65,0		
9	62,9	65,3		
10	63,1	65,7		
11	62,4	65,2		
12	65,7	66,5		
13	63,3	65,3		
14	64,9	65,8		
15	65,4	66,7		
16	66,0	67,2		
17	62,0	65,7		
18	63,9	69,8		
19	63,7	64,5		
20	61,8	65,6		
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Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pAi}}$	67,7	[dB(A)]
Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IAi}}$	65,9	[dB(A)]
Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	1,7	[dB(A)]
Microphone spacing	Mikrofonabstand	Δr	50	[mm]
Average A-weighted sound intensity level	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{IA}	65,9	[dB(A)]
Guaranteed	**Garantierter**	L_{IA}	--	[dB(A)]
Measurement distance	Abstand	x	1,0	[m]
Length of the prescribed contour	Länge des Messpfade	l_m	20	[m]
Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
Area of the effective surface	Flächeninhalt der Messfläche	S	66	[m²]
A-weighted sound power level	**A-bewerteter Schallleistungspegel**	L_{WA}	84,1	[dB(A)]
Guaranteed	**Garantierter**	L_{WA}	--	[dB(A)]

NOTE: / BEMERKUNG:



1,2,3, .. m. points D = 1m Height of the radiating surface: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3	1,2,3, .. Messpunkt D = 1m höhe: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3
Calculation formula:	Berechnungsformel:
$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0,1L_{IAi}}\right]$ $\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$ $L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$	$S = (h + X) \times l_m$ $Sv\{(24,2 \times 23,8 \times 17,6) + (22 \times 20 \times 16,8)\}$ $Sv_1 = 1016\ m^2$ $Sv_2 = 3314\ m^2$ $\Delta r\ 50\ mm - ONAN$ $\Delta r\ 12mm - ONAF$

KOLEKTOR

TRANSFORMER TEST REPORT
TRANSFORMATOR PRÜFPROTOKOLL

Transformer: Transformator:	RT 10000-33	Ser. No.: Fertigungsnummer:	85105

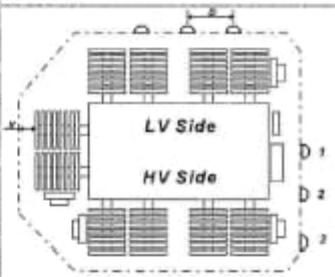
At rated voltage, ONAF, distance 2,0 m	bei der Nennspannung, ONAF, Abstand 2,0 m
With fans!	mit Lüfter!

Supply winding: Einspeise Wicklung:	LV / us	Tap position: Stufe:	9	Frequency: Frequenz:	50 Hz

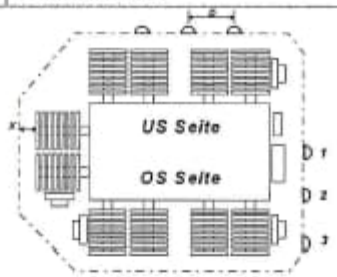
	h = 1/2			
	L_{IAi}	L_{pAi}		
	[dB(A)]	[dB(A)]		
1	50,1	55,3		
2	45,2	54,6		
3	50,6	54,6		
4	49,6	55,2		
5	52,7	56,2		
6	56,6	58,7		
7	56,2	58,7		
8	57,5	59,4		
9	58,3	59,5		
10	56,3	58,1		
11	57,2	58,8		
12	57,7	59,1		
13	57,5	59,0		
14	57,7	59,7		
15	57,3	59,2		
16	57,9	59,8		
17	57,0	59,1		
18	57,6	59,3		
19	57,0	59,0		
20	56,0	58,1		
21	56,0	59,4		
22	47,0	61,3		
23	51,7	59,4		
24	52,9	59,0		
25	51,2	57,9		
26	50,8	56,1		
27	49,9	55,5		
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Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pA0}}$	58,5	[dB(A)]
Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IA0}}$	55,5	[dB(A)]
Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	3,0	[dB(A)]
Microphone spacing	Mikrofonabstand	Δr	12	[mm]
Average A-weighted sound intensity level	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{IA}	55,5	[dB(A)]
Guaranteed	**Garantierter**	L_{IA}	--	[dB(A)]
Measurement distance	Abstand	x	2,0	[m]
Length of the prescribed contour	Länge des Messpfade	l_m	27	[m]
Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
Area of the effective surface	Flächeninhalt der Messfläche	S	116	[m²]
A-weighted sound power level	**A-bewerteter Schallleistungspegel**	L_{WA}	76,2	[dB(A)]
Guaranteed	**Garantierter**	L_{WA}	≤ 80	[dB(A)]

NOTE:



BEMERKUNG:



1,2,3, .. m. points D = 1m Height of the radiating surface: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3	1,2,3, .. Messpunkt D = 1m höhe: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3
Calculation formula:	Berechnungsformel:

$$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0,1 L_{IAi}}\right]$$

$$\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$$

$$L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$$

$$S = (h + X) \times l_m$$

$$Sv\{(24{,}2 \times 23{,}8 \times 17{,}6) + (22 \times 20 \times 16{,}8)\}$$

$$Sv_1 = 1016\ m^2$$

$$Sv_2 = 3314\ m^2$$

$$\Delta r\ 50\ mm - ONAN$$

$$\Delta r\ 12mm - ONAF$$

KOLEKTOR ETRA ČIKH

TRANSFORMER TEST REPORT
TRANSFORMATOR PRÜFPROTOKOLL

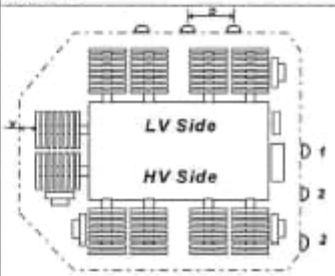
Transformer: Transformator:	RT 10000-33	Ser. No.: Fertigungsnummer:	85105

At rated current, (4 MVA), distance 1,0 m	beim Nennstrom, (4 MVA), Abstand 1,0 m
Without fans!	ohne Lüfter!

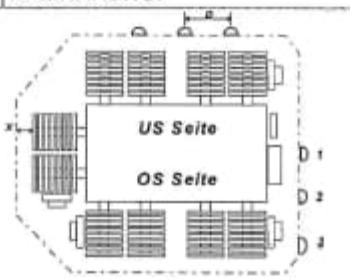
Supply winding; Einspeise Wicklung: HV / os | Tap position: Stufe: 9 | Frequency: Frequenz: 50 Hz

	h = 1/2								
	L_{IAi}	L_{pAi}							
	[dB(A)]	[dB(A)]							
1	19,1	29,3			Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pA0}}$	29,2	[dB(A)]
2	20,7	28,8			Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IA0}}$	22,0	[dB(A)]
3	21,5	29,5			Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	7,8	[dB(A)]
4	21,3	29,6			Microphone spacing	Mikrofonabstand	Δr	50	[mm]
5	24,2	29,2			**Average A-weighted sound intensity level**	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{IA}	22,0	[dB(A)]
6	23,0	31,0			**Guaranteed**	**Garantierter**	L_{IA}	--	[dB(A)]
7	25,5	30,5			Measurement distance	Abstand	X	1,0	[m]
8	23,4	29,5			Length of the prescribed contour	Länge des Messpfade	l_m	20	[m]
9	22,4	29,6			Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
10	21,0	29,4			Area of the effective surface	Flächeninhalt der Messfläche	S	66	[m²]
11	21,0	30,6			**A-weighted sound power level**	**A-bewerteter Schallleistungspegel**	L_{WA}	40,2	[dB(A)]
12	22,2	29,4			**Guaranteed**	**Garantierter**	L_{WA}	--	[dB(A)]
13	21,0	29,6							
14	19,9	29,1							
15	22,0	30,5							
16	20,0	30,1							
17	--	--							
18	--	--							
19	21,5	28,1							
20	20,2	30,3							
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NOTE:



BEMERKUNG:



1,2,3, .. m. points D = 1m Height of the radiating surface: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3	1,2,3, .. Messpunkt D = 1m höhe: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3
Calculation formula:	Berechnungsformel:

$$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0,1L_{IAi}}\right]$$

$$\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$$

$$L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$$

$$S = (h + X) \times l_m$$

$$Sv\{(24,2 \times 23,8 \times 17,6) + (22 \times 20 \times 16,8)\}$$

$$Sv_1 = 1016\ m^2$$

$$Sv_2 = 3314\ m^2$$

$$\Delta r\ 50\ mm - ONAN$$

$$\Delta r\ 12mm - ONAF$$

Measuring equipment:	Messgeräte:
- Sinus - Soundbook; - GRAS - 2x40GK,2x26CB - calibrator B&K - 4331, accuracy ± 0,30 dB	- Sinus - Soundbook; - GRAS - 2x40GK,2x26CB - Kalibrator B&K - 4331, Genauigkeit ± 0,30 dB

KOLEKTOR | ETDC ZTKH

TRANSFORMER TEST REPORT
TRANSFORMATOR PRÜFPROTOKOLL

Transformer: Transformator:	RT 10000-33	Ser. No.: Fertigungsnummer:	85105

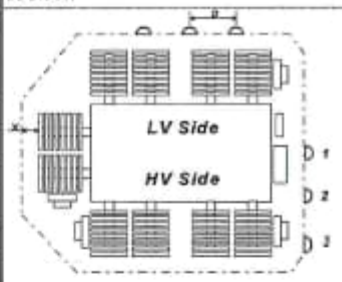
At rated current, (6 MVA), distance 1,0 m	beim Nennstrom, (6 MVA), Abstand 1,0 m
Without fans!	ohne Lüfter!

Supply winding; Einspeise Wicklung: HV / os | Tap position: Stufe: 9 | Frequency: Frequenz: 50 Hz

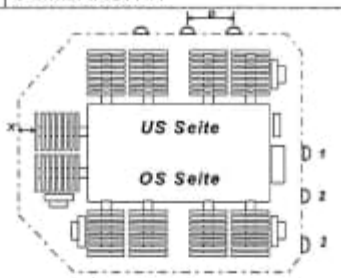
	h = 1/2	
	L_{IAi} [dB(A)]	L_{pAi} [dB(A)]
1	23,8	30,2
2	21,4	29,8
3	25,9	31,5
4	24,5	31,7
5	26,4	30,9
6	24,1	31,5
7	22,8	31,2
8	22,2	31,5
9	22,2	30,4
10	27,3	32,0
11	23,8	30,5
12	26,3	31,3
13	26,2	30,4
14	30,7	34,2
15	27,2	32,8
16	25,6	28,7
17	--	--
18	--	--
19	28,0	35,8
20	28,6	32,2
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Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pAi}}$	31,8	[dB(A)]
Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IAi}}$	26,1	[dB(A)]
Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	5,7	[dB(A)]
Microphone spacing	Mikrofonabstand	Δr	50	[mm]
Average A-weighted sound intensity level	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{IA}	26,1	[dB(A)]
Guaranteed	**Garantierter**	L_{IA}	--	[dB(A)]
Measurement distance	Abstand	X	1,0	[m]
Length of the prescribed contour	Länge des Messpfade	l_m	20	[m]
Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
Area of the effective surface	Flächeninhalt der Messfläche	S	66	[m²]
A-weighted sound power level	**A-bewerteter Schallleistungspegel**	L_{WA}	44,3	[dB(A)]
Guaranteed	**Garantierter**	L_{WA}	--	[dB(A)]

NOTE:



BEMERKUNG:



1,2,3, .. m. points
D = 1m
Height of the radiating surface:
< 2,5 m → 1/2
≥ 2,5 m → 1/3 + 2/3

1,2,3, .. Messpunkt
D = 1m
höhe:
< 2,5 m → 1/2
≥ 2,5 m → 1/3 + 2/3

Calculation formula:

$$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0.1 L_{IAi}}\right]$$

$$\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$$

$$L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$$

Berechnungsformel:

$$S = (h + X) \times l_m$$

$$Sv\{(24{,}2 \times 23{,}8 \times 17{,}6) + (22 \times 20 \times 16{,}8)\}$$

$$Sv_1 = 1016\ m^2$$

$$Sv_2 = 3314\ m^2$$

$$\Delta r\ 50\ mm - ONAN$$

$$\Delta r\ 12mm - ONAF$$

KOLEKTOR ETRA

TRANSFORMER TEST REPORT
TRANSFORMATOR PRÜFPROTOKOLL

Transformer: / Transformator:	RT 10000-33	Ser. No.: / Fertigungsnummer:	85105

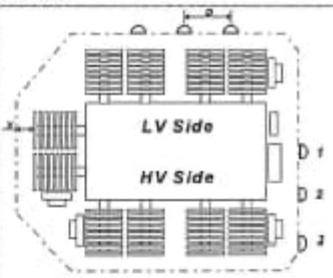
At rated current, (8 MVA), distance 2,0 m	beim Nennstrom, (8 MVA), Abstand 2,0 m
With fans!	mit Lüfter!

Supply winding; Einspeise Wicklung:	HV / OS	Tap position: Stufe:	9	Frequency: Frequenz:	50 Hz

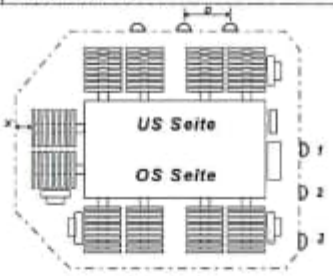
	h = 1/2			
	L_{IAi}	L_{pAi}		
	[dB(A)]	[dB(A)]		
1	48,5	53,4		
2	46,6	52,9		
3	48,1	53,1		
4	48,8	53,3		
5	51,0	54,8		
6	53,5	56,2		
7	56,3	58,0		
8	56,6	58,1		
9	55,8	57,5		
10	56,2	58,1		
11	56,4	58,0		
12	56,3	57,8		
13	57,3	58,8		
14	56,9	58,6		
15	58,2	59,2		
16	57,5	59,2		
17	56,7	58,6		
18	56,9	58,5		
19	56,1	58,0		
20	55,8	58,0		
21	55,0	58,8		
22	47,0	60,9		
23	48,5	59,1		
24	50,9	58,8		
25	51,1	56,6		
26	50,6	55,2		
27	48,6	53,8		
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Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pA0}}$	57,6	[dB(A)]
Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IA0}}$	54,7	[dB(A)]
Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	2,9	[dB(A)]
Microphone spacing	Mikrofonabstand	Δr	12	[mm]
Average A-weighted sound intensity level	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{IA}	54,7	[dB(A)]
Guaranteed	**Garantierter**	L_{IA}	--	[dB(A)]
Measurement distance	Abstand	X	2,0	[m]
Length of the prescribed contour	Länge des Messpfade	l_m	27	[m]
Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
Area of the effective surface	Flächeninhalt der Messfläche	S	116	[m²]
A-weighted sound power level	**A-bewerteter Schallleistungspegel**	L_{WA}	75,4	[dB(A)]
Guaranteed	**Garantierter**	L_{WA}	--	[dB(A)]

NOTE:



BEMERKUNG:



1,2,3, .. m. points D = 1m Height of the radiating surface: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3	1,2,3, .. Messpunkt D = 1m höhe: < 2,5 m → 1/2 ≥ 2,5 m → 1/3 + 2/3
Calculation formula:	Berechnungsformel:

$$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0,1L_{IAi}}\right]$$

$$\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$$

$$L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$$

$$S = (h + X) \times l_m$$

$$Sv\{(24{,}2 \times 23{,}8 \times 17{,}6) + (22 \times 20 \times 16{,}8)\}$$

$$Sv_1 = 1016\ m^2$$

$$Sv_2 = 3314\ m^2$$

$$\Delta r\ 50\ mm - ONAN$$

$$\Delta r\ 12mm - ONAF$$

KOLEKTOR

TRANSFORMER TEST REPORT
TRANSFORMATOR PRÜFPROTOKOLL

Transformer: / Transformator:	RT 10000-33	Ser. No.: / Fertigungsnummer:	85105

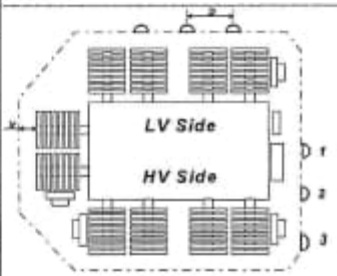
At rated current, (10 MVA), distance 2,0 m	beim Nennstrom, (10 MVA), Abstand 2,0 m
With fans!	mit Lüfter!

Supply winding; Einspeise Wicklung:	HV / os	Tap position: Stufe:	9	Frequency: Frequenz:	50 Hz

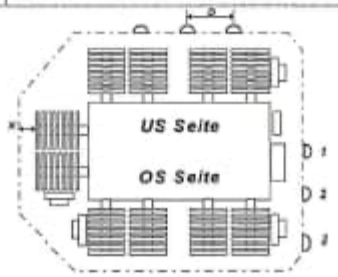
	h = 1/2			
	L_{IAi}	L_{pAi}		
	[dB(A)]	[dB(A)]		
1	47,9	52,9		
2	38,6	53,2		
3	47,7	52,6		
4	48,7	53,5		
5	50,4	54,4		
6	52,9	56,0		
7	55,6	57,8		
8	56,3	57,9		
9	55,7	57,4		
10	56,1	57,9		
11	56,0	57,6		
12	56,2	57,7		
13	56,9	58,5		
14	56,8	58,6		
15	57,1	59,0		
16	57,1	59,0		
17	56,3	58,1		
18	57,0	58,7		
19	55,8	57,7		
20	55,1	57,3		
21	54,7	57,8		
22	51,5	60,0		
23	51,4	59,3		
24	51,5	58,7		
25	52,3	57,0		
26	51,0	55,3		
27	48,7	54,1		
28				
29				
30				
31				
32				
33				
34				
35				
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37				
38				
39				
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41				
42				
43				

Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{pA0}}$	57,4	[dB(A)]
Average sound level	Mittelwert-Schalldruckpegel	$\overline{L_{IA0}}$	54,5	[dB(A)]
Allowable value for ΔL (must be ≤ 8 dB(A))	Der Wert für ΔL (muss ≤ 8 dB(A) sein)	ΔL	2,9	[dB(A)]
Microphone spacing	Mikrofonabstand	Δr	12	[mm]
Average A-weighted sound intensity level	**A-bewerteter Messflächen-Schallintensitätspegel**	L_{SA}	54,5	[dB(A)]
Guaranteed	**Garantierter**	L_{SA}	--	[dB(A)]
Measurement distance	Abstand	X	2,0	[m]
Length of the prescribed contour	Länge des Messpfade	l_m	27	[m]
Height of the radiating surface	Höhe des Prüflings	h	2,30	[m]
Area of the effective surface	Flächeninhalt der Messfläche	S	116	[m²]
A-weighted sound power level	**A-bewerteter Schallleistungspegel**	L_{WA}	75,1	[dB(A)]
Guaranteed	**Garantierter**	L_{WA}	--	[dB(A)]

NOTE:



BEMERKUNG:



1,2,3, .. m. points
D = 1m
Height of the radiating surface:
< 2,5 m → 1/2
≥ 2,5 m → 1/3 + 2/3

1,2,3, .. Messpunkt
D = 1m
höhe:
< 2,5 m → 1/2
≥ 2,5 m → 1/3 + 2/3

Calculation formula:

$$\overline{L_{IA0}} = 10 \times \lg\left[\frac{1}{N}\sum_{i=1}^{N} F_{Diri} \times 10^{0,1 L_{IAi}}\right]$$

$$\Delta L = \overline{L_{pA0}} - \overline{L_{IA0}}$$

$$L_{WA} = \overline{L_{IA}} + 10 \times \log_{10}\frac{S}{S_0}$$

Berechnungsformel:

$$S = (h + X) \times l_m$$

$$Sv\{(24{,}2 \times 23{,}8 \times 17{,}6) + (22 \times 20 \times 16{,}8)\}$$

$$Sv_1 = 1016\ m^2$$

$$Sv_2 = 3314\ m^2$$

$$\Delta r\ 50\ mm - ONAN$$

$$\Delta r\ 12mm - ONAF$$

Measuring equipment:	Messgeräte:
- Sinus - Soundbook; - GRAS - 2x40GK,2x26CB - calibrator B&K - 4331, accuracy ± 0,30 dB	- Sinus - Soundbook; - GRAS - 2x40GK,2x26CB - Kalibrator B&K - 4331, Genauigkeit ± 0,30 dB

KOLEKTOR	ETRA	TRANSFORMER TEST REPORT TRANSFORMATOR PRÜFPROTOKOLL	
Transformer: Transformator:	RT 10000-33	Ser. No.: Fertigungsnummer:	85105

CALCULATION OF OVERALL SOUND POWER LEVEL

Sound pressure method

BERECHNUNG DER GESAMTSCHALLLEISTUNGSPEGEL

Schalldruck-Messverfahren

- BS EN 60076-10:2016 cl.14

Ur_{ONAN} + Ir @ 4 MVA_{ONAN}		ONAN 4 MVA	
A-weighted sound power level at 100% of rated voltage excitation A-bewerteter Schallleistungspegel bei 100% von Nennspannung	$L_{WA,Ur}$	67,7	dB(A)
A-weighted sound power level at 100% of rated current of 4 MVA A-bewerteter Schallleistungspegel bei 100% des Nennstrom von 4 MVA	$L_{WA,Ir}$	40,2	dB(A)
A-weighted sound power level (Overall sound level) **A - bewerteter Schallleistungspegel** (Gesamtgeräusch)	$L_{WA,Sr}$	67,7	dB(A)
Guaranteed **Garantierter**	$L_{WA,Sr}$	--	dB(A)

Ur_{ONAN} + Ir @ 6 MVA_{ONAN}		ONAN 6 MVA	
A-weighted sound power level at 100% of rated voltage excitation A-bewerteter Schallleistungspegel bei 100% von Nennspannung	$L_{WA,Ur}$	67,7	dB(A)
A-weighted sound power level at 100% of rated current of 6 MVA A-bewerteter Schallleistungspegel bei 100% des Nennstrom von 6 MVA	$L_{WA,Ir}$	44,3	dB(A)
A-weighted sound power level (Overall sound level) **A - bewerteter Schallleistungspegel** (Gesamtgeräusch)	$L_{WA,Sr}$	67,7	dB(A)
Guaranteed **Garantierter**	$L_{WA,Sr}$	--	dB(A)

Ur_{ONAN} + Ir @ 8 MVA_{ONAF}		ONAF 8 MVA	
A-weighted sound power level at 100% of rated voltage excitation A-bewerteter Schallleistungspegel bei 100% von Nennspannung	$L_{WA,Ur}$	67,7	dB(A)
A-weighted sound power level at 100% of rated current of 8 MVA A-bewerteter Schallleistungspegel bei 100% des Nennstrom von 8 MVA	$L_{WA,Ir}$	75,4	dB(A)
A-weighted sound power level (Overall sound level) **A - bewerteter Schallleistungspegel** (Gesamtgeräusch)	$L_{WA,Sr}$	76,1	dB(A)
Guaranteed **Garantierter**	$L_{WA,Sr}$	--	dB(A)

Ur_{ONAN} + Ir @ 10 MVA_{ONAF}		ONAF 10 MVA	
A-weighted sound power level at 100% of rated voltage excitation A-bewerteter Schallleistungspegel bei 100% von Nennspannung	$L_{WA,Ur}$	67,7	dB(A)
A-weighted sound power level at 100% of rated current of 10 MVA A-bewerteter Schallleistungspegel bei 100% des Nennstrom von 10 MVA	$L_{WA,Ir}$	75,1	dB(A)
A-weighted sound power level (Overall sound level) **A - bewerteter Schallleistungspegel** (Gesamtgeräusch)	$L_{WA,Sr}$	75,8	dB(A)
Guaranteed **Garantierter**	$L_{WA,Sr}$	--	dB(A)

Calculation formula:	Berechnungsformel:
$L_{WA,Sr} = 10\lg(10^{0,1L_{WA,Ur}} + 10^{0,1L_{WA,Ir}})$	$L_{WA,Sr} = 10\lg(10^{0,1L_{WA,Ur}} + 10^{0,1L_{WA,Ir}})$

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